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DISSERTATION

CONCEPTUALIZING KNOWLEDGE FRICTION

by

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CONCEPTUALIZING KNOWLEDGE FRICTION

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ABSTRACT

This dissertation explores knowledge friction. The concept knowledge flow is defined by many researchers as the transfer of actionable information between individuals, groups and organizations. Knowledge Flow Theory (KFT) frames and offers tools for conceptualizing, analyzing, visualizing, and measuring knowledge flows. Recently, Nissen conceptualized explicitness-based resistance to knowledge transfer; he referred to it as knowledge friction.

This study addresses additional factors that inhibit knowledge transfer through an empirical look at Defense Acquisition University student surveys. These factors are clarity, near and longer-term relevance, certification level, and experience. The data was analyzed through descriptive statistics, multiple-regression analysis models, and a Partial Least Squares Structural Equation Model.

The key findings: Clarity and near-term and longer-term relevance are quantitatively the largest contributing knowledge friction factors. These new factors interact with, but are also additive, to explicitness. Also discovered: The certification level and experience factors independently contribute little directly, but do increase the impact of longer-term relevance on knowledge transfer. Near-term relevance's impact is not affected by certification level and experience.

These findings significantly contribute to KFT by extending and quantifying the factors that contribute to knowledge friction.

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I. INTRODUCTION

Knowledge, the information and skills an individual learns through experience or education, can be transferred from person to person; in other words, it can flow. That knowledge does not transfer perfectly between individuals, much less through organizations, is not a new discovery—it is a basic fact of life. As in our physical world where things that flow encounter resistance that impedes their movement, the flow of knowledge can also be affected by friction that slows its transfer. But what is actually contributing to this impediment is not defined well in current Knowledge Flow Theory. Therefore, the motivation behind this study is to better articulate some of the key factors that contribute to Knowledge Friction through the use of quantitative tools in order to mitigate those factors and improve knowledge flow.

A. THEORETICAL PERSPECTIVE

The concept of *knowledge flow* is defined by many researchers as the movement or transfer of actionable information between individuals, groups, and organizations (Polanyi, 1967; Nonaka, 1994; Grant, 1996; Nissen, 2006b). Expanding on this applied definition, knowledge can be operationalized through the actions that it enables (Nissen, 2006b), and a notable differentiation between tacit and explicit knowledge is developed (Nonaka, 1994). *Tacit knowledge* is experiential and normally transferred through person-to-person collaboration. In contrast, *explicit knowledge* is articulated and predominantly transferred through captured (chiefly written) documentation (James, 1950). Tacit and explicit knowledge are referred to by many as “know-how” and “know-what,” respectively (Spender, 1996), and they can be interrelated as endpoints along the continuum of *explicitness* (Nonaka, 1994; Nissen, 2006b).

Knowledge Flow Theory frames and offers tools for conceptualizing, analyzing, visualizing, and measuring knowledge flows. It describes significant differences between the transfers of tacit and explicit knowledge (Grant, 1996; Spender, 1996; Nonaka, 1994; Dierickx & Cool, 1989; Nissen, 2017): Transfers of tacit knowledge are noted for being relatively slow when compared with explicit transfers, but tacit flows generally enable

higher performance levels for many actions when compared to the actions achieved through explicit flows (Nissen, 2017).

Nissen recently extended Knowledge Flow Theory to conceptualize a resistance to *knowledge transfer* referred to as *Knowledge Friction* (Nissen, 2017), which accounts in part for the comparative slowness of tacit versus explicit flows. While a valuable extension to Knowledge Flow Theory, this friction concept remains very limited and underdeveloped, as it considers only the explicitness of knowledge in its conceptualization. Alternatively, informed by several relevant literatures (e.g., Deci and Ryan's Self-determination Theory [1985, 2015]; Nelson and Winter's The Firm as a Body of Knowledge [1982]; Jensen and Meckling's Agency Theory [1976]; and Davis, Schoorman, and Donaldson's Stewardship Theory [1997]), it appears that one or more additional factors may contribute to, exacerbate, or even mitigate Knowledge Friction. This leads to the primary research question for the current study: What additional factors can complement *explicitness* to extend our understanding of Knowledge Friction?

B. PURPOSE OF THE STUDY

The purpose of this research dissertation is to investigate Knowledge Friction more in depth, to identify and conceptualize additional influencing factors suggested by the literature, and to interrelate those factors empirically as an extension to Knowledge Flow Theory. As a starting point, the focus is on explicit knowledge (in particular, written documents), which is likely to be identified, tracked, and measured more easily than tacit knowledge. Also, by focusing on only explicit knowledge, the research can directly control for explicitness.

C. PROBLEM STATEMENT

Although Nissen recently extended Knowledge Flow Theory to conceptualize a resistance to *knowledge transfer* referred to as *Knowledge Friction* (Nissen, 2017), this concept remains very narrow and underdeveloped as it considers only the explicitness of knowledge in its conceptualization. For this theory to be more predictive of knowledge flow, it must better define those factors that inhibit the transfer of knowledge. Without

addressing the Knowledge Friction aspect of knowledge flow, the theory remains incomplete.

D. RESEARCH QUESTION

The primary research question is: What additional factors can complement *explicitness* to extend our understanding of Knowledge Friction?

E. CONTRIBUTION TO KNOWLEDGE

Applying quantitative research methods, this dissertation conceptualizes and establishes empirical interrelations between one or more additional factors contributing to Knowledge Friction. This extends Knowledge Flow Theory through richer conceptualization and quantitative interrelations between causal variables. It establishes both a starting point and an approach to guide future research along these lines. This dissertation also provides quantifiable metrics that can be further tested in various organizations and environments thereby leading to the generalization of results.

F. DISSERTATION ORGANIZATION

This dissertation is organized as follows. Beginning with the current Introduction section, which introduces the main thesis of the dissertation as the extension of Knowledge Flow Theory through the expansion of the Knowledge Friction concept, the dissertation progresses into the Literature Review of relevant theories (such as Knowledge Flow Theory, Relevance Theory, Self-determination Theory, Mastery Theory of Learning, and Knowledge Transfer Theory) that underpin the proposed concepts and constructs supporting the logic for considering why greater explanation of Knowledge Friction is needed and includes an explanation of the proposed Knowledge Friction Extension.

Next, the Research Design section introduces the research structure and the researcher's Knowledge Friction model. This leads to the three hypotheses of the research and the methods developed to address them. A description of the source of the data studied and when, where, and how it was collected is included. Based on the large volume of data, the analysis design section explains the primary ways the data was analyzed: descriptive statistics leading into factor analysis and linear-multiple regression analysis. This is

followed by the impact of the independent variables interacting with each other as well as with the dependent variable. To address endogenous independent variable interactions, a Structural Equation Model (SEM) is developed using Partial Least Squares (PLS) analysis.

These models' results are examined in the Data Analysis section, which closes with a discussion of the limited focus resulting from the researcher's position and the procedures imposed on the research.

The dissertation's Conclusion section revisits the research's main theses and concludes with the key findings, an explanation of its contribution to existing knowledge and theory, and the potential for future research.

Amplifying and supporting information is provided in the appendices.

II. LITERATURE REVIEW

As stated earlier, this dissertation extends the explanation of Knowledge Friction within the context of the Knowledge Flow Theory. To achieve this requires leveraging the theory and its precursor literature. Knowledge Flow Theory is predicted by Polanyi's articulation of knowledge bifurcation into tacit and explicit knowledge and an early explanation of tacit knowledge (Polanyi, 1967). Also foundational is Simon's discussion of the artificial and insights into how knowledge is ingested, formulated, and held in knowledge chunks (Simon, 1981). Nonaka (1994) and Nissen (2006b) develop Knowledge Flow Theory into a means of operationalizing knowledge movement through an organization; they begin with the individual transfer, expand to the group, and then to the organization. Grant (1996), Spender (1996), Dierickx and Cool (1989) extend the discussion of the expression and impact of knowledge at the organizational level.

Expanding Knowledge Friction requires nominating potential factors, or components, that aggregate into Knowledge Friction. Simon (1981), Collewet and Sauermann (2017) provide underpinning arguments for considering *experience* as one of these contributing factors. Sperber and Wilson (1995) address the importance of *relevance* in *knowledge transfer* through Relevancy Theory, while Deci and Ryan (1985) provide the groundwork of knowledge *relevance* through their research in motivation and the development of Self-determination Theory. To further operationalize motivation as *relevance* requires an understanding of the antecedents of motivation, and Self-determination Theory provides intrinsic and extrinsic as these underpinnings for motivation. These concepts are developed by Bunderson and Reagans (2011); Lawrence et al. (2012); Orr (1990); Contu and Willmott (2003); Marabelli and Galliers (2017); and French and Raven (1959). The best practices for the transfer of knowledge are revealed through a review of Bloom and Carroll's Mastery Theory of Learning (1971) and Kirkpatrick and Kirkpatrick's four-level process (2005).

Visualizing and measuring *knowledge transfer*, and by extension Knowledge Friction, demands a review of Nissen's illustration of Knowledge Flow Theory through its physics analogy model, discussion of *knowledge transfer*, and introduction of the

Knowledge Friction term. Table 1 provides a quick synopsis of the scholarly survey path taken in developing this dissertation.

Table 1. Key Findings from Prior Research.

Prior Research	Linked Ideas
Polanyi, 1967	Tension between knowing and articulating what is known. Link to tacit and explicit knowledge. *
Nonaka, 1994; Nissen, 2006b; Nissen, 2014	Organization knowledge enables action. Action drives performance. Performance supports competitive advantage. *
Nissen, 2006a	Knowledge represents a multifaceted concept. Knowledge must flow rapidly through the organization. *
Simon, 1981; Polanyi, 1964	Knowledge is modified and simplified into mental models at the individual level.
Collewet & Sauermann, 2017	Better developed mental models enable processing of more knowledge in a given period. Individuals have a finite capacity for ingesting new knowledge in a single session, and the – capacity to ingest knowledge dissipates over the session.
Nelson & Winter, 1982; Barney, 1986; Grant, 1996; Spender, 1996; Dierickx & Cool, 1989; Coase, 1937	Expands upon the Theory of the Firm to develop that organizational resources are the knowledge held by the organization. Expands knowledge from the individual to the organization.
Sperber & Wilson, 1995	Develops Relevancy Theory: Receiver sees positive value in expending effort to obtain knowledge. Communicator provides knowledge in an applicable format.
Deci & Ryan, 1985	Develops the Self-determination Theory that governs the relevance of proposed knowledge to the individual.
French & Raven, 1959	Discusses extrinsic motivation derived through the five bases of social power. Emphasis on legitimate base through hierarchy in the organization power literature. *

- Linked to * and adapted from Nissen et al. (2019).

Table 1. Key Findings from Prior Research (continued)

Prior Research	Linked Ideas
Bunderson & Reagans, 2011; Lawrence et al., 2012; Orr, 1990; 1996; Contu & Willmott, 2003; Marabelli & Galliers, 2017	Individual Relevance drives extrinsic motivation through hierarchical organizational power—often embedded in explicit knowledge. It is juxtaposed with tacit knowledge and episodic power. *
Bloom & Carroll, 1971; Ericsson, Krampe & Tesch-Romer, 1993; Johnson, 2009	Develops the Mastery Theory identifying the need to obtain a threshold of knowledge before progression to a higher level. Expands to incorporate the 10,000 hours of experience needed to achieve mastery, and further adds that rote execution does not achieve mastery.
Kirkpatrick & Kirkpatrick, 1994, 2005	Develops a four-level process to measure progress through training, focusing on reaction, learning, behavior, and results.
Nissen, 2002, 2014	Depicts Nonaka's Knowledge Flow Theory in a visual and measurable physics analog model.
Szulanski, 1996; Ko, Kirsch & King, 2005	Develops and expands the knowledge transfer model.
Zack, 1998; Nissen, 2017	Introduces the concept of Knowledge Friction, then incorporates it into Knowledge Flow Theory.

- Linked to * and adapted from Nissen et al. (2019).

A. KNOWLEDGE FLOW THEORY

A number of seminal works serve to guide this research. Polanyi (1967) asserts that “we know more than we can tell,” implying that people’s tacit knowledge is likely to be vast and deep when compared to what can be articulated in explicit form. However, this also implies that much tacit knowledge is trapped within people’s minds, memories, and experiences and is, hence, a challenge to access or observe through research. Polanyi also asserts that learning is believing and the transfer of knowledge, whether from generation to generation through acculturation or from an individual to an individual, requires a framework for accepting others’ information and beliefs. He states, for example, that it is the personal commitment of scientists that leads to the questions they pursue and their understanding of the surrounding world. He contends that the mere execution of the

scientific method does not seamlessly produce useful science. Polanyi's assessment of commitment by the individual begins the chain for understanding what impacts the flow of knowledge. To commit to a knowledge claim requires some level of *relevance* to the individual accepting the new knowledge. (Polanyi, 1964).

Nonaka (1994) builds on Polanyi in part by expressly differentiating between tacit and explicit knowledge through the dimension of *epistemology*, which suggests a categorical contrast between the two knowledge types. He also extends Polanyi's work to conceptualize organization knowledge flowing across individuals, groups, and beyond through the dimension of *ontology*. Specifically, as shown in Figure 1, he conceptualizes knowledge flow as a set of four interrelated processes that involve movements of knowledge through an organization (socialization, combination) and conversions of knowledge between tacit and explicit forms (externalization, internalization). Moreover, knowledge flow is conceptualized through successive iterations via these four processes, and its impact is said to increase as knowledge flows ever more broadly across the organization (from individuals, through groups, to organization-wide flows) through the phenomenon of *amplification*. The combination process, which characterizes explicit knowledge flowing between two or more people in an organization, is the most relevant for, and represents the focus of, this research.

	Tacit Knowledge	to	Explicit Knowledge
Tacit Knowledge	Socialization		Externalization
<i>from</i>			
Explicit Knowledge	Internalization		Combination

Figure 1. Modes of Knowledge Creation. Adapted from Nonaka (1994).

Nissen (2002, 2006a, 2006b) continues the study of knowledge flow by building on Nonaka's work. He effectively visualizes the movement of knowledge flowing through an organization through a three-dimensional grid framework (Nissen, 2006a, 2006b). The vertical axis exhibits the range of explicitness addressing Nonaka's contribution of tacit and explicit knowledge, adding a measurement vector of a continuous ratio (Nonaka, 1994). With the horizontal axis, Nissen visualizes *reach*. Reach depicts the range across which knowledge can flow in an organization: individual, group, organization, place, or time. This visualization clearly articulates knowledge flow through multiple levels of analysis (individual, group, organization). Nissen (2002) further extends Knowledge Flow Theory across levels of analysis by incorporating the dimensions *life cycle* and *flow time* (FT). The orthogonal axis depicts the knowledge's location in the life cycle. It shows the level of maturity of the knowledge flow: Is the knowledge at the early stage of creation or development, is it moving—being shared or transferred—or is it being used and adopted? Flow time depicts how long it takes knowledge to flow across individuals, groups, organizations, places, and times.

Simon (1981) argues that all knowledge is transferred at the individual level. Referring back to Polanyi's expression of tacit knowledge as "we can know more than we can tell," and that individuals frame their world and questions about their world beyond their mere observations (Polanyi, 1964), Simon posits further. He asserts that as rational actors, humans not only shape their observations of their world, but that they must necessarily simplify their framing of the environment into models—the artificial—to effectively navigate their world. To that end, Knowledge Flow Theory accomplishes a simplified model by leveraging a commonly understood analogy (Simon, 1981). Expanding on Simon's model, Collewet and Sauermann (2017) identify that there is a finite amount of time to transfer knowledge. Their research shows that humans can only ingest a finite amount knowledge in a given session, and that humans mentally tire; the effectiveness of work executed decreases by a tenth of a percent for every percent working. Their work also shows that this effective work decrease is less prominent in more experienced workers. Given these two findings, *experience* seems to matter when considering Knowledge Friction. Nonaka (1994) and Grant (1996) assert that knowledge

can be transferred at the group and organizational levels as well. This is noted above through Nonaka's ontological dimension.

Currently, the Knowledge Friction conceptualization develops from Szulanski's (2000) "stickiness," a term he coined to explain the difficulty found in moving knowledge through an organization; it tends to stick at each point along the way, and some kinds of knowledge (especially tacit) are inherently stickier than others (e.g., explicit). Building on Nonaka (1994) and Szulanski (2000), Nissen (2017) argues that it requires more effort to accelerate tacit knowledge than explicit knowledge, and he associates this differential effort with the concept of Knowledge Friction: "sticky" tacit knowledge involves greater friction than explicit and, hence, requires proportionately more knowledge force (KF) to accelerate.

Leveraging Barney's "Strategic Factor Markets" (1986), Dierickx and Cool develop asset stock accumulation and sustainability as the means by which organizations develop and maintain a competitive advantage (Dierickx & Cool, 1989). Essentially, they assert that organizations achieve and maintain a competitive advantage against their competition through the identification, obtainment, and effective flow of strategically unique stocks of resources. They define these resources as strategic because they cannot be easily "imitated" or "substituted" (Dierickx & Cool, 1989). They also expand their definition of resources to include Barney's unique skills and capabilities (Barney, 1986). This definition supports Knowledge Flow Theory's assertion that more effective knowledge flow leads to greater efficiency, which in turn results in a competitive advantage (Nissen, 2017). Identifying what impedes knowledge flowing most efficiently is necessary for an organization to capture the knowledge-based competitive advantage.

Nelson and Winter (1982) and Grant (1996) provide support for Dierickx and Cool's insight on Barney's depiction of skills and capabilities as strategic resources. They propose that an organization is simply a body of knowledge (Spender, 1996). More importantly, they theorize that knowledge is the only strategically unique stock—the one stock that is not easily imitated or substituted. This research draws on a knowledge-based model incorporating the correlating modern definitions provided by Nelson, Winter, Grant, Cool, Dierickx, Barney, and Spender, rather than Coase's economic resources-based model

as defined by his Theory of the Firm (1937). The modern firm is no longer adequately explained through a resource-based view (Nelson & Winter, 1982; Spender, 1996).

Grant (1996) explains that an organization integrates different individual knowledge to achieve more expansive results. His study focuses on *knowledge transfer* at the individual level, but it also views knowledge aggregating at the group and organization levels. This insight is paramount in understanding why group and organizational knowledge is fundamentally different from just the aggregate of the individual knowledge within the group or organization. He asserts that the unique stock of the organization's knowledge is in the effective integration of individuals' different knowledge. It is not that the same knowledge is spread across the organization, but that different types of knowledge (skills, capabilities) are identified, developed, and effectively communicated and integrated within the organization so that they can deliver a desired effect. Vital to this concept is that there is a shared knowledge to communicate the differing specific knowledge within the organization. This is often described as an organizational culture. Grant (1996) also delivers an explanation of why reach matters in Knowledge Flow theory, and why Knowledge Flow Theory spans multiple levels of analysis.

B. RELEVANCE THEORY

Starting with the premise that knowledge is ultimately accepted at the individual level, this dissertation is focused on the individual level of analysis. What motivates an individual to accept the transfer of knowledge? Looking to Aristotle's discourse on persuasion ("persuade: to *move* by argument, entreaty, or expostulation to a belief, position, or course of action" [*italics mine*]*), we find that he identified Logos (an appeal to logic—understanding), Pathos (an appeal to emotion), and Ethos (an appeal to moral principles) as necessary to persuade or move a message. Polanyi (1964) supports Aristotle's premise that understanding is necessary, but not sufficient, to move a message. This dissertation extrapolates that understanding alone also is not sufficient to effectively transfer knowledge. The receiver must also be intrinsically and extrinsically motivated (pathos and

* Merriam-Webster.com dictionary, Merriam-Webster, <https://www.merriam-webster.com/dictionary/persuade>. Accessed 29 Sep. 2020.

ethos). Deci and Ryan (1985) define motivation as intrinsic and extrinsic in their Self-determination Theory explaining Aristotle's pathos and ethos for the modern era. Specifically, they define motivation as two concepts: intrinsic motivation—that which motivates an individual internally through a sense of accomplishment or enjoyment (purpose, competence, progress, autonomy)—and extrinsic motivation—that which motivates the individual through obligation or coercion (pay, bonuses, ranking, fear) (Ryan & Deci, 2000). Given Ryan and Deci's work, quantifying the underlying factors (intrinsic versus extrinsic) in humans is questionable; this dissertation considers the human mind a black box (Capra, 1996)—with an input of knowledge and an output of action. The internal process of the mind is considered beyond the level of analysis for this dissertation. As such it looks at motivation from the external perspective of *relevance*: Is the knowledge relevant to the recipient?

Building on Self-determination Theory with consideration for the limitations associated with determining the internal process for motivation of an individual leads to leveraging Relevance Theory. Relevance Theory holds to two principles. Principle one is that the knowledge being provided has enough positive attributes that the recipient expends the effort required to process it. Principle two is that the communicator of the knowledge is providing the knowledge in the format they believe is most applicable for conveying it (Sperber and Wilson, 1995).

Relevance Theory describes the tension between the two principles and the associated actors (communicator and recipient) and several factors that might inhibit *knowledge transfer*. Orr's study of copier technicians at work uncovers tension resulting from competition between the holders of tacit knowledge (technical power) and explicit knowledge (legitimate power), and how this competition may impede knowledge flow (Orr, 1990). Bunderson and Reagans (2011) explore how the perceived motivation for the execution of power impacts the conveyance of knowledge. They find that knowledge employed by legitimate authority that is perceived by the employee to be imposed for the authority's personal gain seems to inhibit knowledge flow, while knowledge believed to be for the collective benefit seems to be more transferable (Bunderson & Reagans, 2011). The Copier Technician Case Study (Orr, 1990, 1996), as reevaluated by Contu and

Willmott (2003), reinterprets the motivation of the copier technician from “please the customer” to the more utilitarian establishment and maintenance of credibility within their community of interest, namely, fellow copier technicians.

Knowledge flow in an organization may reflect more a network than a linear depiction. Graphically, Barabási’s concept of network node fitness—desirable characteristics—delivers more connections (links) and can be leveraged to explain knowledge *relevance* in Knowledge Flow Theory (Barabási, 2014, 2016). Incorporating Relevancy Theory’s second principle from the organizational communicator’s perspective, the fitness is aligned to the *clarity* with which the communication articulates the organizational priorities; these priorities are defined in the organization’s mission statement or implied in the organizational culture. For those viewed through the communicator’s perspective, the effect is assessed through the receiver through the amount of knowledge that actually transfers.

From the knowledge recipient’s perspective, the *relevance*, depicted in Barabási’s model as node fitness (2016), results in the perceived value of the knowledge that is being imparted to the receiver. This in turn results in the strength and number of links to the node—as depicted in Figure 2.

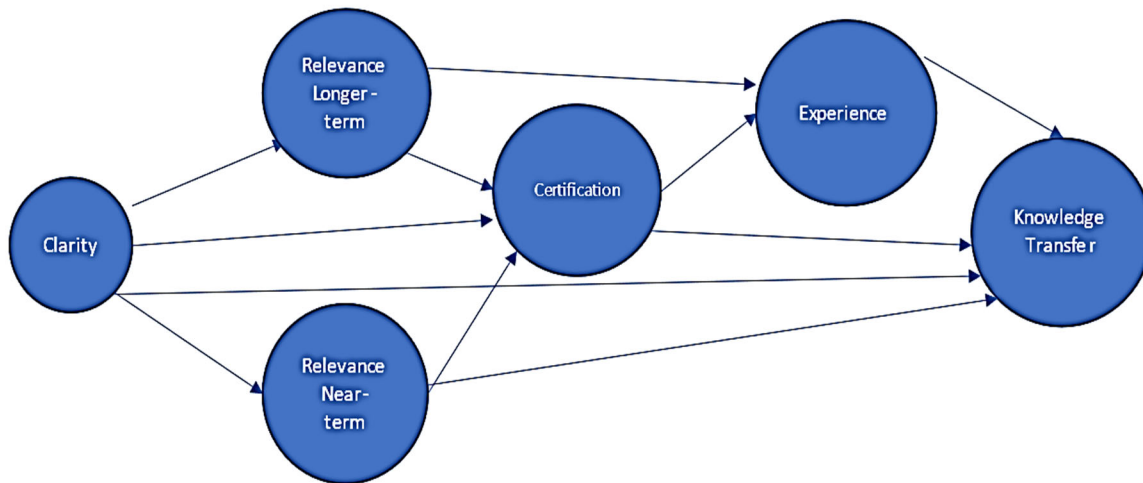


Figure 2. Knowledge Nodes and Links. Adapted from Barabási (2016).

Nissen (2006b) connects Von Krogh’s 2000 Knowledge Regression to Data Model and Tuomi’s 2000 corollary on the migration of data to knowledge with his signals transfer. His insight is that there is always a medium through which knowledge is transferred. This medium is often written or oral language, but can also be symbols (e.g., mathematics). This study leverages the Nissen insight into the transmission medium, extending it as a possible inhibitor to *knowledge transfer*; a proposed factor in Knowledge Friction called *clarity*. An example of *clarity*, or the lack of it, could be a course taught in perfect French to students who do not speak French. The knowledge is effectively encapsulated in information. The information is compiled in transmittable data sets, but the signals are not appropriately ciphered for the knowledge recipients—they cannot decipher the signal; the data are not clear and little knowledge is transferred. This sort of situation is visualized in Figure 3.

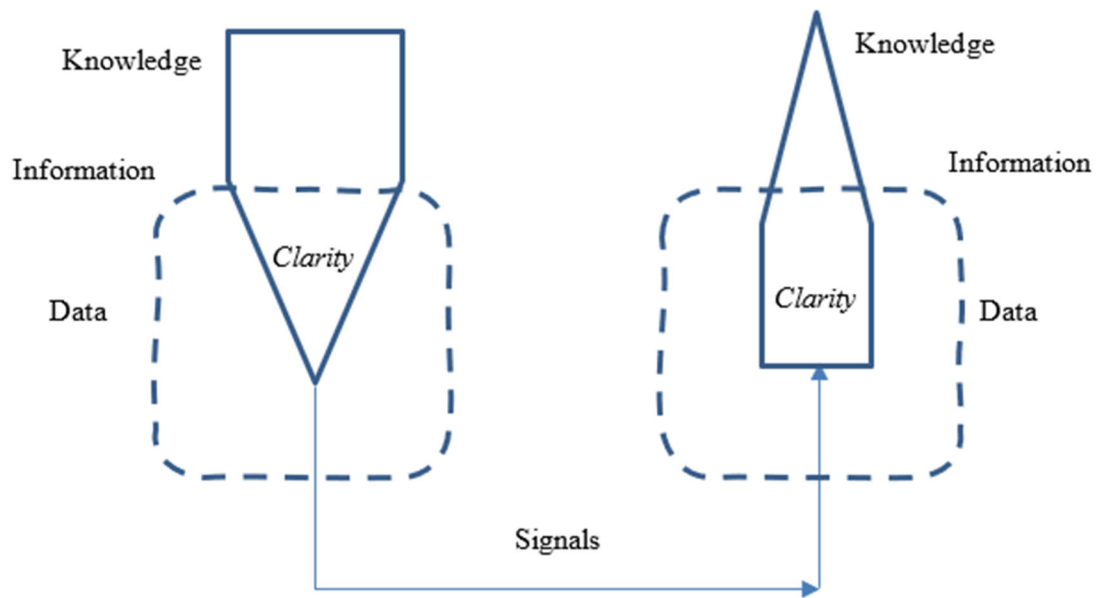


Figure 3. Knowledge Regression to Signals. Adapted from Nissen (2006b).

An integral assumption for this research is that the people get a vote on the assimilation of organizational knowledge flows. In the extreme, they determine that no knowledge flow occurs—the flow is retrograded to an information burst, which is not actionable. As asserted through the node fitness model, the recipient ultimately determines the node’s fitness—knowledge does not transfer if the recipient does not accept and act on it.

Also to be considered when discussing *relevance* is organizational influence and the perception of a power and its use. Of note, McClelland (1975) differentiates between personalized and socialized power. He describes how personalized power imposed for personal or political gain hinders knowledge acceptance by obstructing shared goals, risk taking, and experimentation. He finds the opposite to be true when power is directed toward collective goals and interests (Nissen et al., 2019). A link is established between Knowledge Friction and perceived power and the inhibition of knowledge transferred in a hierarchical organization (Scott, 1981); it follows that organization performance will be

diminished by Knowledge Friction through personalized rather than socialized power (Nissen et al., 2019).

C. MASTERY THEORY AND FOUR LEVELS OF LEARNING

The concept of Mastery, briefly defined here, has been observed for centuries; Bach is attributed with “I have done well. Anyone who works equally hard will do equally as well” (Johnson, 2009). “Learning of Mastery,” first coined by Bloom in 1968, identifies and develops strategies for mastering knowledge in the form of skills, by ensuring that the recipient could achieve a test score at a level of 90 percent or higher before allowing progression in their studies (Bloom & Carroll, 1971). Ericsson, Krampe, and Tesch-Romer (1993) quantify the level of effort required to truly master a skill at about 10,000 hours. This ten-thousand-hour rule is made famous in Malcolm Gladwell’s (2008) best seller, *Outliers*, which also stresses that the opportunity to obtain 10,000 hours of experience is integral to achieving it. Johnson (2009) expands the rule, observing that it takes more than just rote execution for 10,000 hours: constant intellectual rigor and variation are required to truly develop mastery. This research leverages mastery to explain the impact of experience on the transfer of knowledge, which could inform our conceptualization of Knowledge Friction. Experience level could positively correlate to the amount of knowledge that can be absorbed per transfer. Likewise, lack of experience may translate to a factor contributing to Knowledge Friction.

Many instructional organizations, including the Defense Acquisition University (DAU), use the Kirkpatrick Model to measure learning (Kirkpatrick & Kirkpatrick, 1994, 2005). It is a four-level evaluation process designed to progress through a training program to assess how effectively knowledge is transferred in the form of learning, developed skills, or attitude.

The four levels of Kirkpatrick’s evaluation model are Reaction, Learning, Behavior, and Results. The evaluation begins with how well the recipient favorably accepts the training as engaging and relevant. It progresses to evaluating how well the recipient learned the intended training in the form of skills, attitude, confidence, or commitment. It then follows up to assess the application of the provided training by the recipient in their

normal environment—usually their job. Finally, it assesses the results of the training through measured results of the recipient’s actual performance against targeted expected outcomes (Kirkpatrick& Kirkpatrick, 2005).

Understanding this evaluation system is important to this research as many higher learning institutions develop and justify the effectiveness of their curriculum based on surveys and the associated scales developed from the Kirkpatrick Four Levels of Learning. The DAU, a likely provider of Defense Acquisition Professional students’ survey data, is one of them.

D. KNOWLEDGE VISUALIZATION AND MEASUREMENT

Nissen (2014) extends Knowledge Flow Theory by conceptualizing a visualization and measurement scheme. Nissen’s (2002) first major contribution is clear and effective visualization of the movement of knowledge as it flows through an organization. He accomplishes this through the multidimensional diagram shown here as Figure 4. The vertical axis exhibits the range of explicitness, from completely tacit to completely explicit; explicitness is measured as a continuous ratio scale and based on the above referenced Nonaka (1994) article. The horizontal axis visualizes *reach* measured as an integer scale; it depicts the number of people who can utilize knowledge in an organization. The third orthogonal axis depicts the knowledge’s location in the *life cycle*, which is measured as an ordinal scale. Added by Nissen (2002), it shows the level of maturity of the knowledge flow. This third axis raises multiple questions: is the knowledge at the early stage of creation or development, is it being shared or transferred, or is it being used and applied?

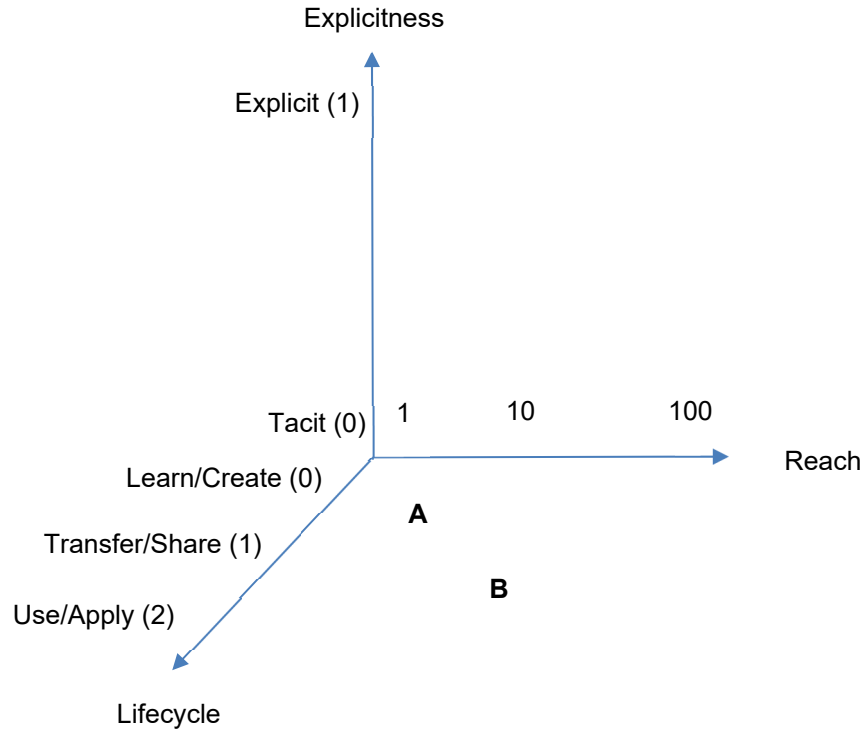


Figure 4. Knowledge Visualization Space. Adapted from Nissen (2017).

Flow time, measured as a ratio scale, was also added by Nissen (2002). It is the time required for knowledge to move through an organization (e.g., Points A and B in Figure 4). Relatively fast knowledge flows are represented by thin flow-time vectors; relatively slow ones are depicted as thick arrows. *Knowledge energy* (KE) is the resulting usefulness of knowledge as it flows through the organization, which can be evaluated through the performance level of the knowledge work (KW) it enables. Relatively high KE is shown as solid vectors; low energy is depicted as dotted arrows.

According to Knowledge Flow Theory, flows of explicit knowledge are normally faster but move with less energy than tacit knowledge flows. Figure 5 depicts two contrasting knowledge-flow patterns. Thin, dotted vectors depict an explicit knowledge flow pattern. Thick, solid vectors show a tacit flow. These depict two contrasting approaches to moving knowledge between Points A and B. Through the first approach (A-M-N-B), the visualization depicts an *explicit knowledge transfer*. Tacit Knowledge is made

explicit ($A \rightarrow M$) at the individual level (e.g., someone codifies the knowledge). The now explicit knowledge is transferred from the individual to the group ($M \rightarrow N$). The knowledge is then exhibited through action ($N \rightarrow B$). Note that this transfer occurs rapidly, but with little energy as depicted by thin yellow arrows. Through the second approach ($A \rightarrow P \rightarrow B$), the knowledge remains tacit throughout the transfer. An individual transfers his or her knowledge to another individual or group ($A \rightarrow P$), who then acts with the newly gained knowledge. This transfer requires higher energy and occurs over a longer period, but normally results in greater retention and a higher level of execution of the knowledge.

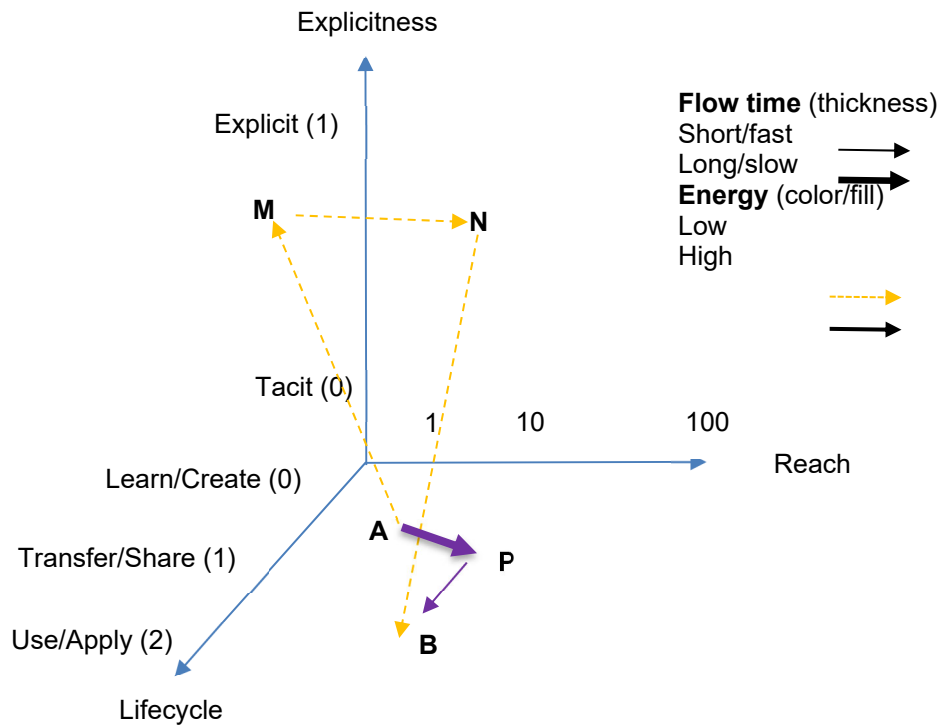


Figure 5. Knowledge Flow Archetypes. Adapted from Nissen (2017).

Nissen (2006b) extends this visualization scheme through his approach to measuring knowledge flows. Using a mechanical dynamics analogy, he adapts simple concepts and constructs from Newtonian physics to develop and interrelate a system of equations to characterize and quantify knowledge flows. This analog model allows for easy visualization of the abstract constructs of *knowledge force* (KF), *knowledge work* (KW),

knowledge energy (KE), *Knowledge Friction*, and *knowledge power (KP)*. These physical analogs allow straightforward correspondence to more difficult knowledge flow concepts and provide the means to measure, analyze, visualize, and ultimately simulate organizational knowledge flow.

In 2019 Nissen et al. further advanced this physics analog. The system provides visualization and formulas to calculate the impact of dynamic knowledge flow on a group or organization and is outlined in Table 2.

Table 2. Analogic Knowledge System. Adapted from Nissen (2017).

Construct	Description	Analogical Equation	Mapping
K-Force (KF)	Effort required to accelerate knowledge	$f(C, E)$	Force
K-Work (KW) = K-Energy (KE)	K-Force applied through reach (R)	$KF \times R$	Work/Energy
Flow Time (FT)	Time required for knowledge to flow	FT	Time
K-Power (KP)	K-Work done per unit flow time	KW / FT	Power

Briefly, KF represents the effort required to accelerate knowledge. In the model, more KF is required to accelerate a larger mass of knowledge, referred to as a *chunk* (Simon, 1981). Correspondingly, the more tacit the knowledge, the more KF is required. *Reach* represents the number of people reached by the knowledge (Nissen, 2017); this represents the simplified origins of Knowledge Friction. Knowledge work, which corresponds to Nonaka's *amplification*, is KF across the reach span in the organization. Knowledge work and KE relate in that KE is expended to perform KW, and KW performance is the realization of the expenditure of KE. As noted earlier, FT is the time required for knowledge to move from one point to another point (e.g., person to person, group, organization). Combining FT with KW establishes KP; this is KW achieved over time. Nissen (2017) illustrates how this system of dynamic knowledge equations can be applied to measure knowledge flows, as depicted in Figure 5.

E. KNOWLEDGE TRANSFER MODEL

Ko, Kirsch, and King (2005) develop a *knowledge transfer* model to articulate the precursors to *knowledge transfer* in support of Enterprise Resource Planning systems by leveraging Szulanski's (1996) three motivational factors of Arduous Relations, Causal Ambiguity, and Absorptive Capacity. Causal Ambiguity proved not to be operationalizable, and so they also incorporated Nelson and Coopride's Shared Understanding (1996), shared understanding being the knowledge created through individuals collaborating; they exchange individual knowledge to gain a collective group knowledge.

The knowledge antecedents of Arduous Relations and Shared Understanding rely heavily on communication: the ability to understand it, the amount and frequency of the communication, and the trustworthiness of the source of the communication. Absorptive Capacity considers the knowledge recipient's capacity to identify the availability of outside information and then absorb it and apply it.

The motivational antecedent generalizes to the intrinsic and extrinsic motivators of both the recipient and the provider of the knowledge being transferred. Weighting these factors, Ko et al.'s (2005) model provides values for each antecedent's effect on *knowledge transfer* and explains 58 percent of the transfer as measured by the model's coefficient of determination (R-squared).

Bischof and Eppler (2011) advance the research on the impact of *clarity* of communication on *knowledge transfer*. They leverage Langer's inductive framework (1989) of simplicity, structure, conciseness, and stimulation in a Delphi study to draw out the value of *clarity* in *knowledge transfer*.

This research expands on these *knowledge transfer* findings and begins establishing them in a more explanative Knowledge Flow Theory through the expansion of the Knowledge Friction construct.

F. KNOWLEDGE FRICTION EXTENSION

Zack (1998) uses the phrase “Knowledge Friction” to mean the long lead time for knowledge to be learned and benchmarked in an organization. He applies the term in the context of an organizational strategy frame, depicting strengths, weaknesses, opportunities, and threats (commonly referred to as SWOT). His definition of Knowledge Friction refers more to the results—slow transfer—rather than the factors that inhibit the knowledge flow and transfer.

Knowledge Friction, as described in Knowledge Flow Theory, explains the delaying or loss of knowledge after it has been collected and imparted by the organizational communicator in the transfer link to the designated recipients; it is the cause of the loss of knowledge between the knowledge transmitter and the knowledge receiver.

In Knowledge Flow Theory, Knowledge Friction is not to be taken as a synonym for Knowledge Barriers. Riege (2005, 2007) and Bloice and Burnett (2016) have articulated knowledge barriers primarily as the barriers to knowledge entering the organization and why knowledge never enters the knowledge flow. Bloice and Burnett highlight the general applicability of Riege’s triad of barriers (2005, 2007), and additionally make the argument for extending these barriers into explaining their impact on government institutions. They develop four categories of knowledge barriers (Bloice and Burnett, 2016): *Individual*, *Organizational*, *Technological*, and *Other*.

It is worth drilling down on these categories to better understand the differentiation Knowledge Flow Theory makes between the terms *knowledge barrier* and *Knowledge Friction*. The individual barriers encompass that knowledge gained through practice is often considered less trusted than that obtained through publications. These barriers are exacerbated by the fear of formalizing knowledge based on informal discussion. Additionally, potential knowledge providers are often uncertain about balancing their presentation of knowledge; they are uncertain of their audience’s expectations for the combination of theory, fact, and practice.

At the organizational level, the barriers to the introduction of knowledge revolve around the transient nature of the workforce when asking for a volunteer effort, which leads

to stunted development of the knowledge catchment process. This immature process normally is only developed to capture explicit knowledge, often neglecting tacit knowledge capture. The transient nature also leads to minimal opportunity to strategically plan and incorporate the knowledge through the identification of effective tools, the development of feedback, and the acceptance of external sharing. Ultimately this immaturity impedes the embracing of communal altruism and the dissemblance of internal competition.

The technological barrier category results from solutions that do not align with or that encumber the way people normally and naturally provide knowledge. Other potential barriers identified are external regulation and policies, often from government entities that limit knowledge collection and sharing, the general complexity of a profession, and the cross-layer effect of bureaucracies, as well as the general difficulty of expressing complex knowledge in concrete, understandable terms.

Riege's (2005, 2007) and Bloice and Burnett's (2016) categories of *Individual*, *Organizational*, *Technological*, and *Other* all express the barriers for knowledge to enter into the transfer process. Again, the research and discussion for this dissertation focuses on what impedes knowledge from reaching the recipient *after* it has cleared all of these barriers to entry, or Knowledge Friction as described in this dissertation.

As noted earlier, the Knowledge Friction concept is currently limited to Szulanski's (2000) "stickiness," and has been expanded as Nonaka's (1994) and Nissen's (2017) linear construct, defining friction as the trade space between tacitness and explicitness. Thus, Knowledge Friction is characterized by "sticky" tacit knowledge that involves greater friction than explicit knowledge and requires proportionately more KF to accelerate (Figure 6.).

In Figure 6, Nissen (2017) illustrates a representative relationship between KF and explicitness. In this representation, tacit knowledge requires ten times (10x) the KF needed to get explicit knowledge flowing ($KF = 10 - 9E$). Clearly other slopes (e.g., 2x, 100x) and functions (e.g., nonlinear) could apply, but the overall relationship is expected to be downward sloping, due to the sticky nature of tacit knowledge.

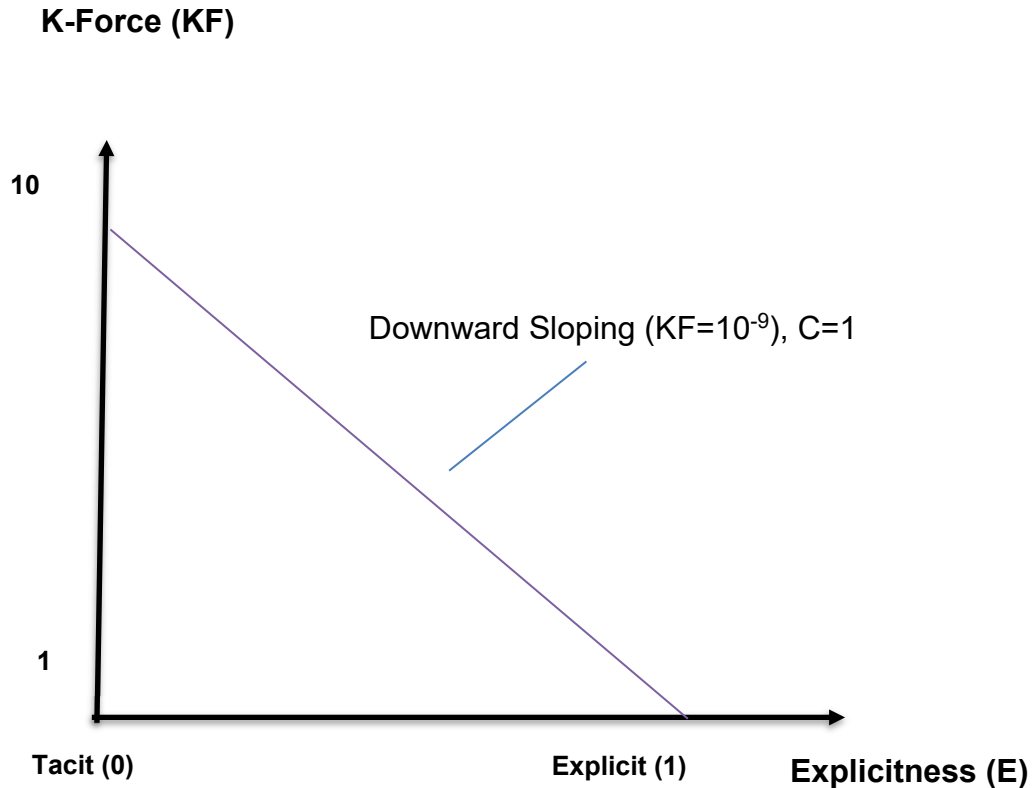


Figure 6. Knowledge Force and Explicitness. Adapted from Nissen (2017).

Leveraging Polanyi's (1967) correlation of knowledge to belief, the theory considers that knowledge is pulled to the recipient, rather than pushed from the deliverer. It is assumed that the deliverer has to have mastered the knowledge to impart it, and the receiver must understand what is being imparted, but that is not enough; the receiver must also believe in the knowledge. Polanyi supports his assertion by noting that in science and other disciplines, much information is provided, but far less is incorporated into the accepted knowledge—consider journal acceptance and rejection rates. Thus, Polanyi suggests one possible approach to extending the Knowledge Friction concept: determining the degree of *relevance* the proposed knowledge has to the recipient as a means of operationalizing belief.

Another consideration for friction to *knowledge transfer* is *clarity*. One of the first expressions of *clarity* comes from René Descartes, who states: “All which I clearly and distinctly apprehend is true” (Rubin, 1977). Smith (2021) explains that *clear* means

differing from another. C. S. Peirce [1878] extends the definition by adding *evident action implications* (Bischof and Eppler, 2011). Taken together, this definition of *clarity* aligns very well with Knowledge Flow Theory's operational definition of knowledge: information that is actionable. So, in concert with *relevance* identified in Ko et al.'s model (2005), *clarity* is integral to *knowledge transfer*, and the impedance to transfer (friction) could be the degree that proposed knowledge is not clear or relevant.

Beyond the need for the information to be clearly portrayed, the receiver has to determine *relevance* in order to focus the limited conscious sensor processing. Tegmark (2017) points out in his discussion of consciousness that of the information our brains process (10^7 bits), we are only aware of 10–50 bits at any given time. He arrives at this conclusion through a thought experiment, where he has a reader focus on the dot in the “i” of the word “desired” in a sentence, then expand their view around it (Tegmark, 2017). This concept of consciousness underpins *knowledge transfer* and the friction impeding the complete and successful transfer of knowledge. Without delving into the inner workings of the mind in this dissertation, it remains that humans physically can sense and take in a finite amount of information; they can only consciously process a much smaller amount—this comprises *knowledge transfer*.

The only expansion point the brain has is its ability to leverage its unconscious substrata developed through expertise. This expertise is gained through extensive experience. Consider again Tegmark's thought experiment (Tegmark, 2017). The novice reader will focus on each letter to sound out words. Consequently, that new reader will gain very little knowledge in each session—no matter how clear the writing or how relevant the knowledge. The advanced reader has become proficient at reading because their brain has delegated the deciphering of the letter, words, and common phrases to unconscious processes—this is often referred to as “flow.” This is sight reading, and it is achieved because of extensive experience in reading. In the most general terms, the brain has developed a framework for language and, more precisely, written language that allows bypassing the conscious requirement to physically sound out each word and then comprehend it. The advanced reader can normally take a short-cut straight to comprehension and context.

Further stressing the importance of *experience*, Willingham (2007) explains the impact of critical thinking in transferring knowledge; his discussion focuses on that, in people, specific experiences are not normally generalized and transferred across disciplines. He theorizes that critical thinking is required to identify the more generalized patterns and to abstract the patterns for problem solving in a complementary but different problem. Critical thinking skills are obtained not by rote memorization, but through practice.

Another aspect of *experience* is measured and articulated through learning curves. While learning curves were originally developed in the nineteenth century (Ebbinghaus, 1913) to express psychology, they came to prominence in the aviation industry in the early twentieth century (Wright, 1936). Essentially, learning curves express the transfer of knowledge (skills) over time. The ideal learning curve, often called the Sigmoid or S Curve (Figure 7), exhibits a slow transfer of knowledge initially, followed by a rapid increase of *knowledge transfer*, and ending with a tapering of the rate of *knowledge transfer* (Ritter and Schooler, 2002).

Sigmoid “S” Curve

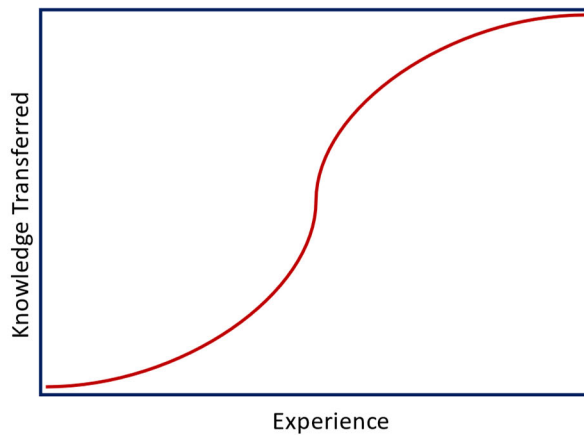


Figure 7. Sigmoid “S” Learning Curve. Adapted from Ritter and Schooler (2002).

The explanation for the early portion of the curve is supported by knowledge flow theory: The initial transfer is predominantly explicit and thus very shallow. The upswing

in transfer can be attributed to Knowledge Flow Theory: As fundamental explicit knowledge is mastered, the more nuanced tacit knowledge is quickly incorporated, building on the explicit knowledge, and transfer is accelerated (Nissen et al., 2019). The final tapering is not as well-defined by Knowledge Flow Theory, nor is the rapidness of retraining after a prolonged layoff from knowledge.

While the tacit versus explicit transfer displayed in the Sigmoid Learning Curve is interesting, it is not the focus of this dissertation. What is within the scope of this dissertation is the variation of transfer over time—commonly called *experience*. Of specific interest to this study is that the *experience* gained is not linear. While learning curves are often depicted in a continuous logarithmic scale to capture the exponential nature of knowledge growth in the first 80 percent of *knowledge transfer* (they then exhibit a tapering off to almost asymptotic), the data for this study are episodic, and in the range of complexity across the courses and curriculums, leave in question where the 80 percent bend in the curves falls. Because of this, the measurement of *experience* is ordinal. More knowledge is transferred over time, so more *experience* equates to more knowledge, but the first increment of *knowledge transfer* may not equate to the second, nor the second to the third.

This study intends to show that more *experience* factors into greater *knowledge transfer*, but it also expects to find that the impact of *experience* may vary over the life cycle of *knowledge transfer*—impacting little at the start, impressively in the middle, and lending to a diminishing return near the end.

Expanding on the above examples, this dissertation seeks to establish that the aspects of *relevance* and *experience*, coupled with *clarity*, can more generally explain the Knowledge Friction that limits *knowledge transfer*.

III. RESEARCH DESIGN

A. RESEARCH STRUCTURE

The research is designed to incorporate a rigorous scientific method. It proposes a model to extend the Knowledge Flow Theory by suggesting additional constructs that result in Knowledge Friction—the impedance of *knowledge transfer* to the intended recipient. These constructs are represented as factors (independent variables)—*clarity*, *relevance (near-term and longer-term)*, *certification (education)*, and *experience*—that impact the final factor (the dependent variable) of *knowledge transfer*. The study is based on DAU data obtained over a nine-month period from three types of surveys recounting the *knowledge transfer experience* of the students and the impact of the *knowledge transfer* as viewed by the students and their managers. The data are broken down into the separate surveys: the post-course student survey is taken immediately after the course is completed; the follow-up student survey is taken approximately six months after course completion; and the managers' survey also taken approximately six months after the student/employee completes the course. The survey data are tested for normality and interrater consistency. Analysis of alternatives and pairwise T-tests are executed to look for significant differences across the surveys. The post-course survey exhibits greater richness of data, particularly in terms of question selection, demographic data, and almost universal participation. Conversely, the follow-up and managers' surveys have far fewer participants, leading to the concern of potential self-selection bias (Tversky & Kahneman, 1973).

Using the factor analysis obtained from DAU with the data, the post-course survey questions are categorized into six questions identifying the *relevance* of the knowledge provided, six questions identifying the *clarity* of the knowledge provided, four questions identifying the perceived *knowledge transferred*, and two demographic questions establishing the participants' level of *experience* in the acquisition field and their level of *certification*. The responses to the first sixteen questions are collected as a Likert scale from one to seven, or as a percentage collected in multiples of ten. The last two questions are recalculated into an ordinal scale from one to six and one to five, respectively.

Course means, standard deviations, and skew are calculated and compared. Based on these comparisons and insight from the DAU staff analyst, three courses are studied in more depth. The General Acquisition (ACQ), Contracting (CON), and Program Management (PMT) curriculums are selected because their means, standard deviation, and skew, when taken together, are not statistically significantly different from the overall students' survey data; they provide a more insightful look at the population in a more manageable format. Specifically, the ACQ courses capture much of the population from a generalist perspective, while the other two curriculums are identified by the DAU as more rigorous and, so, provide more variation in the data collected and in the studied workforce's demography, specifically in the participants' level of *certification* and *experience*.

From this data set, multivariate regressions are run to express the explanatory power of the independent variables representing *clarity*, *relevance (near-term and longer-term)*, *certification* level, and *experience* on the dependent variable representing *knowledge transfer*. Further analysis is conducted in this study to evaluate the likely condition that the independent variables are not completely independent of each other.

A second part of the study considers whether the underlying factors are connected, related, and can be explained through theoretical propositions. In the SEM, constructs (factors) are represented by boxes and the propositions (the relationships between the constructs) are represented by arrows. The direction of the arrows hypothesizes the primary direction of impact one construct has on another. The model takes into account that while the first four constructs are independent variables, they are not likely devoid of interaction. To allow for this potential endogenous interaction, PLS is incorporated into the explanation of the propositions' (arrows) direction and relative impact on each construct. Leveraging the previous work described in the above literature review, the initial logic of the model displayed in Figure 2 and in the SEM model (see Figure 9) derives the proposition relationships for the Knowledge Friction constructs from the Nissen-inspired Knowledge, Information, Data, and Signals progression model (Figure 3).

The PLS model expands explanatory power through identifying not only the direct paths of *knowledge transfer*, but also the exogenous indirect paths across the several independent factors that also add to or inhibit *knowledge transfer*. As the *knowledge*

transfer over each path is not perfect (100 percent), the Knowledge Friction can be more clearly identified and measured.

B. SETTING

This study looks at a fundamental aspect of information flow through a technology organization with somewhat decentralized leadership and flat organizational design—in this case, it is the Defense Acquisition workforce educated by the DAU. The study provides an explanation of what causes friction in Knowledge Flow that impedes the organization’s mission. The courses selected for analysis are high-level program management courses, some of which are taught online. They are selected because of their high degree of complexity, which could draw out from the sample if *experience* and *relevance* are statistically relevant. Comparing the online self-paced–course surveys with the instructor-led–course surveys operationalizes for observation the explicit verses the tacit factor, respectively, for friction. Using the self-paced–course surveys for the preponderance of the research is a control for, and effectively removes, the impact of the tacit variability of instructor intervention that may accelerate *knowledge transfer*. Pragmatically, because these courses are high level, the gains by recipients are more likely observed, if not more valued, by their supervisor, who, in turn, is more likely to complete the post-course six-month survey.

C. POSITIONS

The author takes a number of epistemic positions through this study. For one, this dissertation focuses on the level of analysis at the individual: It accepts that knowledge is incorporated at the individual level (Simon, 1981; Grant, 1996)—even when flying a section formation, each pilot must have the requisite knowledge of flying a plane. This research does not seek to break down the internal motivations or decision processes within the individual. The internal working of the individual mind is accepted as a “black box.” However, the impact of Knowledge Friction on *knowledge transfer* is measured in the aggregate at the organization level (Nonaka, 1994; Nissen, 2017).

For another, this research does not attempt to re-prove or disprove the idea of knowledge as justified true belief. Dating back 2,500 years (Plato, Aristotle), simply put,

this idea states that having evidence to justify one's belief makes that belief true. Additionally, the research will not dwell on the ensuing Gettier Problem that challenges justified true belief (Gettier, 1963).

Finally, in this study, Knowledge Flow is defined as the movement or transfer of actionable information between individuals, groups, and organizations (Polanyi, 1967; Nonaka, 1994; Grant, 1996, Nissen, 2006b), and it is operationalized as the actions that it enables (Nissen, 2006b). For the purposes of this study, Knowledge Friction is the totality or combination of the factors that inhibit the flow on knowledge to its intended point of *knowledge transfer*.

D. PROCEDURES

To execute this research, the DAU courses' post-training supervisors' surveys are evaluated to ensure statistically relevant variance in scores (not all are outstanding employees). Next, the research evaluates the questions to ensure they align to the survey scales developed by the DAU, and they are also reviewed to ensure verifiable factor analysis. The contents of the questions are reviewed to ensure that they do identify the perceived level of *relevance* and *experience*; they will be compared and normalized for each student. As other factors are identified, they also will be normalized before being incorporated into the research. To safeguard the participants' anonymity and stay below the threshold for the Human Research Protection Program reporting requirements for human research, the researcher will ensure that all personal protected information is removed and not associated with the data and assign tracking numbers to their data sets. To further establish validity of this research, it will be executed using accepted statistical analysis practices. All recommendations and conclusions provided by this research will be supported by this valid statistical analysis.

E. KNOWLEDGE FRICTION MODEL

The model is operationalized through surveys collected and provided by the DAU. While these surveys are a veritable treasure trove of over 135,000 participants (surveys), they do come with some issues and limitations. The first constraint is the sheer volume of data: over a hundred fields per survey. There are, in fact, three different surveys provided,

each with different questions. Because the participants are so effectively anonymized, participation between surveys could not be correlated. Finally, only 14 of the survey questions could be structured as independent variables into a quantitative model, and they are, for the most part, ordinal measurements.

The Knowledge Friction Model is designed to provide explanatory power. While the surveys provide a substantial data set, the source of the data establishes some boundaries on the model's ability to explain. Notably, the surveyed population is significantly homogeneous, consisting, for the most part, of college educated, predominantly technically trained, U.S. defense acquisition professionals. Given the tight focus of the surveyed population, the specific results of the model may not be generalizable to all *knowledge transfer* situations. That the model is limited to five factors does make it a reasonably straightforward and logical explanation; it can be tested on other populations (Mun, 2021).

The research is structured to operationalize the pertinent survey data, ensuring testability and falsifiability (Popper, 1963), while ensuring a logical consistency across the model and in its results. Identifying the useful portion of the vast amount of data is achieved through statistical analysis. This analysis is also useful in determining relevant comparisons and contrasts between the types of surveys and the different courses reported on in the surveys. The statistical analysis also provides insight into the interrater reliability of the surveyed population. It can also draw out through factor analysis, covariance, and correlation matrices, aligning survey questions into factors. The Analysis of Variance (ANOVA) test is used to determine data consistency, while multivariate regressions provide explanation of the model through the coefficient of determination (R-squared or R^2). Taking into account that the independent variables are not completely independent of each other, the research further investigates the data through a PLS model. This model further articulates and investigates the multiple paths through the constructed factors for *knowledge transfer* and the ensuing Knowledge Friction along each propositioned vector of knowledge flow. The execution of this research through these techniques should provide a more articulated and quantitative representation of the factors that impede *knowledge transfer* and constitute Knowledge Friction.

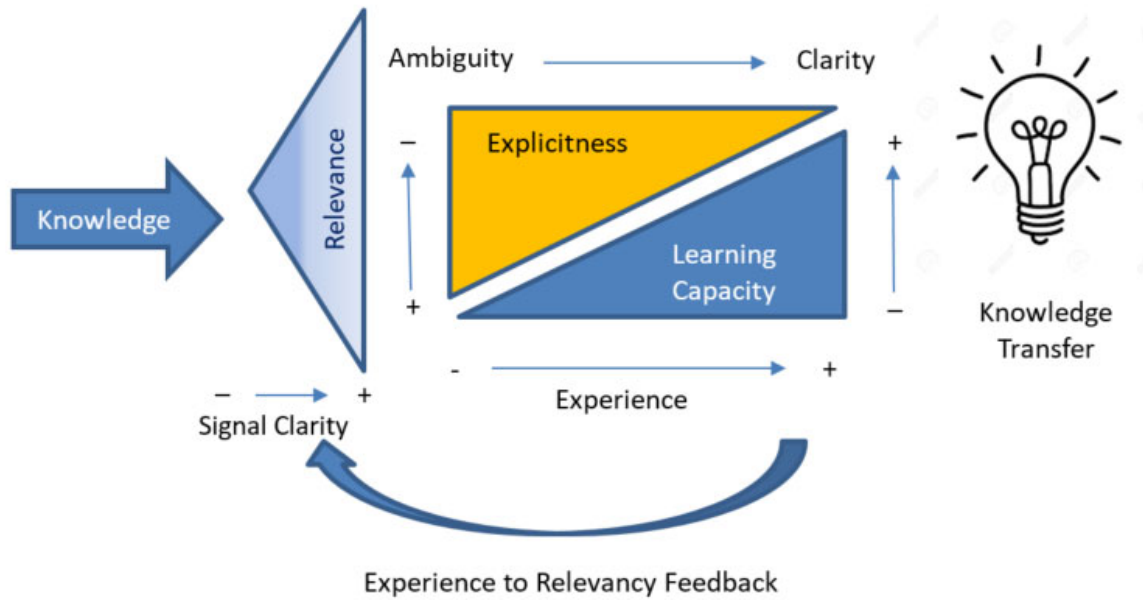


Figure 8. Proposed Knowledge Friction Model.

Building on and integrating the concepts, models, and frameworks gleaned from researching the literature, the author proposes the model depicted in Figure 8. It identifies the factors that may contribute to Knowledge Friction by capturing the potential flow and interplay between the factors (*relevance*, *clarity*, *education [certification level]*, and *experience*). These factors, taken separately and in concert, dynamically build to minimally or extensively inhibit knowledge flow; in other words, they create Knowledge Friction. Moving through the model, the amount of *knowledge transfer* (i.e., the knowledge that is received and able to effect action) is a function of these factors. These factors align into a process that begins with the initial amount of knowledge attempted to be shared. That knowledge is then filtered for *relevance* as perceived by the knowledge receiver, who assigns a level of *relevance* from no interest to high interest. *Relevance* may also be bifurcated into near-term and longer-term *relevance*. *Relevance* may be viewed as operationalizing Deci and Ryan's (1985) extrinsic and intrinsic motivation respectively, as near-term *relevance* (does it help me with my current job?) and longer-term *relevance* (will this advance my career or make me a better professional?). Once the knowledge has cleared the barrier of *relevance*, it competes in two domains: explicitness and learning capacity.

Pinker (2018), in his discussion on language cognition, explains the concept of models: how a framework to hold information and align knowledge is structured to meet the human need to minimize complexity and better plan for the future. As *experience* is gained, the preexisting models can be leveraged to add to and be adjusted with newly obtained knowledge. The availability of the models and the ability to update them is exhibited through, and valued as, *experience*. The vector of gained *experience* and the movement from incorporating only explicit knowledge to adding tacit knowledge make up the learning capacity domain and expand the knowledge shared.

Nissen and Sengupta (2006) reported on an experiment focused on the use of software to enhance supply chain management. One of the findings is the negative impact of ambiguity on automated systems. Software systems require clear instructions in the form of commands and curated, specific data to function effectively; they do not function well with imprecise information. For the software to obtain *clarity* and effectively act, very explicit knowledge is required, and then it is only effective for simplified problems. To act effectively on more complex issues requires mitigating ambiguity. Nissen and Sengupta (2006) addressed this through the addition of the human mind as a factor in their experiment. This is analogous to adding tacit knowledge and is represented in their model as the explicitness continuum. Tacit knowledge is required to meet the nuances of complexity and to expand *experience*. In the model, tacit knowledge is provided to resolve ambiguity and leads to greater *clarity*—a clearer understanding. Finally, *experience* is required to identify and leverage tacit knowledge. *Experience* also feeds back to the beginning of the process by making the initial contact with new knowledge more relevant.

F. HYPOTHESES

Nissen's extension of Knowledge Flow Theory incorporates the concept of resistance into *knowledge transfer*, which he refers to as *Knowledge Friction* (Nissen, 2017). This friction accounts in part for the comparative slowness of tacit versus explicit flows. While a valuable extension to Knowledge Flow Theory, this friction concept remains very simple and underdeveloped, as it considers only the explicitness of knowledge in its conceptualization. Thus, the Primary Research Question is restated here

for context: What additional factors can complement *explicitness* to extend our understanding of Knowledge Friction?

Firstly, Knowledge Friction is implied in Simon's chunks (1981) and Szulanski's stickiness (2000), but drawing from the preceding discussion, the knowledge receiver's understanding and *experience* could likely impact the amount of *knowledge transfer*. Also, considering Relevance Theory (Sperber & Wilson, 1995) and Self-determination Theory (Ryan & Deci, 2000), it stands to reason that additional factors for Knowledge Friction should be considered in Knowledge Flow Theory and, if uncovered, could be well expressed in Nissen's Knowledge Flow Theory visualization and measurement.

Hypothesis 1: A receiver's clear understanding positive perception of (*clarity*), *near- and longer-term relevance*, and higher levels of *certification/education*, and *experience* decrease Knowledge Friction.

Additionally, as discussed earlier, a greater *experience* level could allow for more chunks of knowledge to be absorbed per transfer because a framework exists to sort and place the knowledge. Therefore, lack of *experience* may translate to a factor contributing to Knowledge Friction. Generally, positional seniority in a bureaucratic organization correlates closely with increased *experience*. Technical bureaucracies value merit, but still support an orderly progression through the hierarchy. *Experience* and longevity provide desired organizational continuity.

Hypothesis 2: The *relevance* and *experience* factors' weighting correlate to the level of positional seniority of the receiver in an organization. Restated: Junior knowledge receivers will consider the importance of *relevance* and *experience* differently than will senior receivers.

Finally, the independent variables are probably not completely independent of each other—they are related and likely interact at some level. Because of this, linear multiple regressions will probably explain only part of the impact of these independent variables on Knowledge Friction. Exogenous and endogenous knowledge paths through the independent variables to the dependent variable would provide a richer explanation.

Hypothesis 3: There are multiple additive paths of *knowledge transfer*, and each path incurs Knowledge Friction.

G. METHOD

Evered and Louis (1981) make the point that knowing your intent should lead you to the appropriate epistemology. In terms of epistemology, this study aligns well with Positivism/Post-Positivism: Often described as inquiry from the outside, it requires the researcher to take a god's-eye view; the researcher is detached from the subjects. This epistemology is compatible with well-defined data in clearly articulated analytical categories, where the study's aim is to identify knowledge that can be generalized to many situations.

Quantitative research is for those questions that lend themselves to large amounts of pre-organized data, random samples, and generalizable “what” questions. Qualitative research is best used to address the more abstract research question of “why” or “how” is this phenomenon happening? This research is conducted as a quantitative study of an historical data set and analyzes it through probabilistic tools.

H. DATA COLLECTION

The DAU has been providing acquisition education and training for the Department of Defense for decades. Over the last decade it has been collecting its students' demographic and course feedback data. The DAU measures and monitors its performance through an end-of-course survey learning-evaluation system. In terms of measurable constructs, the DAU administers a post-training questionnaire after each course that is taught, and a follow-on survey is completed by the trainee's supervisor six months after training to assess the trainee's retained knowledge as exhibited in their post-training work performance. The post-course survey captures many potential constructs; the most promising include *trainee experience level*, *assessment of the clarity of the provided training*, and *self-assessment of the relevance of the training provided*.

The survey questions have been officially scaled by the DAU (Table 3; Defense Acquisition University, 2018). The questions were scaled and draw from a database of

performance benchmarks. These benchmarks were derived from data collected in earlier surveys. Developed by a professional team, the survey gathers student assessments of the content *relevance* and job applicability. Survey questions are based on the Kirkpatrick four-level model using a Likert and an incremental percentage scale (Kirkpatrick & Kirkpatrick, 1994; Bontis et al., 2011). The scales for the survey questions have been validated; the questions' factor analysis (Defense Acquisition University, 2018) results in a high factor loading.

The dependent variable is derived from the post-training survey completed by the student. The survey assesses the self-reported *knowledge transfer* expressed in the receiver's expectation to be able to execute in their job (to act). This survey is completed after completion of the course. This post-course survey was developed by the DAU with the same rigor described above (Defense Acquisition University, 2018).

As previously noted, the DAU executed three types of surveys across the years of 2017 and 2018. All the surveys are comprised of a mix of questions answered as a percentage response, a seven-point Likert scale response (one for strongly disagree to seven for strongly agree), and free-form responses.

The surveys contained standard educational questions as well as administrative ones, including the setup of the course, the facility, quality of graded materials, quality of the faculty, and length or pace of the course. This research excluded the administrative and free-form questions to focus on the necessary data from the most relevant questions that addressed factors that likely impacted the knowledge transferred through the DAU's programs.

The following questions are chosen for analysis from the DAU 2017–2018 course surveys (survey data provided by DAU).

Key Questions in the Student Surveys

Post-event Survey (VAR = variable)

- VAR1. I learned new knowledge and skills from this training.
- VAR2. Estimate how much you expect your job performance related to the course subject matter to improve in the next 12 months.

- VAR3. Based on your response to the prior question, how much of the improvement will be a direct result of this training, as opposed to other factors?
- VAR4. Rate your increase in skill level or knowledge of this content before versus after the training.
- VAR5. How many years of experience do you have in your primary career field?
- VAR6. What level of DAWIA [Defense Acquisition Workforce Improvement Act] certification did you have in your primary career field prior to attending this course?
- VAR7. What percent of your total work time requires the knowledge or skills presented in this training?
- VAR8. I will be able to apply the knowledge and skills learned in this class to my job.
- VAR9. What percent of new knowledge and skills learned from this training do you estimate you will directly apply to your job?
- VAR10. I will benefit from what I learned in the course for my career/professional development.
- VAR11. This training was a worthwhile investment for my employer.
- VAR12. On a scale of 0% (not at all) to 100% (extremely critical), how critical is applying the content of this training to your job success?
- VAR13. The scope of the material was appropriate to my needs.
- VAR14. The content was divided into small enough units to allow for sufficient learning.
- VAR15. The exercises added value to my learning.
- VAR16. The examples presented helped me understand the content.
- VAR17. The material was organized logically.
- VAR18. The graphics and illustrations used were meaningful and within context.

Six Month Follow-up Surveys (VAR = variable)

- VAR1. I learned new knowledge and skills from this training.
- VAR2. I was able to apply the training to my job within:
- VAR3. Based on your response to the prior question, estimate how much of the improvement was a direct result of this training.
- VAR4. Given all factors, including this training, estimate how much your job performance related to the course subject matter has improved since the training.
- VAR5. What percent of your total work time have you spent on tasks that require the knowledge/skills presented in the training?
- VAR6. I have been able to successfully apply the knowledge/skills learned in this class to my job.
- VAR7. What percent of new knowledge and skills learned from this training did you directly apply to your job?
- VAR8. This training has improved my job performance.

- VAR9. This training was a worthwhile investment for my employer.
- VAR10. On a scale of 0% (not at all) to 100% (extremely critical), how critical was applying the content of the training to your job success?

Key Questions in the Supervisor Surveys

(VAR = variable)

- VAR1. I feel this employee has learned new knowledge or skills from this training.
- VAR2. This employee has set specific goals for using this training to do his/her job.
- VAR3. Based on your response to the prior question, estimate how much of the improvement was a direct result of this training.
- VAR4. The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.
- VAR5. What percent of this employee's total work time do you feel he/she spends on tasks that require the knowledge/skills presented in this training?
- VAR6. Given all factors, including this training, estimate how much this employee's job performance related to the course subject matter has improved since the training.
- VAR7. What percent of new knowledge and skills learned from this training did you observe being applied by the employee to his/her job?
- VAR8. This training has improved the employee's job performance.
- VAR9. This training was a worthwhile investment in the employee's career development.
- VAR10. This training was a worthwhile investment for my organization.
- VAR11. On a scale of 0% (not at all) to 100% (extremely critical), how critical is applying the content of this training to the employee's job success?
- VAR12. The length of the course was appropriate to cover content. Subject matter has improved since the training.

These questions are analyzed in the context of the survey questions scales provided by the DAU. Per Table 3, a valid factor analysis is provided by the DAU.

Table 3. DAU Survey Factor Analysis Chart. Source: Defense Acquisition University (2018).

DAU Post-course Survey Scales

Factor Analysis

Thematic Spaces (5) of Numeric Survey Q's (High Factor Loadings)

A student responds very similarly to questions within each Thematic Space

See Appendix C for derivations of five factors

Note: This ordering does not match survey order

Variable	Factor 1 (Instructors)	Factor 2 (Course Materials)	Factor 3 (Relevancy/Benefit (Likert))	Factor 4 (Relevancy/Criticality (%))	Factor 5 (Workflow Learning)
The instructor encouraged students to think past in-class questions	0.310	0.004	0.355	0.046	0.346
The instructor was responsive to students' emails and questions	0.318	0.077	0.338	0.038	0.299
The instructor kept students actively engaged	-0.084	0.009	0.394	0.040	0.388
The instructor used knowledge of each student	0.126	0.017	0.367	0.116	0.347
The instructor was prepared and organized for the class	0.318	0.017	0.380	0.006	0.314
The instructor prepared lectures and assignments for the course	0.379	0.315	0.385	0.017	0.302
The class materials and content were relevant to my discipline	0.471	0.297	0.371	0.051	0.320
The material was organized and logical	0.326	0.387	0.393	0.066	0.400
This training was a worthwhile investment for my employer	0.075	0.146	0.350	0.309	0.181
This training will be a worthwhile investment in my career development	0.018	0.252	0.351	0.249	0.200
This benefit from what I learned in the course for my career/professional development	0.040	0.145	0.350	0.256	0.156
This training will improve my job performance	0.076	0.339	0.330	0.387	0.200
Just to show I am happy I worked in this course to my job	0.051	0.323	0.292	0.309	0.214
The material, materials, format, presentation, hardware, etc will be useful on the job	0.765	0.321	0.284	0.255	0.268
My support of this course will be reported to my boss	0.351	0.089	0.295	0.260	-0.218
Received new knowledge and skills	0.393	0.280	0.271	0.287	0.480
The incorporation of course materials and objectives in job and career: Did application area discussed during the course	0.682	0.211	0.285	0.211	0.355
The goals specified were effective in addressing the training in the course	0.233	0.215	0.430	0.009	0.244
If you required any assistance from the Center for Instruction and Student Support, was it helpful?	0.309	0.319	0.044	0.291	0.333
In a sense of the class as a 100% relevancy exercise, how closely is your opinion of the content of this training to your job sector? Check only one	0.407	0.041	0.305	0.791	-0.107
What percentage of new knowledge and skills learned from this course, in your industry, will apply directly to current tasks in your current field?	0.233	0.010	0.275	0.796	-0.353
What percent of your total time over time transfers the knowledge/skills presented in this training? Check only one	0.233	0.010	0.275	0.796	-0.353
Given the course, including its format, questions, material, how much of your job performance would be improved by the course content, material, and format?	0.233	0.010	0.275	0.796	-0.353
Based on your response to the prior question, estimate how much of the improvement will be a direct result of this training. For example, if you feel that half of the improvement is a direct result	0.252	0.030	0.052	0.755	0.240
How your WORM will be used in knowledge of this content before versus after the training. 0% is no increase and 100% is a very significant increase	0.311	0.060	0.076	0.635	0.207
The class content was relevant and applicable to my work	0.331	0.281	0.226	0.626	0.234
DAU course resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) are well organized and easy to use	0.000	0.000	0.000	0.860	0.208
DAU course resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) are well organized and easy to use	0.000	0.000	0.000	0.860	0.208
During the course, DAU's online resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) were used adequately and demonstrated the	0.000	0.000	0.000	0.860	0.208
DAU's online resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) were used adequately and demonstrated the	0.000	0.000	0.000	0.860	0.208
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DAU's online resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) were used adequately and demonstrated the	0.000	0.000	0.000	0.860	0.208
DAU's online resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) were used adequately and demonstrated the	0.000	0.000	0.000	0.860	0.208
DAU's online resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) were used adequately and demonstrated the	0.000	0.000	0.000	0.860	0.208
DAU's online resources (e.g., Communities of Practice, Job Support Tools for the Defense Acquisition Handbook, BMD, and ACCORD) were used adequately and demonstrated the	0.000	0.000	0.000	0.860	0.2

I. ANALYSIS DESIGN

A probabilistic approach is chosen to establish causation between independent variables (likely factors causing friction) and a dependent variable. As expressed in the hypotheses above, the independent variables include *receiver's clarity of understanding*, *near-term relevance*, *longer-term relevance*, *certification/education* and *experience*. The quantitative research controls for explicitness by using DAU online, self-paced courses as the basis for the data; this removes possible additional tacit *knowledge transfer* by instructor intervention. As added triangulation, the research does some quantitative excursions using the two follow-on survey types (student self-report and manager's assessment of the student/employee), but these provide limited insight because of the reduced range of questions and the propensity for self-selection bias—as discussed earlier.

Operational definitions provide meaning to the theoretical concepts captured in the attributes of the variables (Hughes, 1986). Per Popper's (1963) argument that scientific theory must be falsifiable, refutable, and testable, it follows that operationalized concepts

need to be measurable constructs. A hypothesis enables a researcher to operationalize falsifiability because it structures a measurable test of a theoretical construct (Hempel 1966). In this research, *knowledge transfer* effected by *clarity*, *near* and *longer-term relevance*, *certification level* and *experience* are theoretical concepts that must be linked through observed survey data to validate their operationalization as constructs (Feigl, 1970); quantifying these concepts results in objective and empirically acceptable findings.

The statistical treatment regimen for this study begins with the basic statistics of survey questions answered by nearly 30,000 students upon completing three curriculums. The curriculums provide courses gauged at four increasing levels of mastery. The basic statistics begin with considering the mean and skew of the survey data by curriculum and by level. While the Central Limit Theorem (CLT) is likely in play, given the very large sample size, normality is still tested. Tests for normality include the Lilliefors test; a non-parametric test that can establish the normal distribution of the data. The regimen follows with reliability testing: the Kendall's nonparametric inter-rater reliability tests. Correlations between the independent variables are identified, both linear and non-linear, by running the Pearson's linear test and the associated non-linear non-parametric Spearman's test (Mun, 2019).

To determine if the proposed independent variables impact the proposed dependent variables, two-way Analysis of Variance (ANOVA) and two-way Multivariate Analysis of Variance (MANOVA) are executed. ANOVAs that exhibit statistically significant variance are further investigated with the Pairwise T-test for independent variables with equal or unequal variances (Mun, 2019).

To identify the most significant independent variables, Principal Component Analysis (PCA) can be leveraged for a review of the factor analysis through its development of covariance and correlation matrices, and analysis of the eigenvectors and eigenvalues developed to express the matrices. This reduction and refinement of independent variables supports more explanatory and supported econometrics, and multivariate regressions models (Mun, 2018). Stepwise regressions are used to further test the impact of the regression modeling, by expressing the build of the correlating independent variables regression model from the most impactful to the least, or conversely

removing the least impactful, until the optimal model is represented in the regression (Mun, 2018).

Tests for Normality of Data Sample and The Central Limit Theorem

The Lilliefors test is a nonparametric treatment for identifying the normality of the data set. It is focused on the difference between the empirical and cumulative distributions and makes no assumptions about the make-up of the population from which the sample is taken (Mun, 2019). It also does not require an expected value or variance. While this test allows for smaller sample data sets to be analyzed, it is useful to review even a large data set such as the DAU surveys to ensure parametric characteristics before performing analysis using parametric treatments. Notwithstanding the Central Limit Theory's expected impact on a large sample such as the DAU Survey data, a study that is weighted heavily to quantitative parametric analysis must establish, not just assume normality. Besides, some of the data variables are ordinal in nature. If normality is not present in the data, then the goodness-of-fit of a linear regression test is at risk of not being the most powerful or valid. Other issues that could arise from a non-normally distributed data set are autocorrelation and other disruptive results (Mun, 2019).

Tests for Reliability: The Kendall Inter-rater Reliability Tests and the Guttman's Lambda and Split Half Model

The Kendall Inter-rater reliability tests identifies coherence between the raters, for the purposes of this study raters are the individual students reflected in their post-course surveys. The tests compare each responder's answers to each question to determine whether there is a significant correlation between their answers. The null hypothesis states that there is not (Mun, 2019).

The Guttman's Lambda and Split Half Model tests for reliability across questions devised to draw out the same factor. This test substantiates that the students answering questions aligned to the same factor; they answer them consistently. The null hypothesis for this test is that they do not.

Tests for Linear and Non-linear Correlations

The Pearson's linear test and the associated non-linear non-parametric Spearman's test develop a correlation matrix from which associated correlation strengths between variables can be determined and visualized. The range of correlation is between one and negative one, with the magnitude identifying the strength of the correlation between the variables, and the positive or negative sign indicating direct or inverse correlation (Mun, 2019). This test further supports the factorial analysis of questions supporting a single factor and can assist in determining needed and extraneous independent variables as well as point to the strongest dependent variable when developing multiple regression models to explain the impact of Knowledge Friction factors on *knowledge transfer*.

Two-way Analysis of Variance (Two-Way ANOVA) and Two-way Multivariate Analysis of Variance (Two-Way MANOVA)

The Single Analysis of Variance (ANOVA) with Multiple Treatment of the Independent Variable is used to consider the internal consistency of the survey responses. To that end, the treatment through ANOVA determines consistency in the respondent's answers—is there a consistent logic in answering questions, or are they likely randomly answered. Like the t-tests, described above, that are applied to two variables at a time to determine if their means, proportions, or variances reflect statistically significant differences. The ANOVA allows for two or more sample means to be tested at the same time. Specifically, the single ANOVA with multiple treatments tests one category of an independent variable, in this case framed as responses to different survey questions, believed to explain one dependent variable across multiple treatments. The null hypothesis concludes that the population means are equal; the alternate hypothesis is that one or more of the treatments' populations are significantly different. For the purposes of this dissertation, the alternative hypothesis below a level of .05 p-statistic would exhibit that there is internal consistency across the question answers. The respondents are not randomly filling in the answers. Because the sample is very large and encompasses the near totality of up to three acquisition workforce curriculums, the sample selection can be considered random. The single ANOVA with multiple treatments hypotheses are written:

$H_0: \mu_1 = \mu_2 = \mu_t$ [for treatments 1 to t] (there is no effect in the treatments: the answers are randomly selected).

H_a : Population means are not equal (there is statistically significant difference in one or more of the treatments: the answers are not randomly selected) (Mun, 2019).

Pairwise T-test independent variables equal or unequal

Using the **paired T-test** enables testing whether the two samples are representative of the same population. As described by Mun (2019), the pairwise T-test examines the difference between population means for a set of random samples whose variations are almost normally distributed. T-testing is often used to compare subjects for before and after the situation; it can also test for similarity between subjects. The null hypothesis for the paired t-test is that the differences between the two observations is zero.

For this research, the proposed dependent variable for the student post-course survey (I have learned new knowledge/skills from this training) is compared to the associated dependent variable question from the follow-on question (I learned new knowledge and skills from this training) to determine if they are statistically different from the same population. If they are, then the survey data can be used to expand the study. If they are not, then the study will use the post-course survey as it is a larger sample, with more independent variables options and more numerous and inclusive population.

Using another pairwise T-test the study compares whether the self-paced and the instructor-led dependent variable (I have learned new knowledge/skills from this training) data are statistically from the same population: the null hypothesis being the difference is zero. If the two samples are not from the same statistical population; this lends credence to *tacit knowledge transfer* being a factor in Knowledge Friction as theorized in the Nissen's Knowledge Flow Theory (Nissen, 2017).

Principal Component Analysis and corresponding Eigenvalues and Eigenvectors

Principal Component Analysis (PCA) is the basis for **multivariate data analysis** and is used to reduce the number of variables in multivariate data. It also enables better observation of clusters, trends, and outliers. This clustering is illustrated in Figure 9. PCA works because data has as many principal components as variables: the first principal

component represents the largest variance; the second principal component represents the next largest uncorrelated variance; this continues to the n th principal component (Jaadi, 2019).

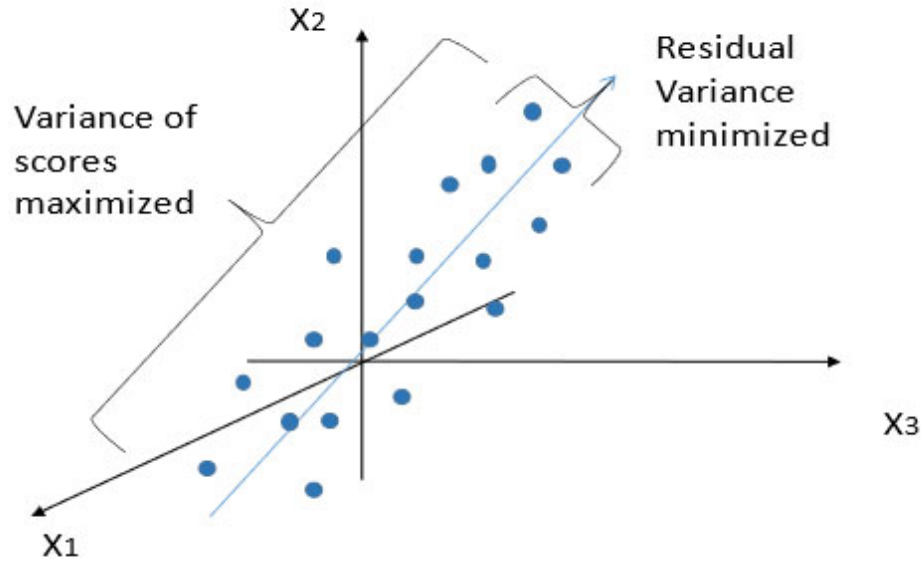


Figure 9. PCA Visualization of the Variance of the Projection Coordinates by Minimizing Residual Variance through Least Squares. Adapted from Jaadi (2019).

For the purposes of this dissertation, PCA is used to construct the correlation matrix for the relevant variables explaining all the factors. The correlation matrix is used as a cross check on the factor analysis and to ensure minimization of covariance between the factors' variables. The PCA correlation matrices also provide a check of multicollinearity between the independent variables. The associated eigenvalues and eigenvectors identify the strongest covariances and correlations that also imply the most impactful independent variables for consideration in multivariate regression models (Mun, 2018).

Factor analysis aligns closely to PCA. While PCA simplifies multivariate data presentation, making it easier to model, Factor analysis provides the means to analyze large numbers of independent variables to determine how independent they are of each other—often times they are not. That is to say, changing the value of one independent variable will

actively impact other independent variables. In a linear multivariate regression, multicollinearity can result in large biases. Factor analysis identifies and recommends a smaller grouping of independent variables, effectively leveraging the larger number of original variables into uncorrelated independent variables. These new variables are combinations of the original set, so most of the variation is accounted for in the new variables. This means most of the variation can be accounted for by using fewer explanatory variables while experiencing little information loss (Mun, 2021).

Multiple Regression Analysis

Multivariate regression is used to determine the correlation and impact of the independent variables on the dependent variable (*knowledge transfer*), and the total R^2 is the explanative power of the regression model. This will provide some insight on the impact of the collective Knowledge Friction factors and how much they inhibit *knowledge transfer* (Mun, 2021). As stated in hypothesis three: there is likely interaction between the independent variables—they are not completely independent of each other. To address this, the next section looks at an SEM implementing PLS.

SEM and PLS

The goal of this analysis is to identify the best-fit regression to evaluate the quantitative level of explanation of each factor of Knowledge Friction. Covariance for the independent variables is evaluated to ensure the data are quantitatively reviewed for internal validity within the survey questions identified for each factor.

Large data sets allow a range of statistical techniques and approaches. One approach used with experimental and quasi-experimental designs is null hypothesis testing (Shadish, Cook, & Campbell, 2002). Data modeling is another approach (Rodgers, 2010); specifically, the use of SEM, which is promising because it simultaneously test multiple hypotheses while also providing a visual model of the mathematically formed relationships. Of concern, however, is the significant level of interpretation required in SEM.

An effective way to measure, and model, the data is estimation through linear regression; this can be achieved through PLS (Wold, 1975). Partial Least Squares is a

scientifically accepted SEM (Chin, 1998; Gefen, Straub, & Boudreau, 2000). It maximizes variance in a dependent variable through explaining multidimensional directions in the independent variables, while minimizing assumptions about the data's distribution.

Advantages of PLS include that it

- (a) No assumption of a normal distribution.
- (b) Allows for multicollinearity and endogeneity.
- (c) Explains complex exploratory relationships.
- (d) Weights variable indicators to scale.
- (e) Employs non-interval scales.

Segments of the raw data set to be used in this research are analyzed by leveraging the effective previous work using PLS. The DAU work of Bontis, Hardy, and Mattox (2011) documented good fits in their supporting linear regressions. PLS considers all path coefficients simultaneously allowing analysis of direct, indirect, and spurious relationships between factors (Mun, 2021). This increase in explanatory power expands the horizon for research through quantitative methods. Each independent variable is evaluated to determine the quantitative level of explanation for each factor relative to the overall Knowledge Friction dependent variable.

As an extension of multiple regression analysis, SEM uses the PLS method. SEM is typically used to solve path-dependent structures such as the one illustrated in Figure 10. Using five variables (VAR1–VAR5), where the final dependent variable is for this research *knowledge transfer* (VAR5), the model is framed to determine what drives the *knowledge transfer* and how much knowledge is transferred from a curriculum to a student enrolled in the DAU. Using the nine months of data collected from participants in three levels of acquisition education measured primarily in seven-point Likert scales and percentages, students self-report on the curriculum's *relevance*, *clarity* of the instruction, their current level of *certification* (documented education) as an acquisition professional, and their years of acquisition *experience*. While regressions are easily run on the data, simple linear regressions do not fully take into account the likely interaction between the independent variables (Mun, 2021). *Relevance*, *clarity*, level of *education*, and *experience* (VAR1–4) are all likely endogenous factors—they build off of and feed back on each other. So, to better understand how these intervening variables contribute to *knowledge transfer*, a PLS

model is employed. Knowledge Flow Theory implies fewer linear paths and feedback effects in knowledge flow and, presumably, *knowledge transfer*.

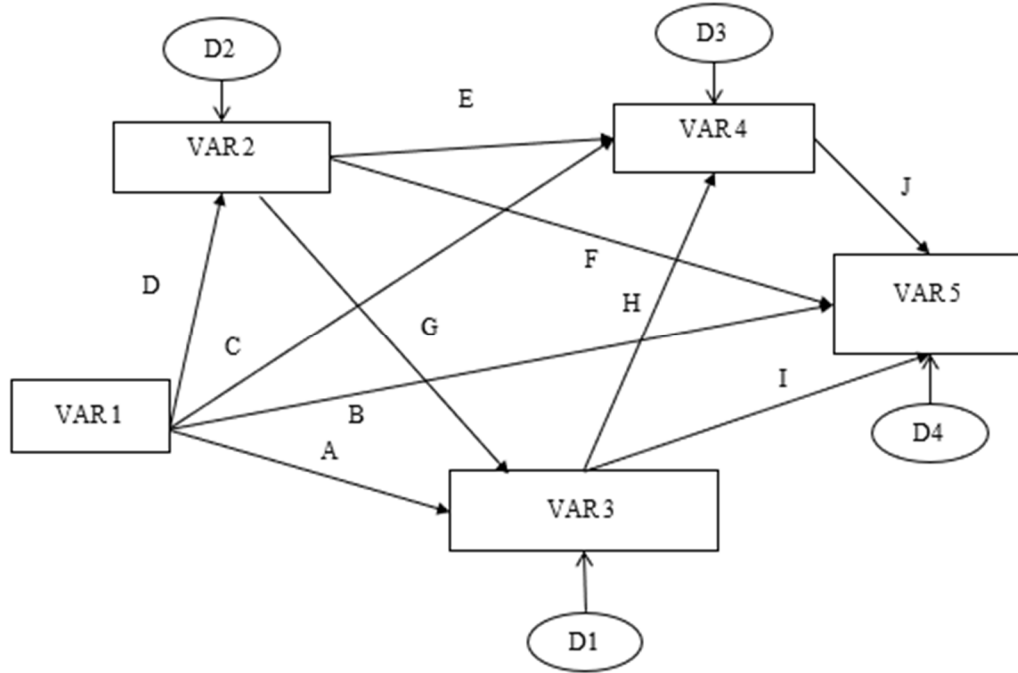


Figure 10. Knowledge Flow Partial Least Squares Model. Adapted from Mun (2021).

In this model, the paths travel in a single direction through one or more independent variables, but all vector rays end at the dependent variable (VAR5—*knowledge transfer*). The vectors B, F, I, and J, emanating from the four independent variables, represent the direct effects on the dependent variable. This model includes the indirect effects that result from combining interim vectors between independent variables (represented as nodes through the model). So, VAR3 indirectly impacts VAR5 through path HJ, which passes through node VAR4. Because the model uses only vectors traveling in one direction, VAR4 only has a direct effect on VAR5. Feedback, or a reverse effect, is not captured in the model in order to limit complexity. The total effect of the model is captured through summing the direct and indirect effects (Mun, 2021).

IV. DATA ANALYSIS

A. DESCRIPTIVE STATISTICS

The descriptive statistics of the DAU are as follows. The DAU survey data was collected over an eight-month period beginning in August 2017. The surveys were of three types: the post-course student survey collected immediately after the completion of the course; the follow-up student survey that was e-mailed out and collected approximately six months after course completion; and a manager's survey that was also e-mailed out to the student's supervisor of record and collected approximately six months after the course was completed. Of the more than 130,000 surveys submitted, 77,177 were completely answered and used in this analysis: 60,826 post-course surveys, 16,142 follow-up surveys, and 209 manager surveys.

The DAU offered 31 curriculums that normally cover four levels of competency; 100-level courses are for entry-level acquisition professionals; 300- and 400-level courses are for advanced acquisition practitioners. Requisite years of professional *experience* are required at each level. They are normally zero to two years for 100-level courses; two to five years 200-level courses; five years and greater for 300-level courses; and, generally, ten or more years and a senior leadership position for 400-level courses. The course levels are operationalized into an ordinal scale for measuring acquisition *experience*. Table 4, 5 and Figure 11 show the distribution of experience level across the course levels and the supporting surveys.

Table 4. DAU Course Survey Data Totals by Course Level and Survey Type

Course Level	Required Years of Professional Experience	Type of Survey			Total
		Post	Follow-up	Manager	
100	0-2	40,670	9,696	45	50,411
200	2-5	19,514	5,783	0	25,297
300	5+	642	587	155	1,384
400	10+ (generally) and senior position	0	76	9	85
Total		60,826	16,142	209	77,177

August 2017–June 2018

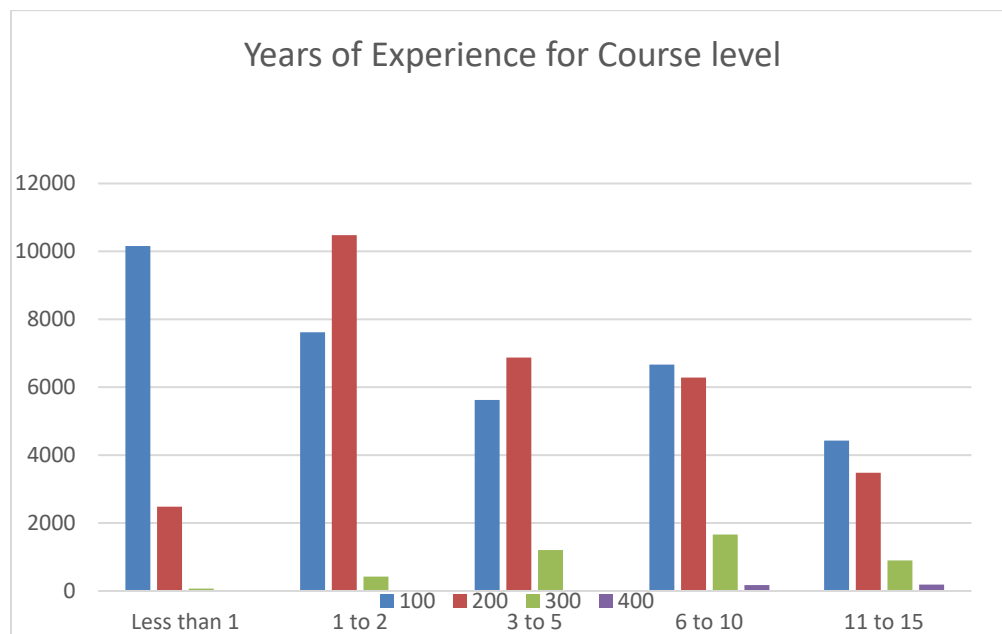


Figure 11. Years of Experience by Course Level.

Table 5. Years of Experience by Course Level

Course Level	Less than 1	1-2	3-5	6-10	11-15
100	10155	7617	5626	6664	4427
200	2481	10478	6875	6282	3483
300	70	422	1205	1664	900
400	2	3	27	173	187

As stated in the Research Design section, establishing the normality of the sample set is an initial requirement for executing parametric and analytic methodologies. The impact of not establishing normality could result in the presence of significant outliers and in invalid linear regression explanations, calling into question the results from the methods used; the result can be an invalid explanation of the phenomena.

The Lilliefors test is a normality test that improves upon the Kolmogorov–Smirnov Test, addressing the small values at the tails of the distribution curve. It is a nonparametric test; that is, no assumptions are made about the shape of the distribution curve of the population or the sample set. While this test permits for smaller sample data sets to be analyzed, the sample size of the data set used for this dissertation is exceptionally large—in excess of 23,000 survey responses—and, so, inclines toward the CLT, which is, simply stated: sampling distributions of large data sets (usually considered samples greater than 30) tend toward a normal distribution (Mun, 2019).

In this dissertation, the sample data set is evaluated against the null hypothesis that states the sample errors are taken from a normally distributed population. Conversely, the alternate hypothesis states the data sample is not normally distributed. In the Lilliefors Test, this is determined by the calculated D-Statistic. If the test statistic (D-Statistic Value) is a significantly large value, then the null hypothesis is rejected; the alternate hypothesis is accepted indicating the data are not normally distributed (Mun, 2019).

The data are reviewed and determined to be normally distributed through the Lilliefors Test for normality. The normality is exhibited in Table 6 generated through Real Options Valuation's Risk Simulator 2021 software application (ROV/RS)

Table 6. Lilliefors Test

Measurements	Results
Average :	6.03208
Stdev : 0.	458348
D Statistic :	0.04085
D Critical at 1% :	0.04735
D Critical at 5% :	0.05094
D Critical at 10% :	0.06065

Key Finding: The data are statistically normal at the 1%, 5%, and 10% significance levels.

The internal consistency of the surveyed population's answers and inter-rater consistency across the survey populations are tested for through the Guttman Lambda and Split Half Model and the Kendall Tau Test, respectively. They both showed a high level of consistency per the ROV/RS generated Table 7 below.

Table 7. Inter Class Correlation (ICC) for Inter-rater Reliability Test

Measurements	Results
Covariance	1.4579
Variance of Total	6.17361
Guttman's Lambda	0.9446
Split Half Approach	
Correlation Coefficient	0.57851
Spearman Brown Correction	0.73299
Odd-Even Split Approach	
Correlation Coefficient	0.9395
Spearman-Brown Correction	0.9688

- Model Inputs: VAR1:VAR15
- Low correlations and lambda scores mean low reliability and low consistency, a high ICC indicates a high level of reliability and. low correlations mean low reliability and low consistency.

Key Finding: The high correlations and Lambda scores indicate that the survey answers exhibit a high level of reliability and consistency across the surveyed population. Those surveyed answered similarly.

The Kendal Tau Test further supported the above finding. The Kendal Tau test null hypothesis indicates that there is zero statistical reliability among the seven survey questions requiring percentage responses. The conclusion is that there is statistical reliability among the percentage responses. The averages of each self-paced course's student responses across the post-course survey questions are statistically reliable. It can be accepted that the responses to the survey are trustworthy and valid, per the Table 8 below.

Table 8. Kendall's W Measure of Concordance

Factors	Measurements
Questions	15
Reviewers	71
Kendall's W	0.258393
Kendall's R	0.247799
Chi-Square	256.8428
DF	14
P-value	0

- Inter-rater Reliability Test (No Ties)
- Null hypothesis: Zero agreement
- (W = 0) among all the judges

Key Finding: There is statistical reliability across the survey question answers. Those surveyed are not randomly answering the questions.

The same battery of tests is executed against the follow-up and managers' survey data. While also supported by the CLT, the normality tests and the inter-rater tests are more mixed and less conclusive, as expressed in Appendix B. These results (Table 9 through 15) imply that these populations are not normally distributed, possibly manifesting Kahneman's self-selection bias; those electing to respond to the survey six-months later tend to the extremes. These results further supported the research focusing on the post-course surveys. Appendix B shows the results of all these tests in detail.

The results from the MANOVA treatments reveal mixed findings for the dependent variable across the averages of all the courses. The Dependent Variable "I/the employee learned new knowledge and skills from this training" shows no significant difference across the post-course instructor-led, follow-up manager surveys and the follow-up student surveys, but that there is a significant difference between the self-paced-course post-course and the follow-up student surveys. When added to the additional factors covered in the self-paced-course post-course surveys, the MANOVA results further support using this

survey for the majority of the research treatments as tacit knowledge, or self-selection, may be influencing the other survey results.

Table 9. General Linear Model: MANOVA for Courses and Post Instructor-led, Follow-up Manager and Follow-up Student Surveys

Source	Stat	F	DF1	DF2	P-value
Pillai Trace	0.36078	0.73365	6	20	0.62838
Wilk's Lambda	0.66731	0.67246	6	18	0.67334
Hotelling Trace	0.45645	0.6086	6	16	0.72016
Roy's Root	0.32817				

Table 10. Null hypothesis: There is Zero Mean Difference among All the Variables.

Research results of Null Hypothesis There is zero mean difference among all the variables		
SSCP Matrix Adjusted for Type (H)		
0.14537	0.15624	0.11338
0.15624	0.18256	0.15855
0.11338	0.15855	0.18041
SSCP Matrix Adjusted for Error (E)		
0.91467	-0.2797	0.62024
-0.2797	2.16801	-0.34889
0.62024	-0.34889	1.09287
Covariance Matrix		
1.06004	-0.12346	0.73361
-0.12346	2.35057	-0.19034
0.73361	-0.19034	1.27329

Table 11. General Linear Model: MANOVA for Curriculum Level
Instructor-led, Follow-up Manager and Six Month Follow-up Student
Surveys

Measured Values	Stat	F	DF1	DF2	P-value
Pillai Trace	0.36078	0.73365	6	20	0.62838
Wilk's Lambda	0.66731	0.67246	6	18	0.67334
Hotelling Trace	0.45645	0.6086	6	16	0.72016
Roy's Root	0.32817				

Table 12. Null hypothesis: There is Zero Mean Difference among All the
Variables.

Research results of Null Hypothesis There is zero mean difference among all the variables		
SSCP Matrix Adjusted for Type (H)		
0.14537	0.15624	0.11338
0.15624	0.18256	0.15855
0.11338	0.15855	0.18041
SSCP Matrix Adjusted for Error (E)		
0.91467	-0.2797	0.62024
-0.2797	2.16801	-0.34889
0.62024	-0.34889	1.09287
Covariance Matrix		
1.06004	-0.12346	0.73361
-0.12346	2.35057	-0.19034
0.73361	-0.19034	1.27329

Table 13. General Linear Model: MANOVA for Curriculum Level Self-paced and Follow-up Post Course Student Surveys.

Measured values	Stat F	DF1	DF2	P-value	
Pillai Trace	0.35819	3.05436	4	56	0.02396
Wilk's Lambda	0.64228	3.34507	4	54	0.01614
Hotelling Trace	0.55624	3.61553	4	52	0.01128
Roy's Root	0.55492				

Table 14. Key Finding.

Key findings	
SSCP Matrix Adjusted for Error (E)	
1.07044	0.72097
0.72097	0.89782
Covariance Matrix	
1.3051	0.69935
0.69935	0.90117
SSCP Matrix Adjusted for Type (H)	
0.23466	-0.02162
-0.02162	0.00336

- There is significant difference among all the variables.
- The p-values indicate that there is a significant difference.
- This finding supports the Pair-wise T-test findings that the students' perception is that they gain knowledge over the six-month period on the job after the training.

Table 15. General Linear Model: MANOVA for Self-paced and Follow-up Post Course Student Surveys.

Measured values	Stat	F	DF1	DF2	P-value
Pillai Trace	1.5366	1.91972	38	22	0.05341
Wilk's Lambda	0.03768	2.1852	38	20	0.0324
Hotelling Trace	10.29963	2.43939	38	18	0.02274
Roy's Root	8.50814				

Key Finding: There is significant difference among all the variables as indicated by the p-values. This finding supports the Pairwise T-test findings that the students' perception is that they gain knowledge over the six-month period on the job after the training.

The mean and standard deviation for the potential dependent variables for each type of survey are calculated for each professional curriculum and each level. The basic statistics of the three survey types are summarized in Table 16 and further exhibited in Appendix B. They show that there is a notable knowledge increase over the sixth month period between the transfer of knowledge and the reassessment by the recipients and their managers; interestingly, it increases in the follow-up surveys of both groups.

Table 16. Basic Statistics for DAU Curriculum.

Measured values	Average	Std Dev	Std Error	Skew	Kurtosis
Total	6.032076	1.101228	294.592	-1.30484	4.906135
post	6.078120	1.1084	501.1726	-1.5509	5.978374
p-inst	6.368266	0.945542	278.6082	-1.89207	7.361944
p-SP	5.681724	1.330896	805.2394	-1.08481	4.088145
FO	6.034172	1.088853	113.2563	-1.13959	4.011056
FO-Inst	6.179887	1.008526	44.21519	-1.22613	4.103478
FO-SP	5.892393	1.165686	182.7722	-1.0601	3.929551
MGR	5.628539	1.148134	10	-0.34268	2.430588
MGR-Inst	5.673685	1.127065	10.05556	-0.31131	2.398309
MGR-sp	5.222222	1.464169	9.5	-0.81325	2.914783

Three curriculums are selected for further statistical analysis based on the variation from means for the aligning potential dependent variable. Of the number of surveys available after the data are cleansed in each survey category, only CON and PMT are represented at all levels in all survey types. The ACQ is selected because it is required of all acquisition professional and serves well as a baseline representing the whole workforce. The two other curriculums are selected as extremes, as they had the largest variation in competency knowledge obtained and a usable sample size in each survey category—the small sample sizes of the manager surveys became a factor for selection of a curriculum. The best fit is provided by CON and PMT because, as noted, they are the only curriculums that are captured in all types of surveys. Table 17 provides their relevant statistics. Appendix B provides a breakdown of all the curriculums.

Table 17. Selected DAU Curriculum Surveys.

Select DAU Curriculum Measurements					
Manager Survey	Number of Participants	Var 11 Mean	Var 11 STDV	Var 12 Mean as %	Var 12 STDV as %
ACQ	42	5.6	.92	46	26
CON	62	5.86	1.10	60	25
PMT	29	5.2	1.65	48	32
Post Survey	Number of Participants	Var 4 Mean as %	Var 4 STDV as %	Var 6 Mean as %	Var 6 STDV as %
ACQ	13900	49	29	45	28
CON	13393	60	30	55	30
PMT	1572	49	29	48	27
Follow-up Survey	Number of Participants	Var 8 Mean	Var 8 STDV	Var 9 Mean	Var 9 STDV
ACQ	4002	5.36	1.54	5.67	1.40
CON	3928	5.76	1.31	5.83	1.26
PMT	320	5.58	1.43	5.39	1.40

One concern of statistical analysis of a small data set is micronumerosity, but also of concern is macronumerosity in a very large data set. The impact of macronumerosity is that very small variations and correlations become defined as significant because of the extreme amount of data (Mun, 2021). To assess the macronumerosity impact of the very large DAU post-course data-set averages, each course's variables are calculated and also combined into the five factors. The truncated data set is tested in parallel with the large three-curriculums' individual data set. As shown in Table 17, both data sets aligned closely through most of the tests.

Per the preceding Research Design section, the paired t-test provides a hypothesis examination of the difference between population means for a set of random samples whose variations are almost normally distributed (Mun, 2019). The research performs a T-test between the post-course and the follow-on surveys' proposed Dependent Variable questions ("I have learned new knowledge/skills from this training" and "I learned new knowledge and skills from this training"). The results are shown in the Table 18, which supports that there is a statistically significant difference in the results for essentially the

same question when asked six months later. This difference can be attributed to the fact that knowledge is not static and that there is tacit knowledge gained through on-the-job execution of the original knowledge. It could also be explained through the Self-Selection Theory proposed by Tversky and Kahneman (1973) referenced earlier.

Table 18. Post-test versus Follow-up Surveys (Averages for All Courses) for Dependent Variable: Two Variable (T) Independent Equal Variance.

Columns	Measured Values	Measurements
1	Sample Mean :	5.672147
	Sample Standard Deviation :	1.359609
2	Observations :	18121
	Sample Mean :	5.928977
	Sample Standard Deviation :	1.195918
	Sample Mean Difference	-0.25683
	t-Statistic	-403.57
	Hypothesized Mean	4

- Two Variable (T) Independent Unequal Variance
- p-Value Two Tailed : 0.000000
- Significant at 1%, 5% and 10%
- Rejected: They are significantly different than the hypothesized mean difference.

Again, the pairwise T-test is deployed in the study to compare whether the self-paced-course and the instructor-led-course dependent variable (“I have learned new knowledge/skills from this training”) data are statistically different from the same population, with the null

hypothesis being that the difference is zero. As exhibited in Tables 19 and 20, the two samples are not from the same statistical population. This result supports Nissen’s Knowledge Flow Theory that the absence of tacit *knowledge transfer* is a Knowledge Friction factor (Nissen, 2017).

Table 19. T-test between Self-paced–Course and Instructor-led–Course
Dependent Variables (Three Curriculums at individual level).

Two Variable (T) Independent Unequal Variance	
Column 1 Observations :	29569
Column 1 Sample Mean :	5.742602
Column 1 Sample Standard Deviation :	1.338379
Column 2 Observations :	13836
Column 2 Sample Mean :	6.439217
Column 2 Sample Standard Deviation :	0.975889
Sample Mean Difference :	-0.696614
t-Statistic :	-412.85687
Hypothesized Mean :	4

p-Value Left Tailed : 0.000000

- significant at 1%, 5% and 10%
- Rejected: They are significantly less than the hypothesized mean difference.

p-Value Two Tailed : 0.000000

- significant at 1%, 5% and 10%
- Rejected: They are significantly different than the hypothesized mean difference.

Table 20. Post-test Instructor-led versus the Post-test Self-paced Dependent Variables (All Curriculums at Course Level).

Two Variable (T) Independent Unequal Variance	
Column 1 Observations :	97
Column 1 Sample Mean :	6.368265
Column 1 Sample Standard Deviation :	0.318934
Column 2 Observations :	71
Column 2 Sample Mean :	5.681724
Column 2 Sample Standard Deviation :	0.221944
Sample Mean Difference :	0.686541
t-Statistic : -103.	334846
Hypothesized Mean :	5

p-Value Left Tailed : 0.000000

- significant at 1%, 5% and 10%
- Rejected: They are significantly less than the hypothesized mean difference.

p-Value Two Tailed : 0.000000

- significant at 1%, 5% and 10%
- Rejected: They are significantly different than the hypothesized mean difference.

Key Finding: There is statistically significant difference between the self-reported knowledge transfer in the self-paced and the instructor-led courses. The surveyed students believe they gained more knowledge from the instructor-led courses.

Given the findings of the above two t-tests, the DAU survey sample data are culled. The two surveys' samples are significantly statistically not of the same population. The student post-course survey is accepted as the more complete and encompassing representation of the survey population, both by size and the requirement to complete upon course completion. The follow-up survey, e-mailed to the student approximately six months after the course completion, lends itself to self-selection bias. It is sparser in both questions and completeness in answering of those questions. These additional reasons compound to limit the study to the student post-course surveys.

Based on the findings of significant difference between instructor-led courses (tacit *knowledge transfer* provided) and self-paced courses (solely explicit *knowledge transfer*),

the sample is further limited to the self-paced courses to remove the possible tacit noise in the data.

Finally, based on discussions with the data researchers at the DAU and a survey of the DAU curriculum, the data are further culled to include three large curriculums: ACQ, CON, and PMT. The ACQ is selected because it is the baseline curriculum that underlies the other career curriculums; the other two programs are made up of large populations and are considered to be highly demanding, which results in a greater range in *knowledge transfer* outcome—not everyone gets the same outcome.

After all these reductions, the data sample set remains over 23,000 surveys with 14 viable independent variables covering 3 and possibly 4 Knowledge Friction factors in addition to the previously identified tacit Knowledge Friction factor.

As discussed in the Methods section, the Single Analysis of Variance (ANOVA) with Multiple Treatment of the Independent Variable is used to consider the internal consistency of the survey responses. The ANOVA treatment determined consistency in the respondents' answers—there is consistent logic rather than randomness in answering the questions. Like the previously described t-tests that are applied to two variables at a time to determine if their means, proportions, or variances are statistically significantly different, in the case of the ANOVA tests, two or more sample means are tested at the same time. Specifically, the single ANOVA with multiple treatments tests one category of an independent variable, in this case, framed as responses to different survey questions and believed to explain one dependent variable across multiple treatments. The null hypothesis tests that the population means are equal; the alternate hypothesis is that one or more of the treatments' populations are significantly different. For the purposes of this dissertation, and because of the large size of the sample, the alternative hypothesis below a level of .05 p-statistic exhibited that there is internal consistency across the question answers; the respondents did not just “bubble” in the answers. The single ANOVA with multiple treatments hypotheses are written:

$H_0: \mu_1 = \mu_2 = \mu_t$ [for treatments 1 to t] (there is no effect in the treatments: the answers were randomly selected).

H_a: Population means are not equal (there is a statistically significant difference in one or more of the treatments: the answers were not randomly selected) (Mun, 2019).

The One-Way ANOVA with Randomized Multiple Treatments of the averages of student responses in the post-course survey for all self-paced courses in all curriculums resulted in Tables 21 and 22.

Table 21. One Way ANOVA with Randomized Multiple Treatments the Averages of Student Responses in the Post-course Survey for all Self-paced Courses in All Curricula.

One Way ANOVA with Randomized Multiple Treatments					
Qualifiers	DF	Sums of Squares	Mean Square	F Stat	p-Value
Between Groups	14	5136.86	366.92	4827.8434	0.0000
Within Groups	1050	79.8	0.08		
Total	1064	5216.66	4.9		
F Critical @ 0.10	1.511079				
F Critical @ 0.05	1.701195				
F Critical @ 0.01	2.098555				

- Measurements in this table included the following: Model Inputs: VAR1; VAR2; VAR3; VAR4; VAR5; VAR6; VAR7; VAR8; VAR9; VAR10; VAR11; VAR12; VAR13; VAR14; VAR15
- The null hypothesis tested is such that all the survey questions requiring percentage inputs are statistically equivalent.

Table 22. Key Finding: At Least One of the Variables is Different from the Rest.

One Way ANOVA with Randomized Multiple Treatments (All variables) of the post-course self-paced three curriculum (ACQ/CON/PMT) data set					
	DF	Sums of Squares	Mean Square	F Stat	p-Value
Between Groups	17	187626724.6	11036866.15	43141.6166	0.00
Within Groups	343458	87866433.28	255.83		
Total	343475	275493157.9	802.08		
F Critical @ 0.10		1.457023			
F Critical @ 0.05		1.622801			
F Critical @ 0.01		1.965268			
One Way ANOVA with Randomized Multiple Treatments (All variables) of the post-course self-paced three curriculum (ACQ/CON/PMT) data set					
	DF	Sums of Squares	Mean Square	F Stat	p-Value
Between Groups	3	33316672.17	11105557.39	20199.9488	0.00
Within Groups	76324	41961520.34	549.78		
Total	76327	75278192.50	986.26		
F Critical @ 0.10		2.083868			
F Critical @ 0.05		2.605025			
F Critical @ 0.01		3.781879			

- One or more of the treatments has statistically significant effect at Alpha 1% on at least one of the levels

Table 22. Key Finding: At Least One of the Variables is Different from the Rest.
(continued)

One Way ANOVA with Randomized Multiple Treatments (Certification/Experience variables) of the post-course self-paced three curriculum (ACQ/CON/PMT) data set					
	DF	Sums of Squares	Mean Square	F Stat	p-Value
Between Groups	1	18581.83	18581.83	9212.5884	0.00
Within Groups	38162	76972.91	2.02		
Total	38163	95554.74	2.50		
F Critical @ 0.10		2.705675			
F Critical @ 0.05		3.841703			
F Critical @ 0.01		6.635559			
One Way ANOVA with Randomized Multiple Treatments (all Relevance variables) of the post-course self-paced three curriculum (ACQ/CON/PMT) data set					
	DF	Sums of Squares	Mean Square	F Stat	p-Value
Between Groups	6	83156303.88	13859383.98	40500.4722	0.00
Within Groups	133567	45707031.09	342.20		
Total	133573	128863334.97	964.74		
F Critical @ 0.10		1.774151			
F Critical @ 0.05		2.098665			
F Critical @ 0.01		2.802117			

- One or more of the treatments has statistically significant effect at Alpha 1% on at least one of the levels

Table 22. Key Finding: At Least One of the Variables is Different from the Rest.
(continued)

One Way ANOVA with Randomized Multiple Treatments (all Clarity variables) of the post-course self-paced three curriculum (ACQ/CON/PMT) data set					
	DF	Sums of Squares	Mean Square	F Stat	p-Value
Between Groups	4	679.81	169.95	134.1037	0.00
Within Groups	95405	120908.95	1.27		
Total	95409	121588.76	1.27		
F Critical @ 0.10		1.944919			
F Critical @ 0.05		2.372025			
F Critical @ 0.01		3.319372			

- One or more of the treatments has statistically significant effect at Alpha 1% on at least one of the levels

The ANOVA results support that all variables align within the factor they support at an alpha significance value of five percent. Again, taking into consideration macronumerosity, there is congruency across the variables (Mun, 2021). The comprehensive run of ANOVAs is captured in Appendix B.

B. PRINCIPAL COMPONENT ANALYSIS

In addition to being the basis for multivariate data analysis, PCA is effective in reducing the number of variables in multivariate data sets, allowing for clusters, trends, and outliers to become more observable. PCA works because data have as many principal components as variables, so the first principal component represents the largest variance. The second principal component represents the next largest uncorrelated variance. This calculation continues to the nth principal component (Jaadi, 2019).

Mun's Risk Simulator Tool (2021) provides a factor analysis (Table 23) is run on the ACQ/CON/PMT self-paced-course post-course surveys at the individual level of

analysis and on the total set of self-paced–course post-course surveys at the aggregated course level of analysis. Both calculations resulted in the top six factors exhibiting a notable level of influence and the top five factors representing the hypothesized factors. From the factorial model, the *clarity* factor weights at 23 percent, the *near-term relevance* weights at 21 percent, the *longer-term relevance* weights at 13 percent, and the *certification* and *experience* factors each weight at about 7 percent.

Table 23. Varimax Rotated Factor Loadings (Ranked)

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	
VAR1	0.0061	0.0987	0.0156	0.981	0.1642	0.0064	0.0011	0.0225	0.0097	0.0012	
VAR2	0.0099	0.0332	0.0023	0.1614	0.9861	0.0066	0.0001	0.0172	0.0043	0.0006	
VAR3	0.1207	0.8982	0.1244	0.0662	0.0152	0.0599	0.0562	0.094	0.0527	0.0149	
VAR4	0.3601	0.3447	0.7575	0.0269	0.0046	0.1635	0.1741	0.2335	0.1212	0.0357	
VAR5	0.1606	0.9051	0.1796	0.0621	0.0267	0.0752	0.1045	0.0847	0.0594	0.0194	
VAR6	0.4277	0.2783	0.7445	0.0123	0.0156	0.1664	0.2382	0.1394	0.1448	0.0456	
VAR7	0.3826	0.2722	0.4125	0.0001	0.0007	0.1788	0.7298	0.1544	0.137	0.0378	
VAR8	0.1508	0.8967	0.1892	0.0493	0.0207	0.0717	0.1064	0.1055	0.0494	0.024	
VAR9	0.4214	0.3227	0.3701	0.0519	0.0419	0.148	0.1597	0.7197	0.0899	0.0513	
VAR10	0.446	0.1326	0.207	0.0107	0.0108	0.822	0.1307	0.1062	0.1846	0.0432	
VAR11	0.8026	0.1804	0.2684	0.0051	0.0024	0.1881	0.1707	0.1393	0.1595	0.0549	
VAR12	0.8916	0.1666	0.2387	0.0021	0.0117	0.1916	0.1255	0.1294	0.1421	0.0677	
VAR13	0.7678	0.1628	0.2329	0.0051	0.0045	0.2207	0.1257	0.1787	0.1406	0.4617	
VAR14	0.5491	0.1378	0.226	0.0237	0.0093	0.2706	0.1388	0.0883	0.7246	0.0404	
Sum of Squares	3.2287	2.9389	1.7962	1.0034	1.0031	0.9925	0.7677	0.7310	0.6959	0.2329	0.1859
Rank	1	2	3	4	5	6	7	8	9	10	11
Proportion	23.06%	20.99%	12.83%	7.17%	7.16%	7.09%	5.48%	5.22%	4.97%	1.66%	1.33%
Cum Proportion	23.06%	44.05%	56.88%	64.05%	71.22%	78.31%	83.79%	89.01%	93.98%	95.64%	96.97%

For the purposes of this dissertation, PCA is used to construct the correlation matrix for the relevant variables explaining all the factors. The correlation matrix is used as a cross check on the factor analysis and to ensure minimization of covariance between the factors' variables. As shown in the correlation matrix heat chart (Figure 12), the independent variables aligned to a factor have high correlation, while they also exhibit a much lower correlation to the other factors; this indicates that the variable is not explaining two factors.

The PCA correlation matrices also provide a check of multicollinearity between the independent variables, specifically, that the separate factors are not explaining the same phenomena. This is indicated in Figure 12 by no alternate factor variables' having a correlation of 75 percent or more—most fell well below 60 percent (Mun, 2019).

Correlation Matrix:																		
	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8	VAR9	VAR10	VAR11	VAR12	VAR13	VAR14	VAR15	VAR16	VAR17	VAR18
VAR1	1	0.4347	0.4758	0.6012	*0.0	*0.0	0.3741	0.6996	0.449	0.7484	0.7188	0.4295	0.5884	0.5653	0.6694	0.6449	0.612	0.6083
VAR2	0.4347	1	0.7906	0.634	*0.0	*0.0	0.7096	0.5082	0.7226	0.4823	0.4781	0.7005	0.4539	0.3208	0.3756	0.3521	0.3403	0.3275
VAR3	0.4758	0.7906	1	0.6387	*0.0	*0.0	0.7015	0.5482	0.7282	0.5157	0.5328	0.7036	0.4798	0.3712	0.4195	0.3885	0.3713	0.3804
VAR4	0.6012	0.634	0.6387	1	*0.0	*0.0	0.4982	0.464	0.5484	0.4968	0.4837	0.5134	0.3642	0.3547	0.4307	0.4032	0.374	0.3904
VAR5	*0.0	*0.0	*0.0	*0.0	1	0.3153	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	0.0064
VAR6	*0.0	*0.0	*0.0	*0.0	0.3153	1	*0.0	*0.0	*0.0	*0.0	*0.0	*0.0	0.0421	0.0235	0.0159	0.024	0.0169	0.0226
VAR7	0.3741	0.7096	0.7015	0.4982	*0.0	*0.0	1	0.5613	0.8305	0.4983	0.4813	0.8432	0.547	0.3198	0.3872	0.367	0.3637	0.3324
VAR8	0.6996	0.5082	0.5482	0.464	*0.0	*0.0	0.5613	1	0.6144	0.8983	0.8002	0.6259	0.819	0.5834	0.6914	0.6607	0.6428	0.6013
VAR9	0.449	0.7226	0.7282	0.5484	*0.0	*0.0	0.8305	0.6144	1	0.5721	0.5536	0.8614	0.5794	0.3685	0.4445	0.422	0.4139	0.3801
VAR10	0.7484	0.4823	0.5157	0.4968	*0.0	*0.0	0.4983	0.8983	0.5721	1	0.8294	0.5722	0.7677	0.6032	0.7295	0.7009	0.6779	0.6387
VAR11	0.7188	0.4781	0.5328	0.4837	*0.0	*0.0	0.4813	0.8002	0.5536	0.8294	1	0.5555	0.7233	0.5921	0.6965	0.6559	0.6375	0.6143
VAR12	0.4295	0.7005	0.7036	0.5134	*0.0	*0.0	0.8432	0.6259	0.8614	0.5722	0.5555	1	0.5967	0.3623	0.4371	0.4157	0.4117	0.3702
VAR13	0.5884	0.4539	0.4798	0.3642	*0.0	0.0421	0.547	0.819	0.5794	0.7677	0.7233	0.5967	1	0.5612	0.6831	0.6665	0.674	0.5627
VAR14	0.5653	0.3208	0.3712	0.3547	*0.0	0.0235	0.3198	0.5834	0.3685	0.6032	0.5921	0.3623	0.5612	1	0.684	0.696	0.6936	0.709
VAR15	0.6694	0.3756	0.4195	0.4307	*0.0	0.0159	0.3872	0.6914	0.4445	0.7295	0.6965	0.4371	0.6831	0.684	1	0.8583	0.7944	0.7524
VAR16	0.6449	0.3521	0.3885	0.4032	*0.0	0.024	0.367	0.6607	0.422	0.7009	0.6559	0.4157	0.6665	0.696	0.8583	1	0.8459	0.759
VAR17	0.612	0.3403	0.3713	0.374	*0.0	0.0169	0.3637	0.6428	0.4139	0.6779	0.6375	0.4117	0.674	0.6936	0.7944	0.8459	1	0.7257
VAR18	0.6083	0.3275	0.3804	0.3904	0.0064	0.0226	0.3324	0.6013	0.3801	0.6387	0.6143	0.3702	0.5627	0.709	0.7524	0.759	0.7257	1

Figure 12. Correlation Matrix Heat Chart. Adapted from Mun (2019).

Another analysis of the data addresses the internal consistency of the responses. The survey data show a strong internal consistency with a solid logic across the answers of the surveyed. This consistency prevails across both surveyed populations—course participants and their supervisors. Of special interest is the supervisors’ survey question on their view of the course’s knowledge implementation by their employees (the participants). Figure 13 illustrates the results from the self-paced–course post-course student surveys from over 60,000 surveyed. More than 95 percent of the respondents value DAU education highly, with a Likert scale of 4 or higher. As shown in Figures 14, 15, and 16, this pattern is replicated across all the survey vehicles to include the 145 supervisors surveyed.

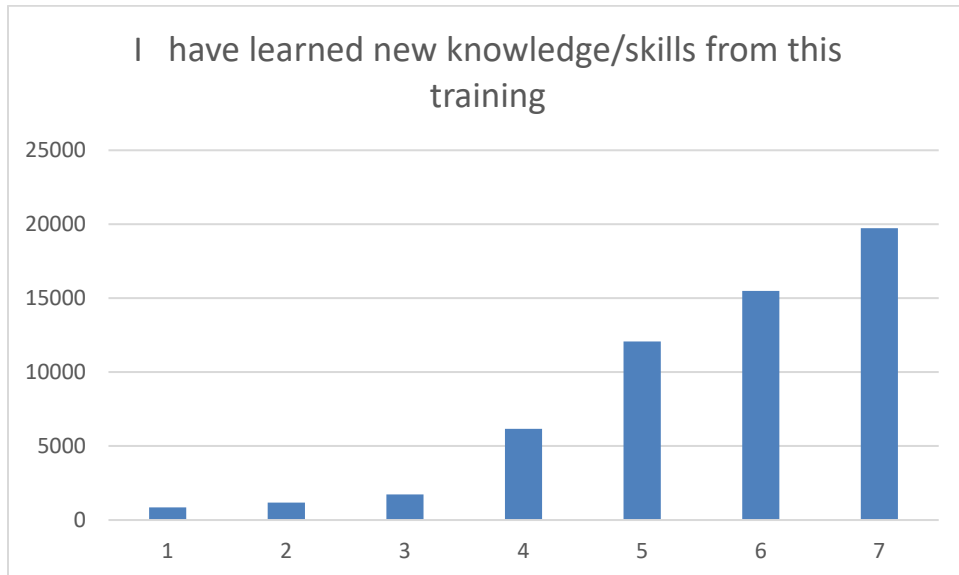


Figure 13. Post Course Self-paced Student Surveys

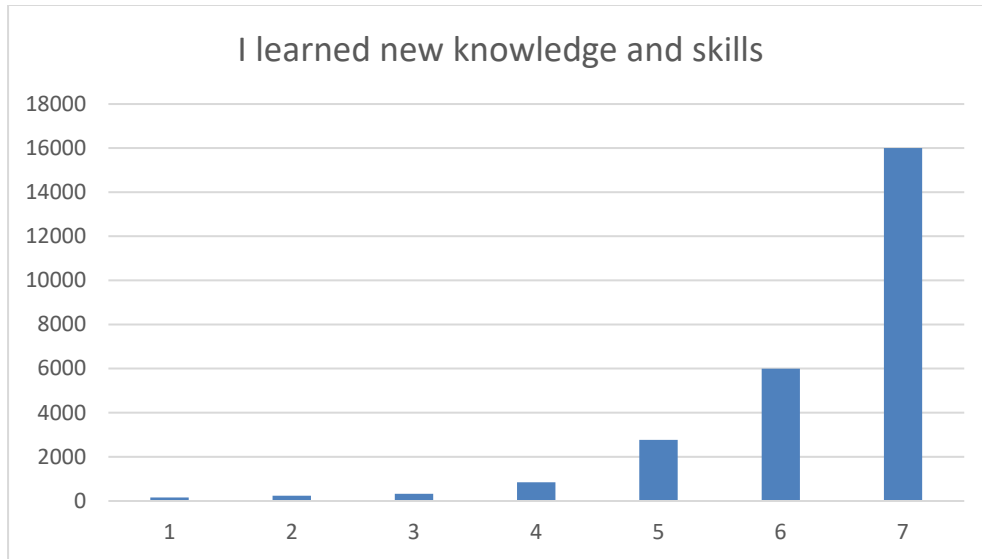


Figure 14. Post Course Instructor-led Student Surveys

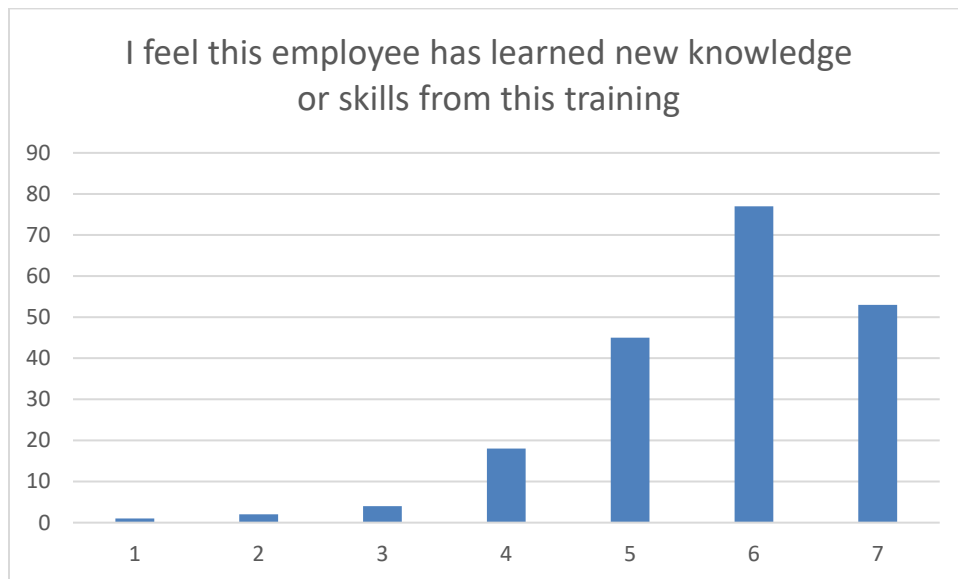


Figure 15. Follow-up Manager Surveys

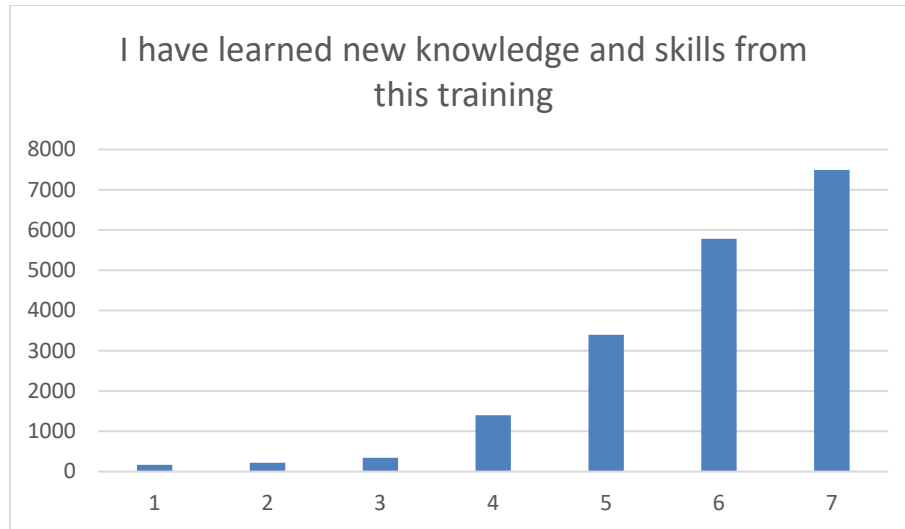


Figure 16. Course Follow-up Student Surveys.

Figure 17, which captures over 16,000 surveys, shows the same pattern for the three selected curriculums (ACQ/CON/PMT), further supporting their use as a representative sample.



-This figure shows the same pattern for the three selected curriculums, which captures over 16,000 surveys.
 -This further supports using the General Acquisition, Contracting and Program Management Curriculums to represent as a representative sample.

Figure 17. ACQ/CON/PNT Post Course Self-paced Student Surveys

Modeling and Analysis

Multiple analytical models are run on all three surveys' results to identify critical and pertinent information. The survey results are evaluated through an Inter-Class Correlation for Inter-rater Reliability Test and the Guttman's Lambda & Internal Consistency and Reliability Test (see Appendix B). These tests provide insight into the survey responses' statistical validity, trustworthiness, reliability, and replicability. Econometric modeling and multivariate tests are also run. The main conclusions follow.

Supervisors' Survey Results

- The 145 supervisor surveys' data exhibited statistically consistent and reliable responses. The supervisors' responses are not random and without any biases but reflect their valid opinions on the value and impact of the training received by their employees. Findings from this data are statistically valid.
- There is statistical significance indicating that, on average, supervisors view that the knowledge provided by the DAU course is acted upon at a statistical significance greater than zero (mid-point of a Likert scale).
- Supervisors value the knowledge obtained for an employee's personal career growth as being the same as the knowledge obtained for the entire organization.
- Supervisors view an employee's knowledge gain from a training initiative as going beyond that of the impact on an employee's job performance. This finding might mean that the value of the knowledge obtained is not entirely quantifiable; it might be intrinsic and subjective.
- Supervisors view the knowledge gained by the organization as being more than a simple summation of the new knowledge added. In addition, organizations perceive knowledge as more than the applications of specific skills.
- Supervisors value that the training helped improve an employee's performance and enabled the employee to successfully apply the knowledge and skills, but only if the training is also worthwhile to the employee's own career development based on specific goals and expectations set prior to the training.

Students' Post-course and Follow-up Survey Results

- 16,142 students responded to the surveys. The responses are statistically reliable and consistent. This indicates the responses are not random, and, so, the conclusions developed from the survey data are statistically valid.
- The students' view on the value of the knowledge obtained from the course changed significantly between the end of the course and six months later on the job. Usefulness of the course material scored materially and significantly differently in the survey taken after spending time on the job.

- The students' assessment of how much the new knowledge is applicable to the job is materially and significantly different between the post-course survey and the follow-up survey taken after spending time on the job.
- The students' assessment of how much their work time would require using the new knowledge is materially and significantly different between the post-course survey and the follow-up survey taken after spending time on the job.
- The follow-up surveys reflected statistically significant improvement in the student's work abilities resulting from the course completed.
- The follow-up surveys reflected statistically significant increases in the student's ability to apply the knowledge obtained in class.
- The post-course surveys indicated a statistically significant amount of new knowledge obtained in class.
- The follow-up surveys showed students' assessment of how much their work improved based on the knowledge provided in the course is directly dependent on their actual *experience* on the job, and not reflected as strongly in the post-course survey executed at the end of the course.

The linear multivariate regression of the first dependent variable question ("I have learned new knowledge/skills from this training") against the 14 independent variables that represented the contributing Knowledge Friction factors is the strongest model. It explained 63 percent of the phenomena based on the calculated adjusted R-squared. The strength of the model is furthered by a high T-statistic and a very low p-value (Mun, 2019). The third dependent variable question ("How much of the improvement will be a direct result of this training, as opposed to other factors?") is the next strongest explanation of the phenomena, at 59 percent, but diminished less than the dependent-variable question 1 as independent variables are removed.

Given that *certification* incorporates minimum time in the community, it might be explaining *experience*. This notion is further supported by how little explanation the *experience* factor adds to the regression models.

Conversely, two strong *relevance* factors emerge in the factor analysis and in the explanatory power of the regression models. The *relevance* questions encompass both specific near-term questions (how much will this help on the job?) and more long-term

statements (I will be able to use this in my job, and this will help me in my career and profession). These factors could operationalize intrinsic and extrinsic motivation without hypothesizing the qualitative “why” inherent in analyzing motivation.

The Auto-Econometrics results also favored the dependent-variable question 1’s regression model, though with an R-squared of 61 percent, they explained slightly less than the linear regression. Of note, the auto-econometric regression models exhibited interaction between independent variables as force multipliers. This finding supports that all the factors likely have interdependency.

C. LINEAR MULTIPLE-REGRESSIONS

The adjusted R-squared for the linear multiple-regression for the self-paced course post-course surveys for the ACQ, CON, and PMT students (individual level of analysis) using all 14 independent variable questions is 63 percent. A reasonably strong explanation of the factors impacting *knowledge transfer*. When done for all self-paced–course post-course surveys aggregated at the course level of analysis, the adjusted R-squared is 82 percent. Calculated through the mean student score for each course, variations and outlier effects are minimized. The results are shown in Tables 24 through 26.

Table 24. Adjusted R-squared for the Linear Multiple-Regression for the Self-paced Post-course Surveys Results.

Regression Statistics: Three Curriculum All Students' Data	
R-Squared (Coefficient of Determination)	0.6283
Adjusted R-Squared	0.6280
Multiple R (Multiple Correlation Coefficient)	0.7926
Standard Error of the Estimates (SEy)	0.8036
Number of Observations	20397
Statistics: All Courses Means Regression	
R-Squared (Coefficient of Determination)	0.8520
Adjusted R-Squared	0.8214
Multiple R (Multiple Correlation Coefficient)	0.9230
Standard Error of the Estimates (SEy)	0.0938
Number of Observations	71

Comprehensive Multiple-regressions are run on both the post-test and follow-up student survey data. The results showed that the post data multiple regression explained appreciably more the impact of the Knowledge Friction factors on *knowledge transfer*.

Key Findings: Based on the adjusted R-squared, the follow-up survey data explained more than 55 percent. Stepwise regression techniques also indicate interaction between the independent variables as well as weighting toward the relevance and clarity variables. The comprehensive regression runs are exhibited in Appendix D.

Table 25. Key Findings: Based on the Adjusted R-squared, the Follow-up Survey Data Explained more than 55 Percent.

Regression Results						
OVERALL FIT						
Multiple R	0.75271	Maximum Log Likelihood	3753.34608			
R-Square	0.56658	Akaike Info Criterion (AIC)	-0.46393			
Adjusted R-Square	0.56647	Bayes Schwarz Criterion (BSC)	-0.45964			
Standard Error	0.1918	Hannan-Quinn Criterion (HQC)	-0.46251			
Observations	16142					
Qualifiers	Coeff	Std. Error	T-stat	P-value	Lower 5%	Upper 95%
Intercept	-0.01274	0.00614	-2.07418	0.03808	-0.02479	-0.0007
VAR3	0.37981	0.0104	36.50831	0.00	0.35942	0.04002
VAR8	0.02617	0.00132	19.87973	0.00	0.02359	0.02875
VAR1	0.25276	0.01001	25.24347	0.00	0.23314	0.27239
VAR5	0.05341	0.00968	5.51641	0.00	0.03443	0.07239
ANOVA						
Parameters tested	DF	SS	MS	F		
Regression	4	776.01	194	5273.63619		
Residual	16137	593.63	0.04			
Total	16141	1369.64				

- Backward Method
- ARRANGEMENT: Y<->X3;X7;X1;X5
- Stepwise regression techniques also indicate interaction between the independent variables as well as weighting toward the relevance and clarity variables.
- The comprehensive regression runs are exhibited in Appendix D.
- Key Findings: The six-month student follow-up surveys showed a significant increase in self-assessed knowledge transfer. This seems to indicate that the knowledge transferred is not static, and that it increases through the actual execution of the knowledge while on the job. This is a possible indication of tacit knowledge transfer from "know-what" to "know-how."

Table 25. Key Findings: Based on the Adjusted R-squared, the Follow-up Survey Data Explained more than 55 Percent (continued)

Hypothesis Test		
Critical F-statistic (99% confidence with DFR1 and DFR2) :	3.320336	
Critical F-statistic (95% confidence with DFR1 and DFR2) :	2.372483	
Critical F-statistic (90% confidence with DFR1 and DFR2) :	1.945208	

- Backward Method
- ARRANGEMENT: $Y \leftrightarrow X_3; X_7; X_1; X_5$
- Stepwise regression techniques also indicate interaction between the independent variables as well as weighting toward the relevance and clarity variables.
- The comprehensive regression runs are exhibited in Appendix D.
- Key Findings: The six-month student follow-up surveys showed a significant increase in self-assessed knowledge transfer. This seems to indicate that the knowledge transferred is not static, and that it increases through the actual execution of the knowledge while on the job. This is a possible indication of tacit knowledge transfer from "know-what" to "know-how."

Table 26. Multiple-Regression and Auto-Econometrics.

Regression Analysis – Dependent Variable 1: I have learned new knowledge/skills from this training

Regression Statistics	
R-Squared (Coefficient of Determination)	0.6283
Adjusted R-Squared	0.6280
Multiple R (Multiple Correlation Coefficient)	0.7926
Standard Error of the Estimates (SEy)	0.8036
Number of Observations	20397

The R-Squared or Coefficient of Determination indicates that 0.63 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.63 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results										
	Intercept	EN	DG	S	BD	CA	CW	DI	EL	ET
Coefficients	0.8695	-0.0108	0.0698	-0.1182	0.1095	0.2641	0.3223	0.2204	-0.2458	-0.1172
Standard Error	0.0347	0.0034	0.0063	0.0390	0.0105	0.0412	0.0110	0.0073	0.0421	0.0078

Table 26. Multiple-Regression and Auto-Econometrics (continued)

Regression Analysis – Dependent Variable 1: I have learned new knowledge/skills from this training										
Regression Results										
	Intercept	EN	DG	S	BD	CA	CW	DI	EL	ET
p-Value	0.0000	0.0016	0.0000	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lower 5%	0.8015	-0.0175	-0.0822	-0.1947	0.0889	0.1834	0.3007	0.2061	-0.3284	-0.1324
Upper 95%	0.9374	-0.0041	-0.0575	-0.0417	0.1301	0.3448	0.3440	0.2346	-0.1632	-0.1020
	AJ	AN	BI	DK	FV					
Coefficients	0.0363	0.1185	0.0826	0.0213	0.0811					
Standard Error	0.0065	0.0100	0.0114	0.0102	0.0079					
t-Statistic	5.5841	11.8405	7.2171	2.0786	10.2978					
p-Value	0.0000	0.0000	0.0000	0.0377	0.0000					
Lower 5%	0.0235	0.0989	0.0602	0.0012	0.0657					
Upper 95%	0.0490	0.1381	0.1050	0.0414	0.0966					
Degrees of Freedom	Hypothesis Test									
Degrees of Freedom for Regression				14	Critical T (99% confidence df of 20382)				2.5761	
Degrees of Freedom for Residual				20382	Critical T (95% confidence df of 20382)				1.9601	
Total Degrees of Freedom				20396	Critical T (90% confidence df of 20382)				1.6449	

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed, and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression, or it should be dropped.

Table 26. Multiple-Regression and Auto-Econometrics (continued)

Regression Analysis – Dependent Variable 1: I have learned new knowledge/skills from this training**Regression Results**

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	22245.41	1588.96	2460.69	0.0000	Critical F (99% confidence with df of 14 and 20382)	2.0824
Residual	13161.39	0.65			Critical F (95% confidence with df of 14 and 20382)	1.6923
Total	35406.80				Critical F (90% confidence with df of 14 and 20382)	1.5049

Auto Econometrics – Dependent Variable 1: I have learned new knowledge/skills from this training**Regression Statistics**

R-Squared (Coefficient of Determination)	0.6114
Adjusted R-Squared	0.6103
Multiple R (Multiple Correlation Coefficient)	0.7819
Standard Error of the Estimates	0.7630
Observations	19588

Regression Results

	Intercept	var1	var4	var5	var8	var9	var10	var11	var12	var13
Coefficients	1.0168	0.0927	0.5058	-2.3562	0.5031	-0.1009	0.2443	0.2059	0.2632	-0.2253
Standard Error	0.2061	0.0229	0.0693	0.3062	0.3043	0.0375	0.0397	0.0708	0.0471	0.0623
t-Statistic	4.9332	4.0511	7.2992	-7.6957	1.6534	-2.6873	6.1583	2.9056	5.5892	-3.6173
p-Value	0.0000	0.0001	0.0000	0.0000	0.0983	0.0072	0.0000	0.0037	0.0000	0.0003

Table 26. Multiple-Regression and Auto-Econometrics (continued)

Regression Results										
Lower 5%	0.6128	0.0479	0.3700	-2.9563	-0.0933	-0.1744	0.1666	0.0670	0.1709	-0.3474
Upper 95%	1.4209	0.1376	0.6417	-1.7561	1.0996	-0.0273	0.3221	0.3447	0.3555	-0.1032
	ln(var3)	var1*var2	var1*var3	var1*var5	var1*var7	var1*var14	var2*var7	var2*var9	var2*var10	var2*var12
Coefficients	-0.1111	-0.0160	-0.0695	0.0425	-0.0136	0.0090	0.0248	0.0252	-0.0160	-0.0298
Standard Error	0.0387	0.0036	0.0190	0.0196	0.0031	0.0033	0.0064	0.0069	0.0064	0.0085
t-Statistic	-2.8678	-4.4547	-3.6661	2.1678	-4.3360	2.7588	3.8510	3.6436	-2.4955	-3.5185
p-Value	0.0041	0.0000	0.0002	0.0302	0.0000	0.0058	0.0001	0.0003	0.0126	0.0004
Lower 5%	-0.1870	-0.0231	-0.1067	0.0041	-0.0197	0.0026	0.0122	0.0116	-0.0286	-0.0464
Upper 95%	-0.0352	-0.0090	-0.0323	0.0810	-0.0074	0.0154	0.0374	0.0387	-0.0034	-0.0132
	var3*var5	var3*var8	var3*var11	var3*var12	var3*var14	var4*var5	var4*var7	var4*var9	var4*var10	var4*var11
Coefficients	0.9702	-1.1014	-0.1099	0.1149	0.0794	-0.0764	0.0271	-0.0236	-0.0366	0.0289
Standard Error	0.1723	0.1753	0.0423	0.0497	0.0395	0.0432	0.0079	0.0079	0.0062	0.0114
t-Statistic	5.6300	-6.2831	-2.5972	2.3112	2.0136	-1.7695	3.4491	-2.9859	-5.9264	2.5424
p-Value	0.0000	0.0000	0.0094	0.0208	0.0441	0.0768	0.0006	0.0028	0.0000	0.0110
Lower 5%	0.6324	-1.4450	-0.1928	0.0174	0.0021	-0.1609	0.0117	-0.0391	-0.0487	0.0066
Upper 95%	1.3080	-0.7578	-0.0269	0.2123	0.1568	0.0082	0.0425	-0.0081	-0.0245	0.0512
	var4*var12	var5*var6	var5*var7	var5*var8	var5*var14	var6*var7	var6*var9	var6*var11	var6*var13	var6*var14
Coefficients	-0.0396	0.1329	0.1153	0.5913	-0.0616	-0.0168	0.0600	-0.0331	-0.0253	0.0287
Standard Error	0.0087	0.0483	0.0388	0.1635	0.0357	0.0075	0.0086	0.0105	0.0085	0.0067
t-Statistic	-4.5528	2.7528	2.9736	3.6172	-1.7273	-2.2558	6.9639	-3.1394	-2.9586	4.2905
p-Value	0.0000	0.0059	0.0029	0.0003	0.0841	0.0241	0.0000	0.0017	0.0031	0.0000
Lower 5%	-0.0566	0.0383	0.0393	0.2709	-0.1315	-0.0314	0.0431	-0.0538	-0.0420	0.0156
Upper 95%	-0.0226	0.2276	0.1913	0.9117	0.0083	-0.0022	0.0769	-0.0124	-0.0085	0.0418
	var7*var8	var7*var13	var8*var12	var9*var10	var9*var11	var9*var14	var11*var13	var12*var14	ln(var1*var14)	ln(var2*var4)
Coefficients	0.0586	0.0209	-0.1056	0.0148	-0.0298	-0.0265	0.0303	0.0100	-0.1342	-1.0426
Standard Error	0.0342	0.0048	0.0388	0.0060	0.0073	0.0067	0.0070	0.0054	0.0338	0.1544
t-Statistic	1.7155	4.3182	-2.7230	2.4535	-4.1021	-3.9565	4.3390	1.8490	-3.9748	-6.7546
p-Value	0.0863	0.0000	0.0065	0.0142	0.0000	0.0001	0.0000	0.0645	0.0001	0.0000
Lower 5%	-0.0084	0.0114	-0.1817	0.0030	-0.0441	-0.0396	0.0166	-0.0006	-0.2004	-1.3451

Table 26. Multiple-Regression and Auto-Econometrics (continued)

Regression Results										
Upper 95%	0.1257	0.0304	-0.0296	0.0266	-0.0156	-0.0134	0.0440	0.0205	-0.0680	-0.7400
	ln(var2*var6)	ln(var2*var8)	ln(var4*var5)	ln(var6*var10)	ln(var6*var11)	ln(var6*var13)				
Coefficients	1.1504	-0.1274	0.4306	-0.3105	-0.2227	0.4532				
Standard Error	0.1610	0.0520	0.0498	0.0801	0.1290	0.1481				
t-Statistic	7.1434	-2.4526	8.6556	-3.8784	-1.7259	3.0597				
p-Value	0.0000	0.0142	0.0000	0.0001	0.0844	0.0022				
Lower 5%	0.8347	-0.2293	0.3331	-0.4675	-0.4756	0.1629				
Upper 95%	1.4660	-0.0256	0.5282	-0.1536	0.0302	0.7436				

Degrees of Freedom				Hypothesis Test			
Degrees of Freedom for Regression			55	Critical t-Statistic (99% confidence with df of 19532)			2.5761
Degrees of Freedom for Residual			19532	Critical t-Statistic (95% confidence with df of 19532)			1.9601
Total Degrees of Freedom			19587	Critical t-Statistic (90% confidence with df of 19532)			1.6449

Regression Statistics for ACQ/CON/PNT all individual students	
R-Squared (Coefficient of Determination)	0.5384
Adjusted R-Squared	0.5384
Multiple R (Multiple Correlation Coefficient)	0.7338

Table 26. Multiple-Regression and Auto-Econometrics (continued)

Regression Statistics for ACQ/CON/PNT all individual students					
Standard Error of the Estimates (SEy)	0.7934				
Number of Observations	19082				

Regression Results					
	Intercept	F1 CLA	F2 Rel L	F3 Rel G	F4 Cert
Coefficients	0.9734	0.3255	-0.1126	0.5317	-0.0803
Standard Error	0.0375	0.0086	0.0263	0.0084	0.0061
t-Statistic	25.9365	38.0337	-4.2820	63.1971	-13.196
p-Value	0.0000	0.0000	0.0000	0.0000	0.0000
Lower 5%	0.8999	0.3087	-0.1641	0.5152	-0.0922
Upper 95%	1.0470	0.3423	-0.0611	0.5482	-0.0684

As exhibited in Table 27, when each factor is assessed individually through a regression model as the independent variable against the dependent variable “I learned new knowledge/skills from this training,” an adjusted R-squared is obtained providing the explanatory power of that factor. This assessment is done at the individual student level across the three curriculums of ACQ, CON, and PMT and over the course averages of students for all curriculums. The *longer-term relevance* factor explained the most in both models: 50 percent and 40 percent, respectively. *Clarity* is the next most explanatory factor, delivering 42 percent and 27 percent of Knowledge Friction, respectively. *Near-term relevance* is also a substantial contributing Knowledge Friction factor, providing 15 percent and 10 percent of the respective models. Also noteworthy: The *certification/education* and *experience* factors show little effect on Knowledge Friction or knowledge transfer in the models. The study hypothesized that they would be strong contributors.

While the different course structure models do not provide the same results, they do indicate a strong alignment of the relative impact for each factor. Also of note, the R-squared of each individual factor added together exceeds the total value of the aggregated model in both cases. This finding further supports that the independent variables interact; they are not completely independent of each other. Table 27 provides a summary, and the complete regression models appear in Appendix D.

Table 27. Potential Knowledge Friction (R-squared) by Independent Factor.

	ACT/CON/PNT CURRICULUMS (19000+)	AVERAGE OF ALL CURRICULUMS (71)
All	54	50
Clarity	42	27
Near-Term Relevance	15	10
Longer-Term Relevance	50	40
Certification	<1	1
Experience	<1	<1

Next, the analysis considers the two strong *relevance* factors that emerge in the factor analysis and in the explanatory power of the regression models. As stated earlier, the *relevance* questions are grouped into specific near-term questions (how much will this help on the job?), and more long-term ones (I will be able to use this in my job, and this will help me in my career and profession). The regression model is used to address the study's second hypothesis and assess if these two factors manifest differently in the lower verses higher certified and more experienced workforces. Again, the study steers clear of the internal psychology inherent in analyzing motivation. It instead identifies statistically different behavior between the groups, potentially operationalizing intrinsic and extrinsic motivation through *near-term* and *longer-term relevance*. Table 28 exhibits a 10 percent difference between the importance placed on *longer-term relevance* by the highly *certified* and *experienced* when compared to the lower *certified* and less *experienced*. Notably, there is almost no difference in their weighting of *near-term relevance*—it explains about 20 percent of the model in both groups. See Appendix D, for the complete regression reports.

Table 28. The Impact of Near and Longer-term Relevance Based on Certification/Experience.

	Near-term Relevance R-squared	Longer-term Relevance R-squared
Low Certification/Experience	21 percent	55 percent
High Certification/Experience	21 percent	65 percent

While the Auto-Econometrics results are slightly less explanatory than the linear regression, they do exhibit interaction between independent variables as force multipliers. This supports that all the factors likely have interdependency.

Taking into account that the independent factors are likely endogenous, they are not only impacting and predicting the dependent factor (*knowledge transfer*) but are also influencing by advancing or negating each other. Further they are doing so with different weightings and the directness of their path of influence on the dependent factor (Mun, 2021).

The research considers the significant difference between the perceived knowledge transfer reported in the self-paced and the instructor led courses. Harkening back to the Explicitness depicted in Figure 6 in the Literature Review an additional independent factor of *explicitness* is added where one (1) depicts the explicit self-paced courses and zero (0) depicts the addition of tacit knowledge in the instructor led courses.

The findings detailed in Appendix D, show the additional *explicitness* factor increased the *knowledge transfer* regression R-squared by almost two percent. Again, the regressions show probable interaction between *explicitness* and the other independent factors. *Explicitness* singularly explains 5.9 percent of *knowledge friction*. Additionally, 6.8 percent of *explicitness* is explained by the *clarity* factor. Adding the additional factor of *explicit* to the factor analysis (Table 29); it rises to the fifth strongest factor—surpassing *certification/education*.

Table 29. Varimax Rotated Factor Loadings with Explicit Factor Added (Ranked).

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
VAR1	KT (DV)	-0.4185	-0.1807	0.3666	-0.0404	-0.1166	0.0201	0.7879	-0.1182
VAR2	N-Rel	-0.1233	-0.9245	0.1577	-0.0646	-0.0010	0.0161	0.0548	-0.0832
VAR3	N-Rel	-0.1637	-0.8694	0.2199	-0.0680	-0.0112	0.0129	0.1137	-0.0811
VAR4	N-Rel	-0.1565	-0.8813	0.2328	-0.0585	-0.0117	0.0066	0.0695	-0.1087
VAR5	L-Rel	-0.3427	-0.3745	0.8019	-0.0464	-0.0221	-0.0260	0.1648	-0.1552
VAR6	L-Rel	-0.4077	-0.2970	0.7732	-0.0468	-0.0249	-0.0056	0.2437	-0.0905
VAR7	Rel	-0.3732	-0.2861	0.5447	-0.0335	-0.0288	-0.0141	0.2814	-0.1723
VAR8	Clarity	-0.8493	-0.1638	0.2765	-0.0357	-0.0806	-0.0257	0.1910	-0.1128
VAR9	Clarity	-0.8910	-0.1499	0.2408	-0.0373	-0.0966	-0.0334	0.1498	-0.1027
VAR10	Clarity	-0.8372	-0.1491	0.2305	-0.0386	-0.0806	-0.0281	0.1184	-0.1188
VAR11	Clarity	-0.4036	-0.3490	0.5130	-0.0526	-0.0353	-0.0521	0.0689	-0.6597
VAR12	Experience	-0.0669	0.0475	-0.0115	0.9798	-0.0076	-0.1787	-0.0289	0.0115
VAR13	Cert	-0.0571	0.0028	0.0135	0.1782	-0.1145	-0.9753	-0.0096	-0.0184
VAR14	Explicit	0.1505	0.0224	-0.0384	0.0006	0.9790	0.1139	-0.0583	0.0180
Sum of Squares		3.0741	2.9263	2.2517	1.0180	1.0111	1.0032	0.8893	0.5746
Rank		1	2	3	4	5	6	7	8
Proportion		21.96%	20.90%	16.08%	7.27%	7.22%	7.17%	6.35%	4.10%
Cum Proportion		21.96%	42.86%	58.94%	66.21%	73.44%	80.60%	86.95%	91.06%

D. STRUCTURAL EQUATIONS MODEL: PARTIAL LEAST SQUARES

Previously discussed in the Research Design section, the SEM performed in this research using the PLS tools provides the means to articulate path-dependent and multi-path problems such as the interaction between the independent factors in the Knowledge Friction model. It expands and focuses the power of multiple regression analysis. In this case there are five factors; four are independent and the final one is the dependent factor: *knowledge transfer*. As stated, the purpose of the model is to identify the flow and interaction of the independent factors: *clarity* of the information received; *near-term* and *longer-term relevance* to the receiver; and level of *certification* and *experience* of the receiver. Through the model, the percent of knowledge transferred is calculated through the direction of flow through the independent factors and the percentage of knowledge transferred through the multiple paths is predicted. The DAU data from the self-paced-course post-course surveys to populate the model is used to run bivariate regressions between each link in the model. Understanding that the independent factors are likely interacting and impacting while they are also predicting *knowledge transfer* effectiveness, some assumptions are made. The first assumption is that *clarity* (F1) precedes *relevance* (F2/F3). A receiver has to be able to interpret the information at some level before they can determine if it interests them, or, at a minimum, could adversely impact them. The second assumption is that *near-term relevance* (F2) precedes *longer-term relevance* (F3), as it is probably more immediate (fight or flight). *Clarity* (F1) and *relevance* (F2/F3) lead to obtaining education and training followed by gaining *experience*, which is documented in *certification* (F4). All these factors, together and separately, impact the flow of knowledge and the effectiveness in which it is transferred—*knowledge transfer* (F5). Figure 18 illustrates the knowledge flow paths and resultant Knowledge Frictions. This mapping is derived from Mun (2021).

Table 30. Model Inputs for ACQ/CON/PNT and Model Results.

Values Compared		
VAR1; VAR2; VAR3; VAR4; VAR5		
VAR1; VAR2; VAR3; VAR4		
VAR1; VAR2; VAR3		
VAR1; VAR2		
F1 CLA, F2 Rel L, F3 Rel G, F4 Cert, F5 KT		
F1 CLA, F2 Rel L, F3 Rel G, F4 Cert		
F1 CLA, F2 Rel L, F3 Rel G		
F1 CLA, F2 Rel L		
Structural Equation Model: Path Estimation (PLS)		
Direct Effects Path		
Dep. VAR5	Var	
R-Square	0.53845	
Disturbance	0.67938	
Independent Var	Coeff	P-Value Std. Beta
Intercept	0.97342	0.00000
VAR1	0.32549	0.00000 0.27914
VAR2	-0.11260	0.00002 -0.02564
VAR3	0.53167	0.00000 0.51352
VAR4	-0.08028	0.00000 -0.06509
Partial Direct Effects Path 1		
Dep. VAR4	Var	
R-Square	0.00536	
Disturbance	0.99731	
Indep. Var	Coeff	P-Value Std. Beta
Intercept	1.65226	0.00000
VAR1	0.04509	0.00001 0.04770
VAR2	-0.27744	0.00000 -0.07792
VAR3	-0.00262	0.79355 -0.00312

Table 30. Model Inputs for ACQ/CON/PNT and Model Results (continued)

Partial Direct Effects Path 2			
Dep. VAR3	Var		
R-Square	0.63356		
Disturbance	0.60534		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	0.97094	0.00000	
VAR1	0.68913	0.00000	0.61189
VAR2	1.34293	0.00000	0.31661
Partial Direct Effects Path 3			
Dep. VAR2	Var		
R-Square	0.16822		
Disturbance	0.91202		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	-0.09661	0.00000	
VAR1	0.10890	0.00000	0.41015
Total Effects			
Dep. VAR5	Var		
Indep. Var	Coeff	P-Value	Std. Beta
VAR1	0.75636	0.00000	0.64864
VAR2	0.62396	0.00000	0.14208
VAR3	0.53188	0.00000	0.51372
VAR4	-0.08028	0.00000	-0.06509
Summary Standardized Path Effects			
Dep. VAR5	Var		
Indep. Var	Direct	Indirect	Total
VAR1	0.27914	0.36951	0.64864
VAR2	-0.02564	0.16772	0.14208
VAR3	0.51352	0.00020	0.51372
VAR4	-0.06509	0.00000	-0.06509

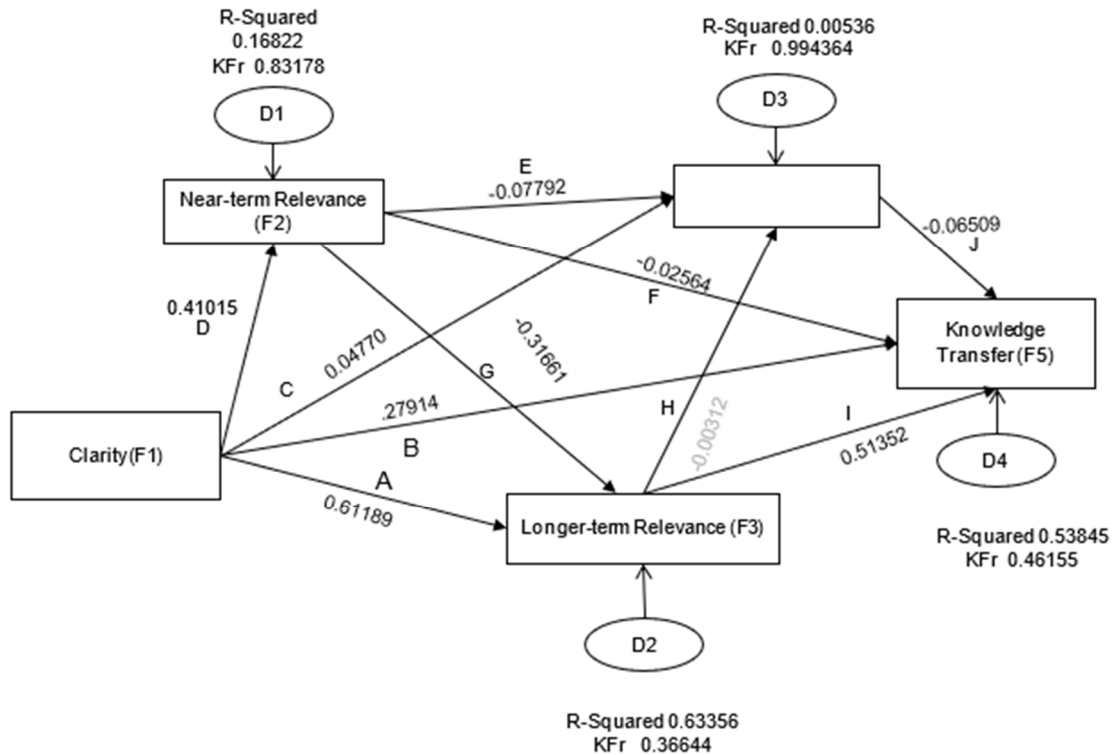


Figure 18. PLS Model for ACQ/CON/PNT Courses.

As shown in Figure 18, the model expressed in Table 30 is adjusted to consider the strong impact of the *relevance* factor, and to reflect the factor analysis indicator that *relevance* acts as two separate factors. As stated earlier, the *experience* factor has shown very little explanatory power, and what little effect it has appears to be also captured in the stronger *certification* factor. On review, this makes sense, as the DAU Certification process requires a minimum number of years tenure to qualify for each level. For that reason, the *certification* factor is renamed *certification/experience*. The *experience* factor data used in the earlier treatments is removed. The aggregate of the direct and indirect paths provides the power of the model, while the individual paths provide the impact of each independent factor on the dependent factor (F5). The direct effects on *knowledge transfer* (F5) are pathways B, F, I, and J from the four independent factors (*clarity* F1, *near-term relevance* F2, *longer-term relevance* F3, and *certification/experience* F4), which add together to explain 53 percent *knowledge transfer*. These factors also have indirect effects. Factor 1 has two valid indirect paths: AI and DF at 61 percent and -10 percent for an indirect effect

of 51 percent. Factors 2 and 3 do not have indirect impacts, and factor 1 does not directly impact factor 5 because their paths' p-value calculations determine that the links are not statistically significant. The full explanation of *knowledge transfer* and the inhibiting Knowledge Friction is the aggregation of all direct and indirect paths through the model to factor 5, which is that as much as 54 percent of the *knowledge transfer* is explained by the model (Mun, 2021). While *certification* and *experience* have not been the major contributing factors, *certification* has been nominally more influential and has an *experience* component in its explanation that is likely capturing the effects of the *experience* factor. For this reason, *experience* is removed from the model and *certification* remains in the model to account for both *certification* and *experience*. Also of note, this model lost some of its scope and granularity because of averaging of individual data for each of the courses in the DAU survey. The research tried to develop a triangulation to assure against macronumerosity as discussed earlier, but the higher level of analysis (course versus individual) might not be supportable in this model. This higher level of analysis is depicted in Tables 31 through 32 and Figure 19.

Table 31. Model Inputs for All DAU Courses Averages and Model Results

Values compared		
F1 CLA, F2 Rel L, F3 Rel G, F4 Cert, F5 KT		
F1 CLA, F2 Rel L, F3 Rel G, F4 Cert		
F1 CLA, F2 Rel L, F3 Rel G		
F1 CLA, F2 Rel L		
Structural Equation Model: Path Estimation (PLS)		

Table 32. Direct Path Results

Direct Effects Path			
Dep. Var	VAR5		
R-Square	0.53335		
Disturbance	0.68312		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	1.78332	0.00383	
VAR1	-0.08199	0.73876	-0.05390
VAR2	-0.85585	0.04331	-0.26426
VAR3	0.86936	0.00002	0.95359
VAR4	-0.13267	0.00038	-0.33082
Partial Direct Effects Path 1			
Dep. Var	VAR4		
R-Square	0.09452		
Disturbance	0.95157		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	-2.81522	0.16831	
VAR1	0.84753	0.31527	0.22346
VAR2	-0.39485	0.78348	-0.04889
VAR3	0.27528	0.66868	0.12110
Partial Direct Effects Path 2			
Dep. Var	VAR3		
R-Square	0.82971		
Disturbance	0.41266		

Table 32. Effects Comparison Table (continued)

Indep. Var	Coeff	P-Value	Std. Beta		
Intercept	0.11082	0.77294			
VAR1	1.07516	0.00000	0.64441		
VAR2	1.57454	0.00000	0.44323		
Partial Direct Effects Path 3					
Dep. Var	VAR2				
R-Square	0.14563				
Disturbance	0.92432				
Indep. Var	Coeff	P-Value	Std. Beta		
Intercept	-0.30056	0.20841			
VAR1	0.17923	0.00102	0.38161		
Total Effects					
Dep. Var	VAR5				
Indep. Var	Coeff	P-Value	Std. Beta		
VAR1	0.79203	0.00000	0.52070		
VAR2	0.50787	0.15998	0.15682		
VAR3	0.83284	0.00011	0.91353		
VAR4	-0.13267	0.00038	-0.33082		
Summary Standardized Path Effects					
Dep. Var	VAR5				
Indep. Var	Direct	Indirect	Total		
VAR1	-0.05390	0.57461	0.52070		
VAR2	-0.26426	0.42108	0.15682		
VAR3	0.95359	-0.04006	0.91353		
VAR4	-0.33082	0.00000	-0.33082		

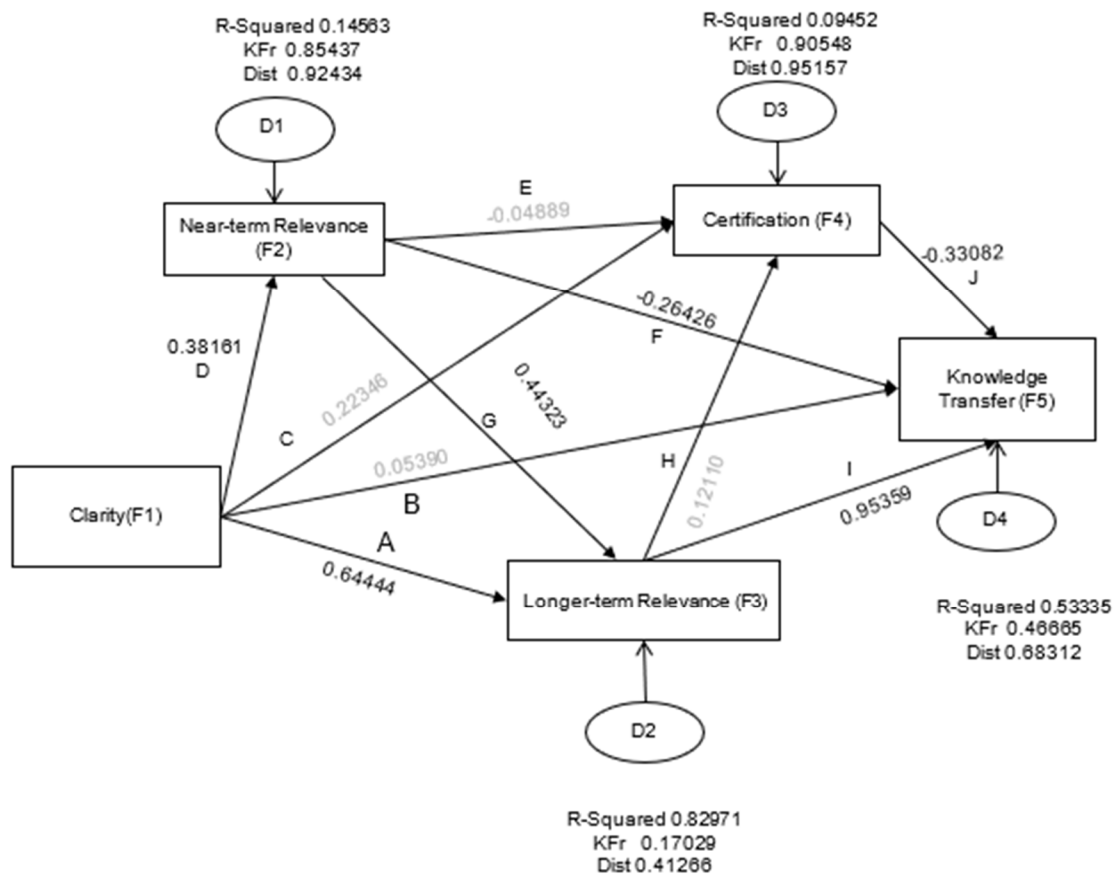


Figure 19. PLS Model All DAU Courses Averages

As explained in the Research Design section, the knowledge vectors flow in one direction. The aggregate of the direct and indirect paths provides the power of the model, while the individual paths provide the impact of each independent factor on dependent factor (F5). The direct effects on *knowledge transfer* (F5) are pathways B, F, I and J, from the four independent factors (*clarity*, F1; *near-term relevance*, F2; *longer-term relevance*, F3; and *certification/experience*, F4), which add together to provide 54 percent *knowledge transfer*. These factors also have indirect effects: Factor 3 indirectly impacts factor 5 at less than 1 percent through path HJ; factor 2 indirectly impacts factor 5 by 16 percent through paths EJ, GI, and GHJ; and factor 1 indirectly impacts factor 5 by 37 percent through paths AEJ, AF, AGI, AGHJ, BJ, DHJ, and DI. The full explanation of *knowledge transfer* and the inhibiting Knowledge Friction is the aggregation of all direct and indirect paths through

the model to Factor 5, which is that as much as 53 percent of the *knowledge transfer* is explained by the model (Mun, 2021). This model articulates a few interesting observations. First, there is an increase of 11 percent in the explanative power of *knowledge transfer* and the associated amount of Knowledge Friction each factor can impose on that transfer. Second, the *clarity* factor greatly impacts both forms of the relevance factors and the *knowledge transfer* factor; it has almost no impact on *certification* and *experience*. *Certification/experience*, in turn, has little impact on the *knowledge transfer* factor. Finally, per the p-Value (0.79: greater than 0.05), the *longer-term relevance* is not associated with the *certification/experience* factor. This final finding supports separating *near* and *longer-term relevance* into two separate factors and lends credence to the association of *longer-term relevance* with intrinsic motivation and self-betterment.

Another excursion is executed of the model, to challenge the selected framework of *clarity* (F1) leading to *relevance* (F2). *Relevance* is combined and placed as the lead factor (F1). *Certification* is moved forward in the model (F2). *Clarity* is F3, and *Experience* is added as the last independent variable (F4). To try to draw out any masked impact of *certification* and *experience*, the data are mapped into blocks established by the two factors' low, medium, and high rankings. Summaries of the models' results are shown below, in Tables 33 through 35 and Figures 20, 21, and 22 provide visualization at the three levels. The complete data and models for the rest of the PLS models discussed are presented in Appendix E.

Table 33. Relevance to KT with Low Certification/Experience Data Summary.

	Total Effects			
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Coeff	P-Value	Std. Beta
Relevance	VAR1	2.15920	0.00000	0.47384
Certification	VAR2	0.00024	0.99301	0.00010
Clarity	VAR3	0.72254	0.00000	0.61104
Experience	VAR4	-0.04233	0.08936	-0.01633
	Summary Standardized Path Effects			
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Direct	Indirect	Total
Relevance	VAR1	0.1722	0.3016	0.4738
Certification	VAR2	-0.0018	0.0019	0.0001
Clarity	VAR3	0.6116	-0.0006	0.6110
Experience	VAR4	-0.0163	0.0000	-0.0163

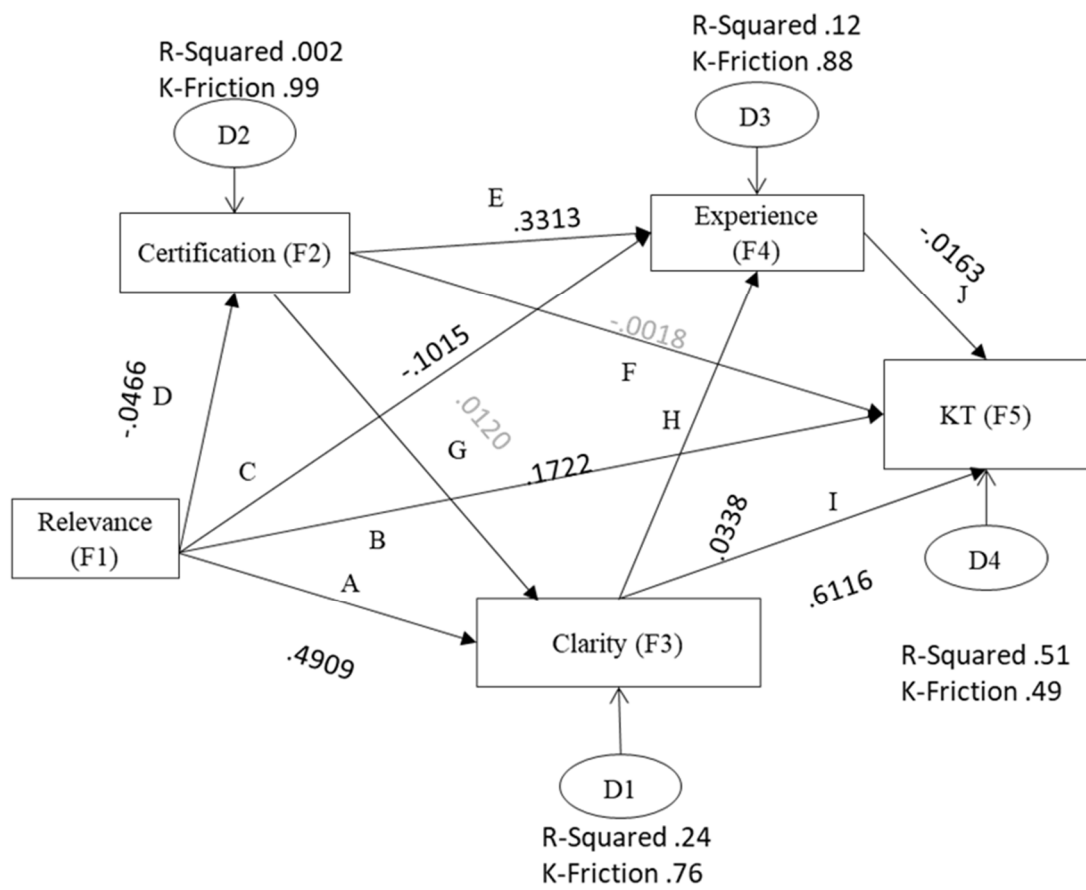


Figure 20. PLS Model Relevance to KT with Low Certification/Experience.

Table 34. Relevance to KT with Medium Certification/Experience Data
Summary

Total Effects				
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Coeff	P-Value	Std. Beta
Relevance	VAR1	2.22374	0.00000	0.43404
Certification	VAR2	-0.04124	0.16080	-0.02522
Clarity	VAR3	0.71771	0.00000	0.59879
Experience	VAR4	-0.12483	0.00214	-0.04463
Summary Standardized Path Effects				
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Direct	Indirect	Total
Relevance	VAR1	0.1699	0.2642	0.4340
Certification	VAR2	-0.0510	0.0258	-0.0252
Clarity	VAR3	0.5999	-0.0011	0.5988
Experience	VAR4	-0.0446	0.0000	-0.0446

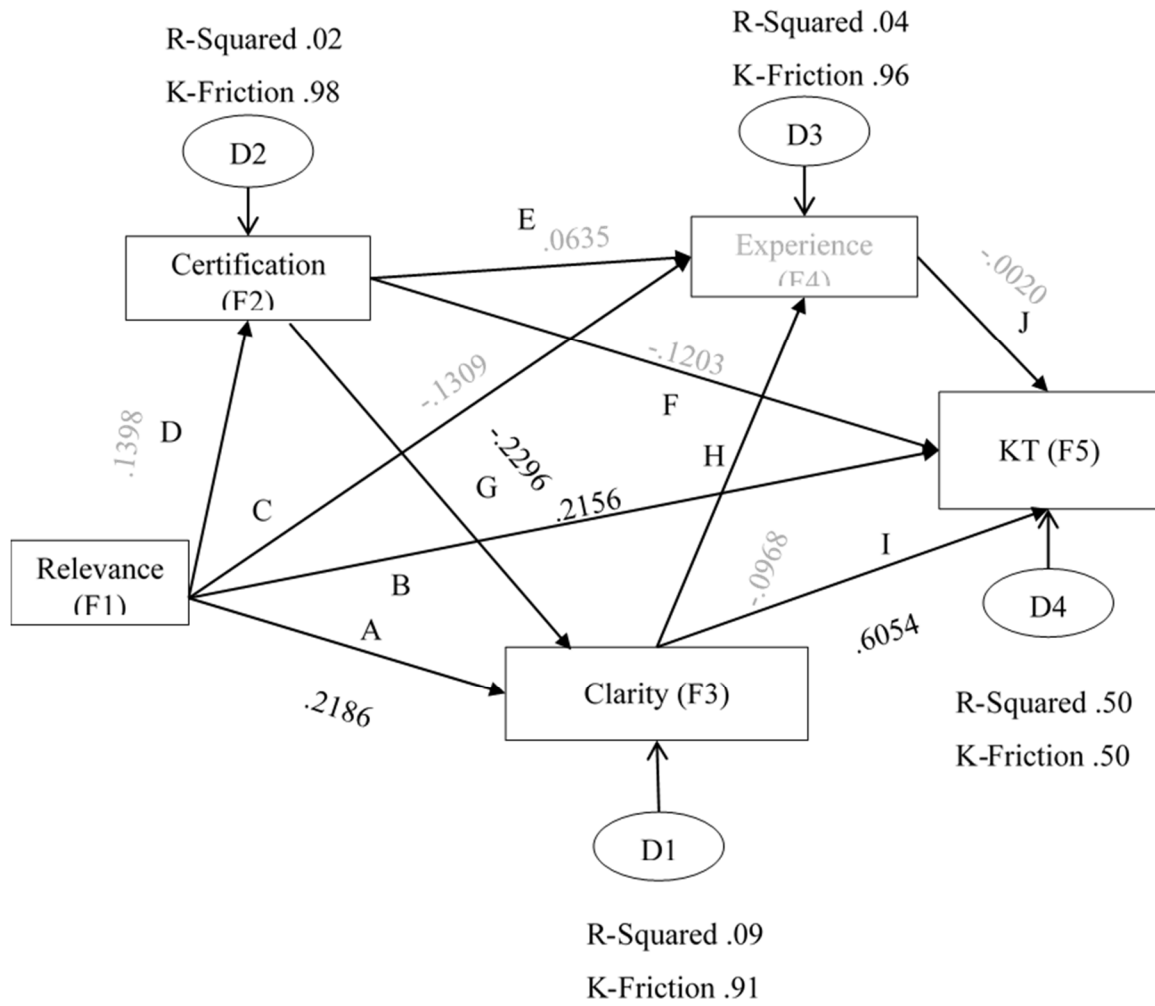


Figure 21. PLS Model Relevance to KT with Medium Certification/Experience

Table 35. Relevance to KT with High Certification/Experience Data Summary.

Total Effects				
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Coeff	P-Value	Std. Beta
Relevance	VAR1	1.57049	0.00764	0.31196
Certification	VAR2	-0.51850	0.02253	-0.25953
Clarity	VAR3	0.65116	0.00000	0.60557
Experience	VAR4	-0.00542	0.98179	-0.00202
Summary Standardized Path Effects				
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Direct	Indirect	Total
Relevance	VAR1	0.2156	0.0963	0.3120
Certification	VAR2	-0.1203	-0.1392	-0.2595
Clarity	VAR3	0.6054	0.0002	0.6056
Experience	VAR4	-0.0020	0.0000	-0.0020

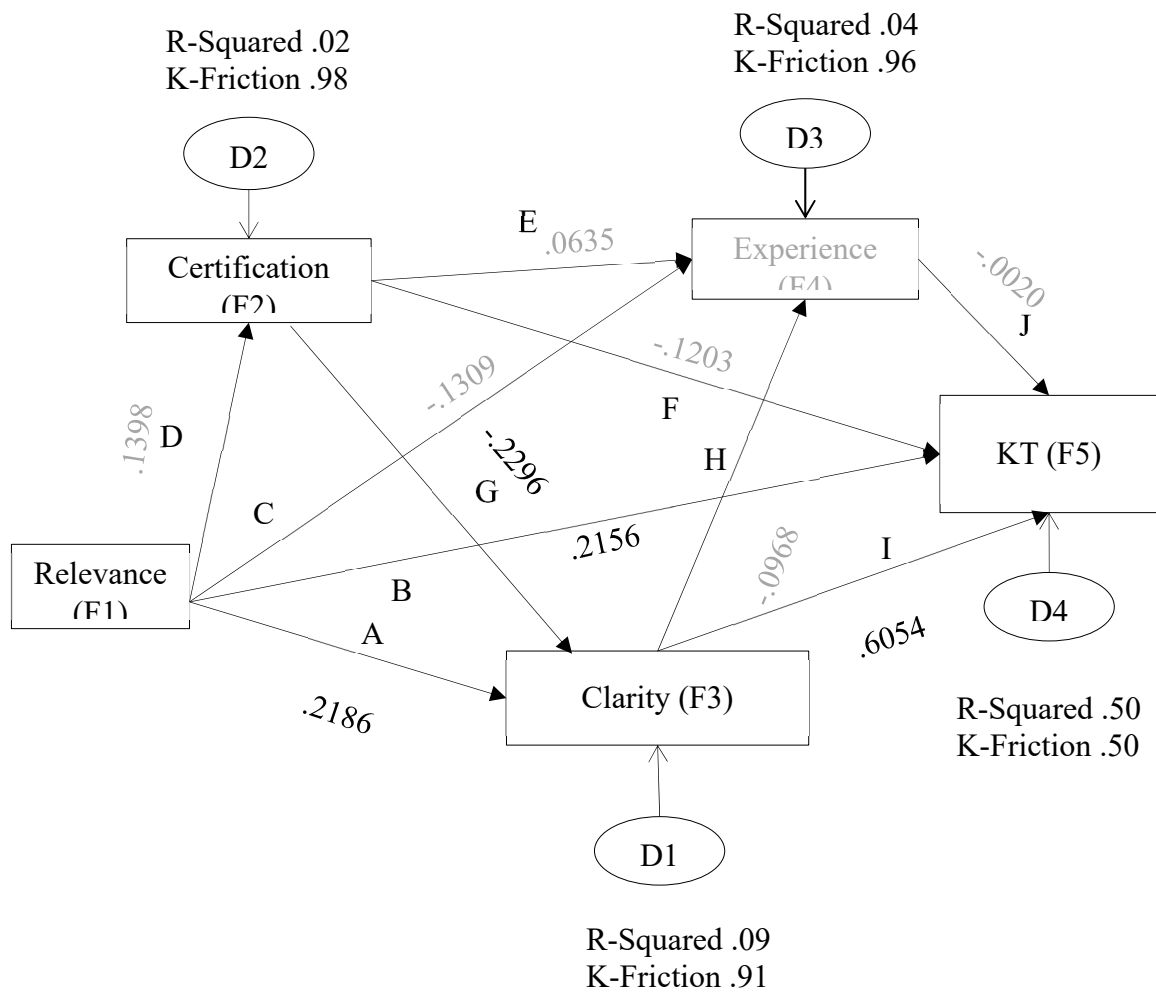


Figure 22. PLS Model Relevance to KT with High Certification/Experience.

Again, referencing Figure 20 through 22, there are now four paths from *relevance* (F1) to *knowledge transfer* (F5). The model is run three times to capture any differences. The most notable is the breakdown and weakening of paths across the model. The overall explanatory effect of the model drops to 50 percent, and several paths are weakened or not statistically significant. As expected, *certification* and *experience* play a very small role in the low *certification/experience* model. They both increase in explanative power in the medium model, but then the two factors' paths drop to not statistically significant in the

high *certification* and *experience* model. This finding is supported by the Learning Curves' Sigmoid Curve literature (Ritter and Schooler, 2002) discussed in Chapter 2.

Bringing the study back to the original KFT model depicted in Figure 6, another excursion is executed of the model incorporating the bootstrapped *explicit* factor data. The model is reframed to start at *explicit* (F1), then move to of *clarity* (F2), followed into *near*, then *longer-term relevance* (F3), and finally (F4). *Certification* and *experience* factors are dropped because they have shown little direct or indirect impact. Summaries of the model's results are shown below in Table 36. Figure 23 provides a visualization of interaction of the most impactful new Knowledge Friction factors and the *explicit* Knowledge Friction factor. The complete data and model for this PLS model are presented in Appendix E.

The knowledge vectors still flow in one direction, and the aggregate of the direct and indirect paths provide the power of the model, while the individual paths provide the impact of each independent factor on dependent factor (F5). The direct effects on *knowledge transfer* (F5) are pathways B, F, I and J, from the four independent factors (*explicit*, F1; *clarity*, F2; *near-term relevance*, F3; and *longer-term relevance*, F4), which add together to provide 58 percent *knowledge transfer*. These factors also have indirect effects: Factor 3 indirectly impacts factor 5 at 7 percent through path HJ; factor 2 indirectly impacts factor 5 by 16 percent through paths EJ, GI, and GHJ; and factor 1 indirectly impacts factor 5 by 61 percent through paths AEJ, AF, AGI, AGHJ, BJ, DHJ, and DI. The full explanation of *knowledge transfer* and the inhibiting Knowledge Friction is the aggregation of all direct and indirect paths through the model to Factor 5, which is that as much as 58 percent of the *knowledge transfer* is explained by the model (Mun, 2021). This model articulates a few interesting observations. First, adding the *explicit* factor results in an increase of 4 percent in the explanative power of *knowledge transfer* and the associated amount of Knowledge Friction each factor imposes on that transfer. Second, the *explicit* factor does not greatly impact the other Knowledge Friction factors which implies that while it is interactive with the new independent factors, it is a standalone independent factor as well. Said another way, the new factors interact with the *explicit* factor, but are not subsets of the *explicit* factor—they are additional Knowledge Friction factors.

Table 36. Relevance to KT with Explicit Data Summary.

	Total Effects			
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Coeff	P-Value	Std. Beta
Explicit	VAR1	-0.66009	0.00000	-0.24871
Clarity	VAR2	0.81842	0.00000	0.65575
Near-term Certification	VAR3	0.76421	0.00000	0.16860
Longer-term Certification	VAR4	0.47982	0.00000	0.49747
	Summary Standardized Path Effects			
	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Direct	Indirect	Total
Explicit	VAR1	-0.09482	-0.15389	-0.24871
Clarity	VAR2	0.32104	0.33472	0.65575
Near-term Certification	VAR3	-0.03010	0.19870	0.16860
Longer-term Certification	VAR4	0.49747	0.00000	0.49747

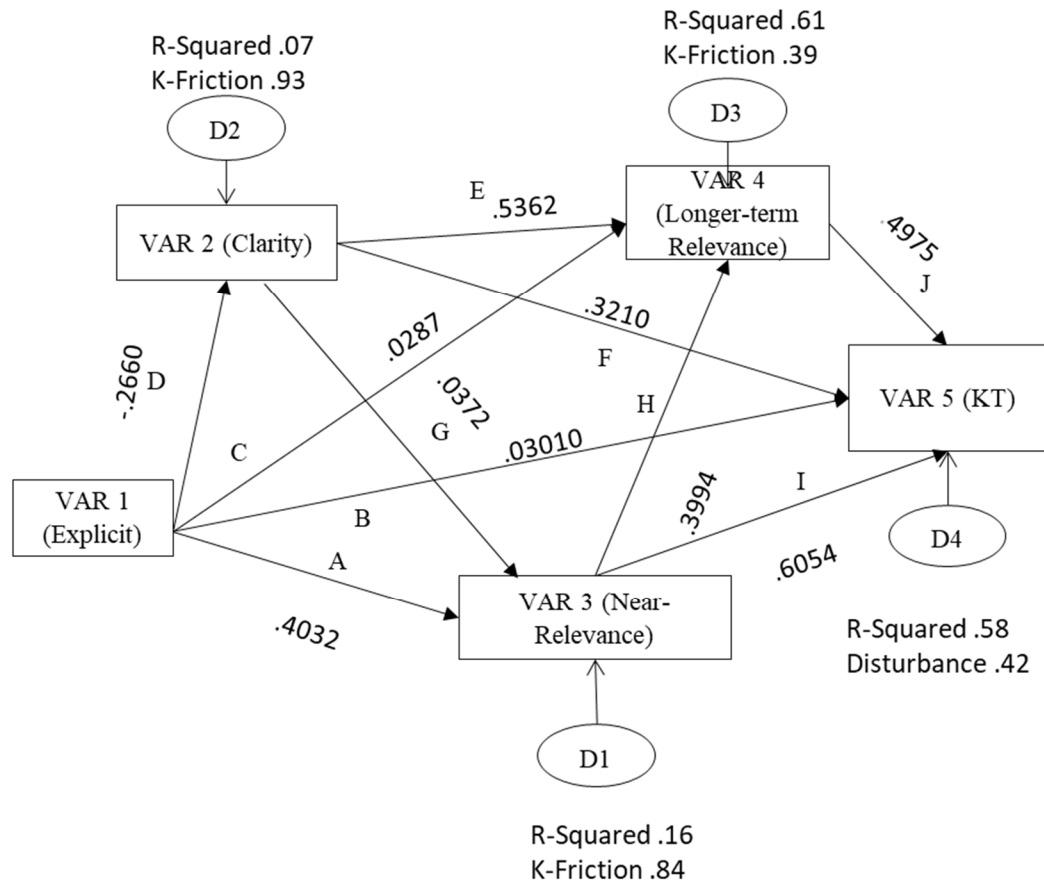


Figure 23. PLS Model Explicit to KT through Clarity, Near and Longer-term Relevance.

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V. CONCLUSION

A. KEY FINDINGS

The purpose of the dissertation is to identify and quantify factors that inhibit *knowledge transfer*; this is called Knowledge Friction in Knowledge Flow Theory, which currently only identifies Knowledge Friction through the Tacit-Explicit Continuum. This dissertation considers and quantitatively addresses five additional Knowledge Friction factors. They are *clarity*, *near-term and longer-term relevance*, *certification*, and *experience*. It further examines these new factors' connection with the existing *explicit* Knowledge Friction factor and their combined impact on *knowledge transfer*.

All survey types (student post-course, student six-month follow-up, manager's six-month assessment of student) provide insight into the value of the knowledge transferred and trended, if not aligned, similarly. The post-course surveys provide the most usable quantitative data. While all the survey types address the dependent variable, how much knowledge is gained, and *near-term relevance*, the post-course surveys address *clarity* of the curriculum, *long-term relevance*, as well as the student's level of *certification*, and level of professional *experience*. The *explicit* factor was extrapolated through the differences between the Self-paced and the Instructor-led Post-course surveys.

Recalling back to the hypothesis section and reflecting on the stated problem: Nissen's extension of Knowledge Flow Theory incorporated the concept of resistance to *knowledge transfer*, which he referred to as *Knowledge Friction* (Nissen, 2017). This friction accounts in part for the comparative slowness of tacit versus explicit flows. The pair-wise T-test between the self-paced-course survey response, "I learned new knowledge/skills from this training" and the instructor-led-course survey response to the same question results in a significant difference (almost a full point on a Likert seven-point scale) in the respondents' perceived gain in knowledge. While this finding correlates strongly with Nissen's theory, showing that the lack of tacit knowledge exchanged by the instructor diminishes the knowledge transferred, and supports Nissen's valuable extension to Knowledge Flow Theory, this friction concept remains un-extended and

underdeveloped, with only one Knowledge Friction factor considered: the explicitness of knowledge in its conceptualization. The rest of this section concludes with the findings supporting the Primary Research Question is reviewed again: What additional factors can complement *explicitness* to extend our understanding of Knowledge Friction?

The first hypothesis for this research: A receiver's clear understanding, *relevance*, and *experience* decrease Knowledge Friction.

Clarity is drawn out in the factor analysis model and again in the PLS model as a strong factor for explaining Knowledge Friction. A lack of *clarity* inhibits knowledge flow by as much as 23 percent in the linear model, and possibly greater than 40 percent in the multi-path inter-related PLS model. Two strong *relevance* factors emerge in the factor analysis and in the explanatory power of the regression models. The *relevance* factors are individually explanatory enough and the supporting questions are divergent enough to stand as separate factors. The *relevance* questions break into near-term questions (how much will this help in our job?), and longer-term (I will be able to use this in my job, and this will help me in my career and profession). This could operationalize intrinsic and extrinsic motivation without hypothesizing the qualitative “why” inherent in analyzing motivation.

Conversely, the *certification* and *experience* factors explain far less than hypothesized. In the factor analysis model and in the linear model, they provide well less than ten percent of the Knowledge Friction explanation. They provide little more in the PLS model, minimizing their interactive impact. The models indicate the *certification* factor incorporates minimum time in the community, and so is likely explaining *experience*. This makes the *experience* factor redundant. This is further supported by how little explanation the *experience* factor adds to the regression models—one to two percent Knowledge Friction impedance.

The findings in this research do not strongly support the expectation derived from the literature on *experience*. Specifically, that a greater *experience* level could allow for more chunks of knowledge to be absorbed per transfer because a framework exists to sort

and place the knowledge. The lack of *experience* does not strongly translate to a factor significantly contributing to Knowledge Friction—at least not as a standalone factor.

The second hypothesis: The *relevance* and *experience* factors' weighting correlate to the level of positional seniority of the receiver in an organization. Restated: Junior knowledge receivers will consider the importance of *relevance* and *experience* differently than will senior receivers.

Most noteworthy is the delta between Level 3 and Level 1 *certified* employees' weighting of *longer-term relevance*. The more senior employees score *longer-term relevance* 10 percent higher than the junior employees. This may operationalize extrinsic and intrinsic motivation as described in Self-determination Theory (Deci & Ryan, 1985).

Also varying from the researcher's preconceptions is the finding throughout the analysis that *experience* provides less explanatory power than hypothesized. Even considering it in the context of the *certification* factor, it is a distant fourth in quantitatively impacting knowledge flow and transfer. The PLS model does show that it is most impactful in the intermediate level of the curriculum with intermediate respondents. This is supported by the Sigmoid Learning Curve literature.

This research also considers that the independent variables are probably not completely independent of each other. They likely interact with each other as well as the dependent variable and impact on knowledge flow and the ensuing Knowledge Friction. The PLS model is developed and run because linear multivariate regressions only explain part of the impact of these independent variables on Knowledge Friction if they are interconnected. Exploring the possible exogenous and endogenous knowledge paths through the independent variables to the dependent variable provides a more complete explanation.

The third hypothesis: There are multiple additive paths of *knowledge transfer*, and each path incurs Knowledge Friction.

While the overall linear multivariate regression models produce an explanatory power of 63 percent as expressed in the Adjusted R-squared, the individual Factors explain only half of the overall model's 63 percent. Further, when run in an auto-econometric

model, while not dramatically increasing the predictive power, several interactive variable models are identified. This supports that there is interaction between the independent variables amplifying the overall model.

The PLS model articulates the additive and multiplicative effects of the Knowledge Friction factors along the multiple knowledge flow paths to *knowledge transfer*. Specifically noteworthy is the additive impact of the *clarity* factor; while the Knowledge Friction impact is nominal in the linear regression model (less than 10 percent) its additive impact in the PLS model is nearly 40 percent. The PLS model also shows *experience* is a more transitional factor, exhibiting most influence at the intermediate level of training.

Other aspects of *knowledge transfer* suggested by this research's parsing of the DAU surveys' data:

There is a strong correlation between students' assessment of their implementation of the information (knowledge) obtained from the course, as provided in the follow-up survey, and their perception of the course's *relevance* to them, and their assessment of the *clarity* with which the course is organized and presented. There is less of a correlation between *experience* level and *knowledge transfer*.

Experience is not locked to the time when the course is taken. A positive seasonal trend occurs in the follow-up survey from the post-course survey. Much as the internal temperature of food increases even after being removed from the cooking process, this trend exhibits an increase in the knowledge obtained well after the course is completed, based on the self-reported increase in ability to act with the information provided in the course over time. The knowledge simmered, but then is reinforced when the opportunity arose to use it.

B. SUMMARY OF KEY CONCLUSIONS

There is a statistically significant difference between the self-reported *knowledge transfer* in the self-paced and in the instructor-led courses. The surveyed students believe they gained more knowledge from the instructor-led courses. This supports Nissen's assertion (2017) that minimizing *tacit* knowledge inhibits *knowledge transfer*.

There is significant difference among post and follow-up surveys. This finding supports the students' perception that they gained knowledge over the six-month period on the job after the training. The six-month student follow-up surveys showed a significant increase in self-assessed *knowledge transfer*. This seems to indicate that the *knowledge transferred* is not static, and that it increases through the actual execution of the knowledge while on the job. This is a possible indication of *tacit knowledge transfer* from “know-what” to “know-how.”

Clarity, *near-term* and *longer-term relevance* factors explain the preponderance of the Knowledge Friction—nearly 90 percent of the model. The *explicit* factor explains as much as 4 percent, while *certification level* and *experience* explain less than 2 percent as independent variables.

The follow-up survey data explained more than 55 percent of the Knowledge Friction with weighting toward the *relevance* and *clarity* variables.

There is indicated interaction between the independent variables. The independent variables are not completely independent of each other.

Longer-term relevance positively correlates to higher levels of *certification* and *experience*. *Longer-term relevance* increases by as much as 10 percent in the higher *certified* and *experienced* students. *Near-term relevance* remains virtually unchanged.

The survey answers exhibit a high level of reliability and consistency across the surveyed population; those surveyed answered similarly. There is also reliability across the survey question answers; the surveyed are not randomly answering the questions.

The *explicit* factor results in an increase of 4 percent in the explanative power of *knowledge transfer* and the associated amount of Knowledge Friction each factor imposes on that transfer.

The *explicit* factor does not greatly impact the other Knowledge Friction factors which implies that while it is interactive with the new independent factors, it is a stand-alone independent factor as well.

The new factors interact with the *explicit* factor, but are not sub-sets of the *explicit* factor—they are additional Knowledge Friction factors.

The six Knowledge Friction factors split into positive and negative factors in the regression model. The positive factors are *clarity*, *longer-term relevance* and *experience*. The negative factors are *near-term relevance*, *explicit*, and *certification*. As each positive factor increases knowledge transfer increases; conversely, as each of the negative factors increases knowledge transfer decreases.

C. CONTRIBUTIONS TO KNOWLEDGE AND THEORY

This dissertation adds to the body of knowledge explaining organizational Knowledge Flow Theory. Specifically, through quantitative analysis, the research successfully conceptualizes and demonstrates empirical interrelations between four factors that significantly contribute to Knowledge Friction and inhibit *knowledge transfer*. This dissertation extends Knowledge Flow Theory through richer conceptualization and quantitative interrelations between causal variables. It also establishes both a starting point and an approach to guide future research along these lines.

This research does not claim to measure knowledge throughput in the narrowest sense. This would have been best accomplished by measuring the variance in the scores of students at the completion of the course against the independent variables. The DAU could not provide test score data aligned to the surveys. This research does not empirically capture how much was learned; it is not known how well the students--individually or collectively--performed in the courses because there is no final independent assessment (a final exam score). The data does provide the students' self-assessment of how much they believed they learned. Though a student may have performed poorly yet perceived his or her learning as more substantial than another student this performance-perception should be minimized over the large sample. Additionally, the six-month follow-up and the managers' assessment of displayed knowledge, further support the students' reported knowledge gain.

The research models assess how much variation in the dependent variable is accounted for through linear regression and along the direct and indirect paths between the

independent variables and dependent variable. Sticking with the statistics, the aggregation of all direct and indirect paths through the model, associates the average amount of Knowledge Friction associated with the DAU courses through the additional Knowledge Friction factors. The self-reported survey Likert scoring on: “I learned new knowledge/skills from this training.” The factors *clarity*, *near* and *longer-term relevance*, and to a far lesser degree *certification* and *experience*, are extensions on *explicitness* and *tacitness* viewed through the perspective of the knowledge receiver; these factors are what inhibit (or allow) the receiver (student) to experience *knowledge transfer*. Further the research identifies that the independent factors are likely impacting each other; they are interactive. Specifically, while *certification/education* and *experience* exhibit little direct effect on the dependent variable, they derivatively impact through their interaction with the *longer-term relevance* factor.

These factors are an extension of the Knowledge Flow Theory. They expand and explain the Knowledge Friction factors that bundle as explicit Knowledge Friction in the analysis. They likely also impact tacit knowledge transfer as well, but the DAU data did not provide a clear path to explicitly analyze in this research as depicted in Figure 24.

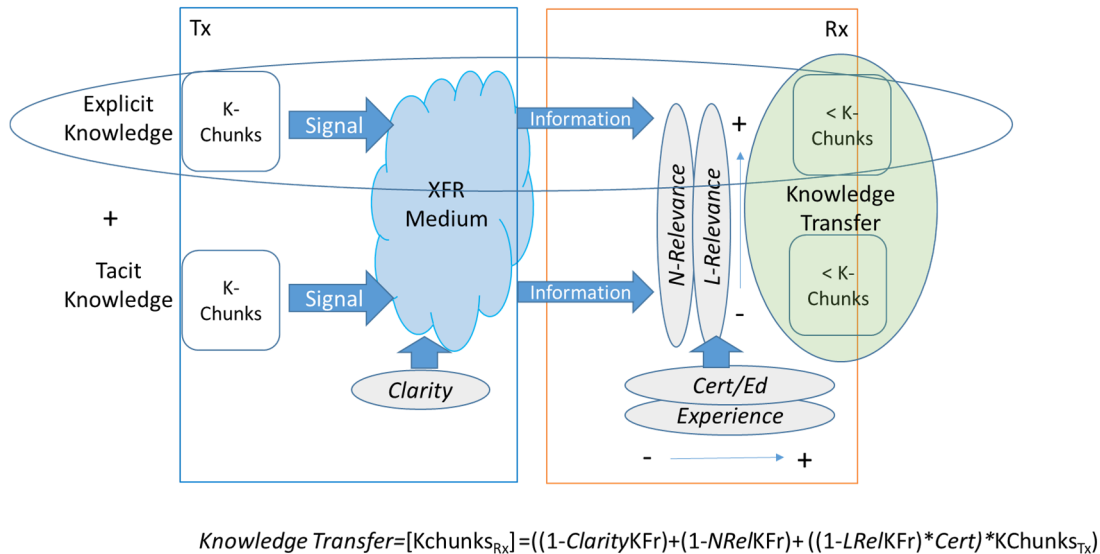


Figure 24. Knowledge Friction Factors Extant to Knowledge Flow Theory Model

The equation:

$$KT = 1.0861 \text{experience} - 0.0116 \text{certification} - 0.2909 \text{explicit} \\ + 0.4018 \text{clarity} - 0.1558 \text{near relevance} + 0.4847 \text{longer relevance}$$

explains over 58 percent of the impedance of *knowledge transfer* by the six Knowledge Friction factors. It extends KFT by adding five additional Knowledge Friction factors to the existing *explicit* Knowledge Friction factor. While this equation is not an exhaustive explanation, it does show that KFT can be further explored quantitatively, and depicts a more complicated interaction between the factors of Knowledge Friction and the resulting *knowledge transfer*. Specifically, the equation and model show an inverse correlation between increase knowledge transfer and *near-term relevance*, *explicitness*, and *certification/education*. Increases in these factors decreases the *knowledge transferred*.

Finally, the dissertation supports quantifiable metrics that can be further tested in various organizations and environments thereby leading to generalization of results.

D. LIMITATIONS OF THE STUDY

There are limitations to this research both theoretically and operationally. The dissertation is focused on extending the Knowledge Flow Theory. Consequently, while it references several other theories in the literature review and methodology section, the constructs, propositions, logic, and boundaries are framed in Knowledge Flow Theory.

The models developed and used are analogies; they are explanative, but by no means exhaustive. They impose a constructive limit because they are focused on explaining through simplifying the complexity of the problem being addressed. In doing so, they also limit the focus, which may omit other considerations against the problem. The propositions posed by the models' alignment and flow of information from one point to another, while developed, are not exhaustive. Specifically, all propositions are expressed as one-way vectors, in the attempt to capture the primary direction of the process. The feedback, while depicted in model cartoons, is not considered in the mathematical expression of the model logic.

While the survey data provided by the DAU is extensive, much of it is not usable in the study. The usable data set is still very large, so sample curriculums are statistically studied. The dissertation does show that the larger population does compare well with the selected sample, but a trade is accepted to offset macro-numerosity concerns.

The population studied presents limitations from considering the findings in this dissertation generalizable to all students or all workforces. The DAU student population is homogeneous. It is comprised of a largely male, highly and specifically educated, middle-aged workforce focused on defense acquisition. The same factors might not explain a liberal arts student population or a labor-intensive worker population in the same way.

What this dissertation does exhibit is explanatory power, simplicity of narrative, testability and falsifiability, operationalizability and logical consistency. The explanatory power of dissertation lies in using the descriptive statistics and the R-squared in the different regression treatments provides a means to measure the predictive and explanatory power; it provides support for the theory. All things equal the simplest solution is usually the preferred one. This dissertation explains Knowledge Friction through four factors portrayed through one-way interactions between the independent variables and the on the dependent variable. While the narrative is not completely linear, it is not exceedingly complex.

As noted by Karl Popper (1963), to be considered science, research must be testable and falsifiable. This research is done using quantitative tools from an established data set of a population. While the individual surveys might not be completely repeatable, the DAU population is repeatable. They train about 100,000 students per year, so the survey questions would likely result in very similar statistics. The research is based on regression analysis, so falsifiability is empirically evaluated through statistical significance (p-value) and the coefficient of determination (R-squared). They statistically assess the likelihood of the causation and the model's explanative value of the phenomena. The model effectively operationalizes Knowledge Friction by measuring self-reported *knowledge transfer* on a Likert scale and comparing it with responses from the participants on questions measuring *clarity* of the information provided, in terms of *near-term* and *longer-term relevance*, as

well as the respondent's level of DAWIA *certification*, which includes their level of *experience*.

The model, while simplified, captures the primary direction of Knowledge Flow; the information must achieve a minimum level of *clarity* (comprehensibility) before the students determine its *relevance* (*near-term*: important for keeping job; *longer-term*: could help further standing in career, profession, or job). They then focus on achieving requirements for *certification* and requisite *experience*. There is an internally consistent logic, bounded by the limits of DOD Acquisition Community education process.

E. FUTURE RESEARCH

This dissertation expanded the explanation of Knowledge Friction in Knowledge Flow Theory by adding five factors: *Clarity*, *near-term relevance*, *longer-term relevance*, *certification* and *experience*. The research also expands the understanding of the existing *explicit* Knowledge Friction factor, and its impact on *knowledge transfer* and interaction with the new factors. Variations in these factors are shown to inhibit the transfer of knowledge in measurable ways. While noteworthy, the dissertation is not exhaustive in identifying possible factors to Knowledge Friction. As noted, the *tacit to explicit* factor is shown to be a contributor, as conjectured in much on Nissen's theoretical work, but this study is limited to a bootstrapped dataset due to the structure of the DAU surveys and the data they provided. More work is justified in exploring the true impact of the *tacit to explicit* Knowledge Friction continuum on *knowledge transfer*.

The preponderance of this dissertation is focused on the explicit knowledge transferred through self-paced (online distance education courses) student surveys. The self-paced surveys were contrasted against student surveys from instructor-led courses. The research uses the instructor-led course data to imply additional *tacit knowledge transfer* but does not focus nor explore in-depth the impact of these or other Knowledge Friction factors. The impact of these factors on *tacit knowledge transfer* would be a likely next step in the further development of Knowledge Friction and a further extension of KFT.

Again, while the data provided by the DAU is impressive in its volume and scope, there are disconnects across the different survey types. Some data shortfalls are the

traceability of an individual from one type of survey to the next, the minimal demographics, and the absence of final exam scores. The questions not asked imposed limits to this research and the factors it considers. Based on this research, 35 to 45 percent of the Knowledge Friction in the theory is still not defined. Assessing other populations would also contribute to the future of Knowledge Flow Theory, its operationalization, and its generalization.

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APPENDIX A. ETHICAL CONSIDERATIONS

Per email sent from Rikki Nguyen, Deputy Director, Research and Sponsored Programs Office, on 23 DEC 2020, the need for Institutional Review Board (IRB) approval was determined not required; the data was collected in the course of the DAU's normal education process and has no information defining individual students or managers. The perceived physical risk to participants is minimal. Precautions were taken by DAU to ensure students' and their managers' survey responses are not associated with their identity. The data sets received and used in this research had no survey participant names, and no reasonable means to connect survey responses to individuals, so that experiment data are rendered non-attributable.

A-1 IRB FINDING PROVIDED

From: [Nguyen, Rikki](#) (CIV)
Sent: Wednesday, December 23, 2020 5:02 PM
To: [Nissen, Mark \(CIV\)](#); [Shigley, Paul R CIV USN NIWC PACIFIC CA \(USA\)](#); [Shigley, Paul \(CIV\)](#)
Cc: [Ramos, Scott](#) (CIV)
Subject: IRB Determination NPS.2021.0042-DD-N

Good Afternoon,

The IRB Chair has reviewed the dataset received for Paul Shigley's PhD dissertation and does not believe identity of individuals can be readily ascertained by the researchers therefore the work does not involve the use of human subjects. To avoid potential non-compliance please submit all work involving the collection of information about people to the IRB for review before accessing.

Happy Holidays,

Rikki A. Nguyen

*Deputy Director, Research and Sponsored Programs Office
Office of the Dean of Research
Naval Postgraduate School
699 Dyer Road, HA 222
Monterey, CA 93943
Phone: (831) 656-2998*

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APPENDIX B. RESEARCH QUESTION STATISTICAL ANALYSIS

OVERVIEW

The statistical analysis for Appendices B through E are achieved through the Real Options Valuation's Risk Simulator 2021 software application (ROV/RS) tools (Mun, 2021).

Appendix B has five sections detailing the research analysis of the following areas:

Normality of data.....	B-1
Reliability of data	B-1
Truncated student surveys experience level by course and course level.....	B-6
Distributional fitting	B-9
Dependent variable means and standard deviations	B-9

B-1 NORMALITY OF DATA

Null hypothesis: The data are normally distributed, see Table 37.

Table 37. Normality of data: Lilliefors Test Results.

Measurements	Results
Average	6.032076
Stdev	0.458348
D Statistic	0.040852
D Critical at 1%	0.047353
D Critical at 5%	0.050941
D Critical at 10%	0.060647

- The data are statistically normal at the 1%, 5% and 10% significance level
- (null hypothesis tested is that the data are normally distributed)

B-2 RELIABILITY OF DATA

Inter Class Correlation for Inter-rater Reliability Test

Model Inputs: VAR1; VAR3; VAR5; VAR7

	DF	Sums of Squares	Mean Square	F-Stat	p-Value
Rows	16141	4501.85	0.28	12.95516	0.00000
Columns	3	38.93	12.98	602.77198	0.00000
Error	48423	1042.48	0.02		
Total	64567	5583.26			

Interclass Correlation 0.74236

- A high ICC indicates a high level of reliability vs. low correlations mean low reliability and low consistency.
- The null hypothesis indicates that there is zero statistical reliability among the four follow-up survey questions requiring percentage responses.

Conclusion: There is statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the follow-up survey, the responses as a whole exhibited statistical reliability. We can conclude that the responses to the follow-up survey are valid and trustworthy, rather than being completed haphazardly.

Inter Class Correlation for Inter-rater Reliability Test

Model Inputs: VAR2; VAR4; VAR6

	DF	Sums of Squares	Mean Square	F-Stat	p-Value
Rows	16141	3729.17	0.23	17.11696	0.00000
Columns	2	23.24	11.62	860.85623	0.00000
Error	32282	435.73	0.01		
Total	48425	4188.14			

Interclass Correlation **0.83608**

- A high ICC indicates a high level of reliability vs. low correlations mean low reliability and low consistency.
- The null hypothesis indicates that there is zero statistical reliability among the three survey questions requiring percentage responses that were asked immediately after the conclusion of the course.

Conclusion: There is statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the end-of-course survey, the responses as a whole exhibited statistical reliability. We can conclude that the responses to the follow-up survey are valid and trustworthy, rather than being completed haphazardly.

Inter Class Correlation for Inter-rater Reliability Test

Model Inputs: VAR8; VAR9

	DF	Sums of Squares	Mean Square	F-Stat	p-Value
Rows	16141	32933.22	2.04	1.04379	0.00324
Columns	1	249.48	249.48	127.62848	0.00000
Error	16141	31551.52	1.95		
Total	32283	64734.22			
Interclass Correlation 0.02126					

- A low ICC indicates a low level of reliability and low correlations mean low reliability and low consistency.
- The null hypothesis indicates that there is zero statistical reliability between the follow-up responses of the quantity of new knowledge learned versus knowledge actually applied.

Conclusion: There is no statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the follow-up survey, the responses as a whole exhibited no reliability with respect to the amount of knowledge learned and retained versus the amount of knowledge actually applied in their jobs.

Guttman's Lambda & Internal Consistency and Reliability Test

Model Inputs: VAR1; VAR3; VAR5; VAR7

Covariance 0.25622
Variance of Total..... 1.11563
Guttman's Lambda..... 0.91866

Split Half Approach

Correlation Coefficient 0.86983
Spearman-Brown Correction 0.93038

Odd-Even Split Approach

Correlation Coefficient 0.84957
Spearman-Brown Correction 0.91867

- High correlations and lambda scores mean high reliability and high consistency.
- The null hypothesis states that there is zero statistical consistency among the four follow-up survey questions requiring percentage responses.

Conclusion: There is statistical consistency among the follow-up survey questions. We can conclude that the survey data are statistically valid and can be trusted.

Guttman's Lambda & Internal Consistency and Reliability Test

Model Inputs: VAR2; VAR4; VAR6

Covariance	0.14515
Variance of Total	0.69311
Guttman's Lambda	0.83769

Split Half Approach

Correlation Coefficient	0.92573
Spearman-Brown Correction	0.96143

Odd-Even Split Approach

Correlation Coefficient	0.87888
Spearman-Brown Correction	0.93553

- High correlations and lambda scores mean high reliability and high consistency.
- The null hypothesis states that there is zero statistical consistency among the three end-of-course survey questions requiring percentage responses.

Conclusion: There is statistical consistency among the end-of-course survey questions.
We can conclude that the survey data are statistically valid and can be trusted.

Guttman's Lambda & Internal Consistency and Reliability Test

Model Inputs: VAR8; VAR9

Covariance 0.04280
Variance of Total 4.08069
Guttman's Lambda 0.04195

Split Half Approach

Correlation Coefficient 0.02144
Spearman-Brown Correction 0.04198

Odd-Even Split Approach

Correlation Coefficient 0.02144
Spearman-Brown Correction 0.04198

- Low correlations and lambda scores mean low reliability and low consistency.
- The null hypothesis indicates that there is zero statistical reliability between the follow-up responses of the quantity of new knowledge learned versus knowledge actually applied.

Conclusion: There is no statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the follow-up survey, the responses as a whole exhibited no reliability with respect to the amount of knowledge learned and retained versus the amount of knowledge actually applied in their jobs.

B-3 TRUNCATED STUDENT SURVEYS EXPERIENCE LEVEL BY COURSE AND COURSE LEVEL

Table 38. Student Survey Level by Course and Course Level.

Form Type	Post Event								
Count of Course			[How many years of experience do you have in your primary career field?]3						
Course Level	Course	Course Num	Less than 1	1-2	3-5	6-10	11-15	More than 15	Grand Total
100	ACQ	101	2398	1362	1004	1120	832	1941	8657
		120	47	58	71	134	76	163	549
		130	17	34	38	92	60	106	347
		160	16	17	26	60	55	106	280
		165	14	21	36	54	41	96	262
	BCF	103	86	77	79	121	55	65	483
		106	7	6	6	9	3	14	45
		110	81	98	122	130	80	118	629
		130	127	86	88	109	65	97	572
	CMA	100	4	9	8	19	19	42	101
	CMC	100	38	53	71	86	34	44	326
		130	16	43	86	77	31	45	298
		150	1	1	6	7	3	5	23
	CMI	100	7	32	55	55	26	71	246

Form Type	Post Event								
Count of Course			[How many years of experience do you have in your primary career field?]						
Course Level	Course	Course Num	Less than 1	1-2	3-5	6-10	11-15	More than 15	Grand Total
		103	2		3	13	7	23	48
		140	2	8	10	9	8	14	51
	CMQ	100	51	52	78	109	67	185	542
		131	20	23	34	34	27	64	202
		140	15	80	24	21	9	29	178
		142	23	10	18	16	18	20	105
	CON	100	807	247	182	262	154	263	1915
		121	831	543	321	424	259	369	2747
		124	746	574	318	337	204	317	2496
		127	624	574	279	332	181	270	2260
	ENG	101	1195	771	640	793	515	1040	4954
	EVM	101	214	349	302	309	213	339	1726
	ISA	101	130	324	314	413	320	593	2094
	LOG	100	297	207	208	209	180	359	1460
		101	20	24	21	21	16	37	139
		102	200	185	175	175	124	306	1165
		103	304	522	340	376	256	530	2328

Form Type	Post Event								
Count of Course			[How many years of experience do you have in your primary career field?]3						
Course Level	Course	Course Num	Less than 1	1-2	3-5	6-10	11-15	More than 15	Grand Total
	PQM	101	194	132	127	139	114	206	912
	RQM	110	82	43	60	75	63	167	490
	SBP	101	15	20	31	64	23	62	215
		110	4	4	9	33	11	24	85
		120	2	11	14	33	8	19	87
	STM	101	71	83	75	90	67	163	549
	TST	102	170	167	101	111	87	135	771
200	ACQ	202	608	1096	858	973	471	861	4867
		255	2	11	19	33	28	43	136
	BCF	220	29	98	56	65	36	55	339
	CME	201	1	7	14	18	14	27	81
		203	1	2	5	8	2	7	25
	CMI	207	10	24	57	52	32	73	248
	CMQ	200	20	13	23	32	17	44	149
		201	1		5	4	3	8	21
		206	4	30	105	93	44	98	374

Form Type	Post Event								
Count of Course			[How many years of experience do you have in your primary career field?]3						
Course Level	Course	Course Num	Less than 1	1-2	3-5	6-10	11-15	More than 15	Grand Total
		210	20	13	11	10	13	22	89
		215	1	4	6	17	1	10	39
		216		2	10	15	7	7	41
		220	32	25	14	18	17	27	133
		230	15	18	18	22	11	21	105
		232	4	5	8	4	2	12	35
	CON	200	207	691	274	164	65	102	1503
		216	152	738	260	136	66	97	1449
		237	314	344	414	444	310	588	2414
	ENG	201	44	296	238	171	87	172	1008
	FE2	201	73	154	118	207	154	460	1166
	ISA	220	10	14	28	32	30	104	218
	LOG	200	45	237	119	106	75	144	726
		204	43	112	93	107	66	138	559
		206	10	200	128	93	67	138	636
		215	13	37	27	31	23	63	194
		235	64	187	127	117	109	158	762

Form Type	Post Event								
	PMT	251	1	14	14	21	12	15	77
		252	25	93	85	94	70	71	438
	PQM	201	52	153	67	62	31	81	446
	SBP	201	1	9	4	15	3	15	47
		220		4	5	14	7	10	40
	SYS	202	22	162	96	68	38	102	488
300	PMT	355	7	59	87	96	57	53	359
Grand Total			10709	11702	8773	9813	6279	12273	59549

B-4 DISTRIBUTIONAL FITTING

- 1. Tests of Normality
- 2. Tests of Homoscedasticity

B-5 DEPENDANT VARIABLE MEANS AND STANDARD DEVIATIONS

B-5.1 Survey Topics

Table 39. Managers’ Survey Focus

Scope	Employee Focused Objective Measured
A: Average	Was able to successfully apply the knowledge/skills learned in this class to his/her job.
B: Average	
C: Average	
D: StdDev	
E: Average	
F: StdDev	
G: Total Average	
H: Total Average	

- The Scope was measured against the employee focused objective and given a comparative value.

Table 40. What Percent of New Knowledge and Skills Learned from this Training do You Estimate you will directly Apply to your Job?

Course	100			200			300			Total Count of Course	Total Average of VAR 4	Total StdDev of VAR 4_2
	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2		Total Average of VAR 4	Total StdDev of VAR 4_2
CMC	600	0.57	0.33							600	0.57	0.33
CMA	93	0.55	0.32							93	0.55	0.32
SBP	684	0.61	0.32	166	0.66	0.31				850	0.62	0.32
CME				100	0.51	0.32				100	0.51	0.32
CMI	314	0.51	0.32	235	0.49	0.32				549	0.50	0.32
CMQ	952	0.55	0.31	902	0.53	0.31				1854	0.54	0.31
EVM	1559	0.43	0.30							1559	0.43	0.30
CON	8515	0.61	0.29	4878	0.57	0.30				13393	0.60	0.30
TST	1438	0.51	0.30							1438	0.51	0.30
ISA	1941	0.45	0.29	201	0.60	0.30				2142	0.46	0.29
SYS				872	0.44	0.29				872	0.44	0.29
ACQ	9292	0.49	0.29	4608	0.49	0.29				13900	0.49	0.29
LOG	4585	0.47	0.29	4592	0.48	0.29				9177	0.47	0.29
PMT				930	0.50	0.28	642	0.48	0.30	1572	0.49	0.29
BCF	1575	0.50	0.29	303	0.54	0.29				1878	0.51	0.29
FE2	1069	0.45	0.29							1069	0.45	0.29
PQM	1652	0.51	0.28	812	0.50	0.29				2464	0.51	0.28

Table 40. What Percent of New Knowledge and Skills Learned from this Training do You Estimate You will Directly Apply to your Job? (continued)

Course	100			200			300			Total Count of Course	Total Average of VAR 4	Total StdDev of VAR 4_2
	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2		Total Average of VAR 4	Total StdDev of VAR 4_2
ENG	4459	0.48	0.28	915	0.45	0.29				5374	0.48	0.28
RQM	928	0.57	0.28							928	0.57	0.28
STM	1014	0.44	0.28							1014	0.44	0.28
Grand Total	40670	0.52	0.30	19514	0.51	0.30	642	0.48	0.30	60826	0.51	0.30

Table 41. What Percent of your Total Work Time Requires the Knowledge or Skills Presented in this Training?

Course	100			200			300			Total Count of Course	Total Average of VAR 6	Total StdDev of VAR 6_2
	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2		Total Average of VAR 6	Total StdDev of VAR 6_2
CMA	93	0.49	0.32							93	0.49	0.32
CMC	600	0.53	0.32							600	0.53	0.32
SBP	684	0.58	0.32	166	0.61	0.31				850	0.59	0.32
CON	8515	0.57	0.29	4878	0.52	0.30				13393	0.55	0.30
CMQ	952	0.49	0.30	902	0.44	0.30				1854	0.47	0.30
CMI	314	0.44	0.30	235	0.36	0.29				549	0.41	0.30
TST	1438	0.47	0.29							1438	0.47	0.29
ACQ	9292	0.45	0.28	4608	0.46	0.28				13900	0.45	0.28
ISA	1941	0.42	0.28	201	0.49	0.32				2142	0.42	0.28
LOG	4585	0.42	0.28	4592	0.45	0.29				9177	0.43	0.28
RQM	928	0.53	0.28							928	0.53	0.28
SYS				872	0.40	0.28				872	0.40	0.28
BCF	1575	0.45	0.28	303	0.53	0.29				1878	0.46	0.28
PQM	1652	0.47	0.28	812	0.47	0.28				2464	0.47	0.28
EVM	1559	0.37	0.28							1559	0.37	0.28
CME				100	0.41	0.28				100	0.41	0.28

Table 41. What Percent of your Total Work Time Requires the Knowledge or Skills Presented in this Training? (continued)

Course	100			200			300			Total Count of Course	Total Average of VAR 6	Total StdDev of VAR 6_2
	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2		Total Average of VAR 6	Total StdDev of VAR 6_2
FE2	1069	0.45	0.28							1069	0.45	0.28
PMT				930	0.48	0.27	642	0.48	0.28	1572	0.48	0.27
ENG	4459	0.44	0.27	915	0.43	0.28				5374	0.44	0.27
STM	1014	0.39	0.26							1014	0.39	0.26
Grand Total	40670	0.47	0.29	19514	0.47	0.29	642	0.48	0.28	60826	0.47	0.29

Table 42. I Have been Able to Successfully Apply the Knowledge/Skills Learned?

Course	100			200			300			400			Total Count of Course	Total Average of VAR 8	Total StdDev of VAR 8
	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8		Total Average of VAR 8	Total StdDev of VAR 8
FE2	247	4.87	1.60										247	4.87	1.60
GRT				23	5.96	1.58							23	5.96	1.58
ACQ	2178	5.33	1.52	1631	5.33	1.58	137	5.92	1.25	56	5.89	1.11	4002	5.36	1.54
STM	136	5.43	1.33	15	4.67	1.95	7	4.43	2.51				158	5.31	1.48
CMI	109	5.39	1.47	162	5.38	1.49							271	5.38	1.48
LOG	989	5.32	1.45	724	5.49	1.52	68	5.68	1.46	12	6.00	0.74	1793	5.41	1.48
SYS				171	5.13	1.48							171	5.13	1.48
FE3	71	4.99	1.47										71	4.99	1.47
PQM	184	5.39	1.43	195	5.54	1.45	2	5.00	1.41				381	5.46	1.44
ENG	936	5.34	1.42	249	5.25	1.54	79	5.10	1.36				1264	5.30	1.44
PMT				181	5.59	1.37	131	5.56	1.52	8	5.88	1.36	320	5.58	1.43
EVM	336	5.34	1.44	78	5.58	1.38							414	5.38	1.43
BCF	405	5.44	1.38	225	5.56	1.44	18	5.17	2.20				648	5.47	1.43
TST	159	5.45	1.38	30	5.50	1.25	27	5.63	1.60				216	5.48	1.39
CMC	191	5.59	1.46	78	6.35	1.02							269	5.81	1.39
ISA	454	5.34	1.39	118	5.60	1.32	31	5.84	1.24				603	5.42	1.37
FCR	114	5.61	1.37										114	5.61	1.37
RQM	115	5.54	1.39				12	5.75	0.87				127	5.56	1.35
CON	2428	5.79	1.24	1425	5.69	1.42	75	6.21	1.14				3928	5.76	1.31
CMQ	279	5.55	1.27	340	5.84	1.29							619	5.71	1.28
SBP	92	5.88	1.25	29	6.03	1.12							121	5.92	1.22

Table 42. I Have been Able to Successfully Apply the Knowledge/Skills Learned? (continued)

Course	100			200			300			400			Total Count of Course	Total Average of VAR 8	Total StdDev of VAR 8
	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8		Total Average of VAR 8	Total StdDev of VAR 8
SE1	22	5.77	1.19										22	5.77	1.19
AQN	29	5.90	1.14	13	5.54	1.27							42	5.79	1.18
COR				3	6.33	1.15							3	6.33	1.15
CME	13	6.08	1.04	71	5.76	1.16							84	5.81	1.15
FPM	121	5.83	1.09										121	5.83	1.09
TEV	11	5.82	1.08										11	5.82	1.08
FCN	46	6.07	0.95										46	6.07	0.95
CMA	12	5.75	0.87	22	6.41	0.85							34	6.18	0.90
IND	17	6.76	0.44										17	6.76	0.44
BCE	2	7.00	0.00										2	7.00	0.00
Grand Total	9696	5.48	1.41	5783	5.52	1.48	587	5.67	1.44	76	5.91	1.07	16142	5.51	1.44

Table 43. I Have Learned New Knowledge/Skills from this Training.

Course	100			200			300			Total Count of Course	Total Average of VAR 9	Total StdDev of VAR 9_2
	Count of Course	Average of VAR 9	StdDev of VAR 9_2	Count of Course	Average of VAR 9	StdDev of VAR 9_2	Count of Course	Average of VAR 9	StdDev of VAR 9_2			
CMC	600	5.58	1.56							600	5.58	1.56
FE2	1069	5.16	1.56							1069	5.16	1.56
SYS				872	5.04	1.46				872	5.04	1.46
ISA	1941	5.50	1.44	201	6.02	1.23				2142	5.55	1.43
PMT				930	5.44	1.38	642	5.32	1.43	1572	5.39	1.40
ACQ	9292	5.75	1.38	4608	5.53	1.42				13900	5.67	1.40
ENG	4459	5.57	1.37	915	5.24	1.46				5374	5.51	1.40
CMQ	952	5.69	1.35	902	5.65	1.41				1854	5.67	1.38
CMI	314	5.54	1.41	235	5.67	1.31				549	5.59	1.37
LOG	4585	5.64	1.32	4592	5.67	1.37				9177	5.66	1.35
EVM	1559	5.75	1.34							1559	5.75	1.34
STM	1014	5.52	1.33							1014	5.52	1.33
BCF	1575	5.74	1.34	303	5.67	1.24				1878	5.73	1.33
SBP	684	5.85	1.28	166	5.61	1.42				850	5.81	1.31
CMA	93	5.81	1.30							93	5.81	1.30
PQM	1652	5.67	1.26	812	5.53	1.32				2464	5.63	1.28
CON	8515	5.88	1.22	4878	5.76	1.33				13393	5.83	1.26

Table 43. I Have Learned New Knowledge/Skills from this Training (continued)

Course	100			200			300			Total Count of Course	Total Average of VAR 9	Total StdDev of VAR 9_2
	Count of Course	Average of VAR 9	StdDev of VAR 9_2	Count of Course	Average of VAR 9	StdDev of VAR 9_2	Count of Course	Average of VAR 9	StdDev of VAR 9_2			
CME				100	5.60	1.26				100	5.60	1.26
TST	1438	5.77	1.23							1438	5.77	1.23
RQM	928	5.80	1.20							928	5.80	1.20
Grand Total	40670	5.70	1.34	19514	5.60	1.39	642	5.32	1.43	60826	5.67	1.36

Table 44. Survey Questions from the Three Surveys Affinized by Color.

The Follow up questions are related by color to the similar post questions					
(note that the dark orange follow up question relates to two very similar post questions)					
Follow Up Survey Questions		Post Survey Questions		Manager Survey Questions	
Column	Follow up Question	Column	Post Question	Column	Manager Question
T	[On a scale of 0% (not at all) to 100% (extremely critical), how critical was applying the content of the training to your job success? Check only one.]	O	SP[I have learned new knowledge/skills from this training.]	N	[The length of the course was appropriate to cover content.]
AG	[What percent of new knowledge and skills learned from this training did you directly apply to your job? Check only one.]	S	[What percent of your total work time requires the knowledge or skills presented in this training? Please check only one.]	Q	[On a scale of 0% (not at all) to 100% (extremely critical), how critical is applying the content of this training to the employee's job success? Check only one.]
BU	[Would you recommend this course to your colleague?]	W	IL[I learned new knowledge and skills.]	AD	[This training has improved the employee's job performance.]
DB	[After training, my manager and I discussed how I will use the learning on my job.]	X	[How many years of experience do you have in your primary career field?]	AE	[Given all factors, including this training, estimate how much this employee's job performance related to the course subject matter has improved since the training.]
DC	[What percent of your total work time have you spent on tasks that require the knowledge/skills presented in the training? Check only one.]	AB	[When contacted, the help desk was beneficial.]	AF	[This training was a worthwhile investment for my organization.]

Table 44. Survey Questions from the Three Surveys Affinized by Color (continued)

Follow Up Survey Questions		Post Survey Questions		Manager Survey Questions	
Column	Follow up Question	Column	Post Question	Column	Manager Question
DF	[I was able to apply the training to my job within:]	AJ	[The content was divided into small enough units to allow for sufficient learning.]	BJ	[I set expectations with this employee for this learning prior to their attending/participating in training.]
DH	[Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]	AN	[The exercises added value to my learning.]	BK	[This employee has set specific goals for using this training to do his/her job.]
DI	[This training was a worthwhile investment for my employer.]	BD	[I will be able to apply the knowledge and skills learned in this class to my job.]	BL	[What percent of this employee's total work time do you feel he/she spends on tasks that require the knowledge/skills presented in this training? Check only one.]
EM	[I have been able to successfully apply the knowledge/skills learned in this class to my job.]	BE	[The instructor covered course objectives and student requirements for satisfactory completion at the beginning of the course.]	CB	[What percent of new knowledge and skills learned from this training did you observe being applied by the employee to his/her job? Check only one.]
ER	[If you have NOT been able to successfully apply the knowledge and skills, why not? (check all that apply)]	BI	[The examples presented helped me understand the content.]	CC	[This training was a worthwhile investment in the employee's career development.]

Table 44. Survey Questions from the Three Surveys Affinized by Color (continued)

Follow Up Survey Questions		Post Survey Questions		Manager Survey Questions	
Column	Follow up Question	Column	Post Question	Column	Manager Question
EX	[Given all factors, including this training, estimate how much your job performance related to the course subject matter has improved since the training.]	BO	IL[What is your education level?]	CY	[After training, this employee and I discussed how he/she will use the learning on his/her job.]
EY	[This training has improved my job performance.]	BQ	IL[How many years of experience do you have in your primary career field?]	CZ	[I feel this employee has learned new knowledge or skills from this training.]
FT	[I learned new knowledge and skills from this training.]	BV	[What level of DAWIA certification did you have in your primary career field prior to attending this course?]	DH	[Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]
		BW	[Was the self-test and/or feedback from the exams helpful in mastering this course?]	DJ	[The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]

Table 44. Survey Questions from the Three Surveys Affinized by Color (continued)

Follow Up Survey Questions		Post Survey Questions		Manager Survey Questions	
Column	Follow up Question	Column	Post Question	Column	Manager Question
		BY	[Estimate how much you expect your job performance related to the course subject matter to improve in the next 12 months. Include in your estimate any performance improvements due to this training, as well as all other factors like on-the job experience, incentives, and process improvements. (For example, if you feel that you can improve your performance by 20% in the next 12 months based on this training plus all other factors, enter 20% here.)]	EH	[The employee has been able to successfully access and apply DAU online resources to his/her job (Defense Acquisition Portal (DAP), Acquisition Community Connection (ACC), Defense Acquisition Guidebook (DAG), and Continuous Learning Modules (CLM))]
		BZ	[Based on your response to the prior question, how much of the improvement will be a direct result of this training, as opposed to other factors? (For example, if you indicated a 20% performance improvement above, and feel that 70% of it is attributable to this training, enter 70% here. If no other factors will influence your performance over the next 12 months, enter 100% here.)]		
		CA	[What percent of new knowledge and skills learned from this training do you estimate you will directly apply to your job? Check only one.]		

Table 44. Survey Questions from the Three Surveys Affinized by Color (continued)

Follow Up Survey Questions		Post Survey Questions		Manager Survey Questions	
Column	Follow up Question	Column	Post Question	Column	Manager Question
		CF	[Rate your INCREASE in skill level or knowledge of this content before versus after the training. A 0% is no increase and a 100% is a very significant increase.]		
		CJ	[Please identify from one of the three sections below your current Military, GS or ACQ DEMO position grade level. Active duty military personnel:]		
		CW	[I will benefit from what I learned in the course for my career/professional development.]		
		CX	IL[The instructor was knowledgeable about the subject.]		
		DG	SP[What level of DAWIA certification did you have in your primary career field prior to attending this course?]		
		DI	[This training was a worthwhile investment for my employer.]		
		DK	[The material was organized logically.]		
		DP	[I would recommend that my colleagues take this course.]		
		DQ	[Please identify from one of the three sections below your current Military, GS or ACQ DEMO position grade level. GS Personnel:]		

Table 44. Survey Questions from the Three Surveys Affinized by Color (continued)

Column	Follow up Question	Column	Post Question	Column	Manager Question
		EL	[On a scale of 0% (not at all) to 100% (extremely critical), how critical is applying the content of this training to your job success? Check only one.]		
		EN	SP[How many years of experience do you have in your primary career field?]		
		EQ	[During the course, the DAU online resources listed (below) were adequately explained and demonstrated for use on the job. (Defense Acquisition Portal (DAP), Acquisition Community Connection (ACC), Defense Acquisition Guidebook (DAG), and Continuous Learning Modules (CLM)]		
		ES	[What level of DAWIA certification did you have in your primary career field prior to attending this course?]		
		ET	[The scope of the material was appropriate to my needs.]		
		FT	IL[I learned new knowledge and skills from this training.]		
		FV	SP[The graphics and illustrations used were meaningful and within context.]		

Table 45. Descriptive Statistics

A NORMALITY OF DATA

Null hypothesis: The data are normally distributed
Lilliefors Test

Average : 6.032076
Stdev : 0.458348
D Statistic : 0.040852
D Critical at 1% : 0.047353
D Critical at 5% : 0.050941
D Critical at 10% : 0.060647

The data are statistically normal at the 1%, 5% and 10% significance level
(null hypothesis tested is that the data are normally distributed).

B RELIABILITY OF DATA

Inter Class Correlation for Inter-rater Reliability Test

Model Inputs: VAR1; VAR3; VAR5; VAR7

	DF	Sums of Squares	Mean Square	F-Stat	p-Value
Rows	16141	4501.85	0.28	12.95516	0.00000
Columns	3	38.93	12.98	602.77198	0.00000
Error	48423	1042.48	0.02		
Total	64567	5583.26			

Interclass Correlation **0.74236**

A high ICC indicates a high level of reliability vs. low correlations mean low reliability and low consistency.

The null hypothesis indicates that there is zero statistical reliability among the four follow-up survey questions requiring percentage responses.

Conclusion: There is statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the follow-up survey, the responses as a whole exhibited statistical reliability. We can conclude that the responses to the follow-up survey are valid and trustworthy, rather than being completed haphazardly.

Inter Class Correlation for Inter-rater Reliability Test

Model Inputs: VAR2; VAR4; VAR6

	DF	Sums of Squares	Mean Square	F-Stat	p-Value
Rows	16141	3729.17	0.23	17.11696	0.00000
Columns	2	23.24	11.62	860.85623	0.00000
Error	32282	435.73	0.01		
Total	48425	4188.14			

Interclass Correlation **0.83608**

A high ICC indicates a high level of reliability vs. low correlations mean low reliability and low consistency.

The null hypothesis indicates that there is zero statistical reliability among the three survey questions requiring percentage responses that were asked immediately after the conclusion of the course.

Conclusion: There is statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the end-of-course survey, the

responses as a whole exhibited statistical reliability. We can conclude that the responses to the follow-up survey are valid and trustworthy, rather than being completed haphazardly.

Inter Class Correlation for Inter-rater Reliability Test

Model Inputs: VAR8; VAR9

	DF	Sums of Squares	Mean Square	F-Stat	p-Value
Rows	16141	32933.22	2.04	1.04379	0.00324
Columns	1	249.48	249.48	127.62848	0.00000
Error	16141	31551.52	1.95		
Total	32283	64734.22			
Interclass Correlation		0.02126			

A low ICC indicates a low level of reliability and low correlations mean low reliability and low consistency.

The null hypothesis indicates that there is zero statistical reliability between the follow-up responses of the quantity of new knowledge learned versus knowledge actually applied.

Conclusion: There is no statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the follow-up survey, the responses as a whole exhibited no reliability with respect to the amount of knowledge learned and retained versus the amount of knowledge actually applied in their jobs.

Guttman's Lambda & Internal Consistency and Reliability Test

Model Inputs: VAR1; VAR3; VAR5; VAR7

Covariance	0.25622
Variance of Total	1.11563
Guttman's Lambda	0.91866

Split Half Approach

Correlation Coefficient	0.86983
Spearman-Brown Correction	0.93038

Odd-Even Split Approach

Correlation Coefficient	0.84957
Spearman-Brown Correction	0.91867

High correlations and lambda scores mean high reliability and high consistency.

The null hypothesis states that there is zero statistical consistency among the four follow-up survey questions requiring percentage responses.

Conclusion: There is statistical consistency among the follow-up survey questions. We can conclude that the survey data are statistically valid and can be trusted.

Guttman's Lambda & Internal Consistency and Reliability Test

Model Inputs: VAR2; VAR4; VAR6

Covariance	0.14515
Variance of Total	0.69311
Guttman's Lambda	0.83769

Split Half Approach

Correlation Coefficient	0.92573
Spearman-Brown Correction	0.96143

Odd-Even Split Approach

Correlation Coefficient	0.87888
Spearman-Brown Correction	0.93553

High correlations and lambda scores mean high reliability and high consistency.

The null hypothesis states that there is zero statistical consistency among the three end-of-course survey questions requiring percentage responses.

Conclusion: There is statistical consistency among the end-of-course survey questions. We can conclude that the survey data are statistically valid and can be trusted.

Guttman's Lambda & Internal Consistency and Reliability Test

Model Inputs: VAR8; VAR9

Covariance	0.04280
Variance of Total	4.08069
Guttman's Lambda	0.04195

Split Half Approach

Correlation Coefficient	0.02144
Spearman-Brown Correction	0.04198

Odd-Even Split Approach

Correlation Coefficient	0.02144
Spearman-Brown Correction	0.04198

Low correlations and lambda scores mean low reliability and low consistency.

The null hypothesis indicates that there is zero statistical reliability between the follow-up responses of the quantity of new knowledge learned versus knowledge actually applied.

Conclusion: There is no statistical reliability among the percentage responses. This means that for the 16,157 students who responded to the follow-up survey, the responses as a whole exhibited no reliability with respect to the amount of knowledge learned and retained versus the amount of knowledge actually applied in their jobs.

Table 46. Truncated Student Surveys Experience Level by Course and Course Level.

Form Type	Post Event								
Count of Course		[How many years of experience do you have in your primary career field?]							
Course Level	Course	Course Num	Less than 1	1-2	3-5	6-10	11-15	More than 15	Grand Total
100	ACQ	101	2398	1362	1004	1120	832	1941	8657
		120	47	58	71	134	76	163	549
		130	17	34	38	92	60	106	347
		160	16	17	26	60	55	106	280
		165	14	21	36	54	41	96	262
	BCF	103	86	77	79	121	55	65	483
		106	7	6	6	9	3	14	45
		110	81	98	122	130	80	118	629
		130	127	86	88	109	65	97	572
	CMA	100	4	9	8	19	19	42	101
	CMC	100	38	53	71	86	34	44	326
		130	16	43	86	77	31	45	298
		150	1	1	6	7	3	5	23
	CMI	100	7	32	55	55	26	71	246
		103	2		3	13	7	23	48
		140	2	8	10	9	8	14	51
	CMQ	100	51	52	78	109	67	185	542
		131	20	23	34	34	27	64	202
		140	15	80	24	21	9	29	178
		142	23	10	18	16	18	20	105
	CON	100	807	247	182	262	154	263	1915
		121	831	543	321	424	259	369	2747
		124	746	574	318	337	204	317	2496
		127	624	574	279	332	181	270	2260
	ENG	101	1195	771	640	793	515	1040	4954
	EVM	101	214	349	302	309	213	339	1726

200	ISA	101	130	324	314	413	320	593	2094
	LOG	100	297	207	208	209	180	359	1460
		101	20	24	21	21	16	37	139
		102	200	185	175	175	124	306	1165
		103	304	522	340	376	256	530	2328
	PQM	101	194	132	127	139	114	206	912
	RQM	110	82	43	60	75	63	167	490
	SBP	101	15	20	31	64	23	62	215
		110	4	4	9	33	11	24	85
		120	2	11	14	33	8	19	87
	STM	101	71	83	75	90	67	163	549
	TST	102	170	167	101	111	87	135	771
	ACQ	202	608	1096	858	973	471	861	4867
		255	2	11	19	33	28	43	136
	BCF	220	29	98	56	65	36	55	339
	CME	201	1	7	14	18	14	27	81
		203	1	2	5	8	2	7	25
	CMI	207	10	24	57	52	32	73	248
	CMQ	200	20	13	23	32	17	44	149
		201	1		5	4	3	8	21
		206	4	30	105	93	44	98	374
		210	20	13	11	10	13	22	89
		215	1	4	6	17	1	10	39
		216		2	10	15	7	7	41
		220	32	25	14	18	17	27	133
		230	15	18	18	22	11	21	105
		232	4	5	8	4	2	12	35
	CON	200	207	691	274	164	65	102	1503
		216	152	738	260	136	66	97	1449
		237	314	344	414	444	310	588	2414
	ENG	201	44	296	238	171	87	172	1008
	FE2	201	73	154	118	207	154	460	1166
	ISA	220	10	14	28	32	30	104	218
	LOG	200	45	237	119	106	75	144	726

		204	43	112	93	107	66	138	559
		206	10	200	128	93	67	138	636
		215	13	37	27	31	23	63	194
		235	64	187	127	117	109	158	762
	PMT	251	1	14	14	21	12	15	77
		252	25	93	85	94	70	71	438
	PQM	201	52	153	67	62	31	81	446
	SBP	201	1	9	4	15	3	15	47
		220		4	5	14	7	10	40
	SYS	202	22	162	96	68	38	102	488
300	PMT	355	7	59	87	96	57	53	359
Grand Total			10709	11702	8773	9813	6279	12273	59549

C DISTRIBUTIONAL FITTING

1. Tests of Normality
2. Tests of Homoscedasticity

D DEPENDANT VARIABLE MEANS AND STANDARD DEVIATIONS

Managers' Survey

- A: Average of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- B: Average of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- C: Average of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- D: StdDev of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- E: Average of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- F: StdDev of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- G: Total Average of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]
- H: Total Average of [The employee has been able to successfully apply the knowledge/skills learned in this class to his/her job.]

Table 47. Manager’s Survey.

Course Name	090			300 Courses			400 Courses			Count		
	Count	A	B	Count	C	D	Count	E	F		G	H
ACQ451							1	6.00		1	6.00	
CON370				1	6.00					1	6.00	
PMT352A				1	5.00					1	5.00	
RQM310				1	7.00					1	7.00	
BCF301				5	4.80	2.28				5	4.80	2.28
PMT360				9	5.13	1.89				9	5.13	1.89
LOG350				4	4.00	1.73				4	4.00	1.73
ISA320				4	4.75	1.50				4	4.75	1.50
PMT355				19	5.33	1.41				19	5.33	1.41
LOG340				17	5.50	1.24				17	5.50	1.24
CON360				16	5.79	1.19				16	5.79	1.19
CON090	45	5.90	1.07							45	5.90	1.07
TST303				6	6.00	1.00				6	6.00	1.00
ENG301				17	5.65	1.00				17	5.65	1.00
ACQ315				33	5.30	0.95				33	5.30	0.95
ACQ450							5	6.20	0.84	5	6.20	0.84
FE302				17	5.47	0.62				17	5.47	0.62
ACQ370				3	7.00	0.00				3	7.00	0.00
LOG465							3	6.00	0.00	3	6.00	0.00
PQM301				2	6.00	0.00				2	6.00	0.00
Grand Total	45	5.90	1.07	155	5.44	1.21	9	6.11	0.60	209	5.57	1.18

Course Name	Count of Course Name		090		300 Courses		400 Courses		Total Count of Course Name	
	Average of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]		StdDev of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]							
	Count of Course Name		Average of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]		StdDev of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]					
	Count of Course Name		Average of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]		StdDev of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]					
	Count of Course Name		Average of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]		StdDev of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]					
	Total Average of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]									
	Total StdDev of [Based on your response to the prior question, estimate how much of the improvement was a direct result of this training. For example if you feel that half of the improvement was a direct result of the training, enter 50% here.]									
ACQ451			1	0.80			1	0.20		
CON370			1	0.10			1	0.80		
PMT352A			1	1.00			1	0.10		
RQM310			1				1			

ISA320				4	0.48	0.41				4	0.48	0.41
ACQ370				3	0.57	0.40				3	0.57	0.40
PMT360				9	0.41	0.39				9	0.41	0.39
BCF301				5	0.56	0.36				5	0.56	0.36
LOG465							3	0.50	0.35	3	0.50	0.35
LOG350				4	0.23	0.33				4	0.23	0.33
TST303				6	0.57	0.32				6	0.57	0.32
PMT355				19	0.48	0.32				19	0.48	0.32
LOG340				17	0.46	0.29				17	0.46	0.29
PQM301				2	0.40	0.28				2	0.40	0.28
ACQ450							5	0.48	0.27	5	0.48	0.27
FE302				17	0.34	0.27				17	0.34	0.27
ACQ315				33	0.46	0.26				33	0.46	0.26
CON090	45	0.60	0.25							45	0.60	0.25
CON360				16	0.53	0.23				16	0.53	0.23
ENG301				17	0.46	0.20				17	0.46	0.20
Grand Total	45	0.60	0.25	155	0.46	0.29	9	0.46	0.27	209	0.49	0.28

Table 48. What Percent of New Knowledge and Skills Learned from this Training do you estimate you will directly Apply to your Job?

Course	100			200			300			Total Count of Course	Total Average of VAR 4	Total StdDev of VAR 4_2
	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2			
CMC	600	0.57	0.33							600	0.57	0.33
CMA	93	0.55	0.32							93	0.55	0.32
SBP	684	0.61	0.32	166	0.66	0.31				850	0.62	0.32
CME				100	0.51	0.32				100	0.51	0.32
CMI	314	0.51	0.32	235	0.49	0.32				549	0.50	0.32
CMQ	952	0.55	0.31	902	0.53	0.31				1854	0.54	0.31
EVM	1559	0.43	0.30							1559	0.43	0.30
CON	8515	0.61	0.29	4878	0.57	0.30				13393	0.60	0.30
TST	1438	0.51	0.30							1438	0.51	0.30
ISA	1941	0.45	0.29	201	0.60	0.30				2142	0.46	0.29
SYS				872	0.44	0.29				872	0.44	0.29
ACQ	9292	0.49	0.29	4608	0.49	0.29				13900	0.49	0.29
LOG	4585	0.47	0.29	4592	0.48	0.29				9177	0.47	0.29
PMT				930	0.50	0.28	642	0.48	0.30	1572	0.49	0.29
BCF	1575	0.50	0.29	303	0.54	0.29				1878	0.51	0.29
FE2	1069	0.45	0.29							1069	0.45	0.29
PQM	1652	0.51	0.28	812	0.50	0.29				2464	0.51	0.28

Table 48. What Percent of New Knowledge and Skills Learned from this Training do You Estimate You will Directly Apply to your Job? (continued)

Course	100			200			300			Total Count of Course	Total Average of VAR 4	Total StdDev of VAR 4_2
	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2	Count of Course	Average of VAR 4	StdDev of VAR 4_2		Total Average of VAR 4	Total StdDev of VAR 4_2
ENG	4459	0.48	0.28	915	0.45	0.29				5374	0.48	0.28
RQM	928	0.57	0.28							928	0.57	0.28
STM	1014	0.44	0.28							1014	0.44	0.28
Grand Total	40670	0.52	0.30	19514	0.51	0.30	642	0.48	0.30	60826	0.51	0.30

Table 49. What Percent of your Total Work Time Requires the Knowledge or Skills Presented in this Training?

Course	100			200			300			Total Count of Course	Total Average of VAR 6 Total Average of VAR 6	Total StdDev of VAR 6_2 Total StdDev of VAR 6_2
	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2			
CMA	93	0.49	0.32							93	0.49	0.32
CMC	600	0.53	0.32							600	0.53	0.32
SBP	684	0.58	0.32	166	0.61	0.31				850	0.59	0.32
CON	8515	0.57	0.29	4878	0.52	0.30				13393	0.55	0.30
CMQ	952	0.49	0.30	902	0.44	0.30				1854	0.47	0.30
CMI	314	0.44	0.30	235	0.36	0.29				549	0.41	0.30
TST	1438	0.47	0.29							1438	0.47	0.29
ACQ	9292	0.45	0.28	4608	0.46	0.28				13900	0.45	0.28
ISA	1941	0.42	0.28	201	0.49	0.32				2142	0.42	0.28
LOG	4585	0.42	0.28	4592	0.45	0.29				9177	0.43	0.28
RQM	928	0.53	0.28							928	0.53	0.28
SYS				872	0.40	0.28				872	0.40	0.28
BCF	1575	0.45	0.28	303	0.53	0.29				1878	0.46	0.28
PQM	1652	0.47	0.28	812	0.47	0.28				2464	0.47	0.28
EVM	1559	0.37	0.28							1559	0.37	0.28
CME				100	0.41	0.28				100	0.41	0.28

Table 49. What Percent of your Total Work Time Requires the Knowledge or Skills Presented in this Training? (continued)

Course	100			200			300			Total Count of Course	Total Average of VAR 6 Total Average of VAR 6	Total StdDev of VAR 6_2 Total StdDev of VAR 6_2
	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2	Count of Course	Average of VAR 6	StdDev of VAR 6_2			
FE2	1069	0.45	0.28							1069	0.45	0.28
PMT				930	0.48	0.27	642	0.48	0.28	1572	0.48	0.27
ENG	4459	0.44	0.27	915	0.43	0.28				5374	0.44	0.27
STM	1014	0.39	0.26							1014	0.39	0.26
Grand Total	40670	0.47	0.29	19514	0.47	0.29	642	0.48	0.28	60826	0.47	0.29

Table 50. I Have been Able to Successfully Apply the Knowledge/Skills Learned in this Class to my Job.

100									200				300		
	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8					Total Count of Course	Total Average of VAR 8	Total StdDev of VAR 8
Course									400						
									StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8		Total Average of VAR 8	Total StdDev of VAR 8
FE2	247	4.87	1.60												
GRT				23	5.96	1.58							247	4.87	1.60
ACQ	2178	5.33	1.52	1631	5.33	1.58	137	5.92					23	5.96	1.58
STM	136	5.43	1.33	15	4.67	1.95	7	4.43	1.25	56	5.89	1.11	4002	5.36	1.54
CMI	109	5.39	1.47	162	5.38	1.49			2.51				158	5.31	1.48
LOG	989	5.32	1.45	724	5.49	1.52	68	5.68					271	5.38	1.48
SYS				171	5.13	1.48			1.46	12	6.00	0.74	1793	5.41	1.48
FE3	71	4.99	1.47										171	5.13	1.48
PQM	184	5.39	1.43	195	5.54	1.45	2	5.00					71	4.99	1.47
ENG	936	5.34	1.42	249	5.25	1.54	79	5.10	1.41				381	5.46	1.44
PMT				181	5.59	1.37	131	5.56	1.36				1264	5.30	1.44
EVM	336	5.34	1.44	78	5.58	1.38			1.52	8	5.88	1.36	320	5.58	1.43
BCF	405	5.44	1.38	225	5.56	1.44	18	5.17					414	5.38	1.43
TST	159	5.45	1.38	30	5.50	1.25	27	5.63	2.20				648	5.47	1.43
CMC	191	5.59	1.46	78	6.35	1.02			1.60				216	5.48	1.39
ISA	454	5.34	1.39	118	5.60	1.32	31	5.84					269	5.81	1.39
FCR	114	5.61	1.37						1.24				603	5.42	1.37
RQM	115	5.54	1.39				12	5.75					114	5.61	1.37
CON	2428	5.79	1.24	1425	5.69	1.42	75	6.21	0.87				127	5.56	1.35
CMQ	279	5.55	1.27	340	5.84	1.29			1.14				3928	5.76	1.31
SBP	92	5.88	1.25	29	6.03	1.12							619	5.71	1.28

Table 50. I Have been Able to Successfully Apply the Knowledge/Skills Learned in this Class to my Job (continued)

Course	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8	Count of Course	Average of VAR 8	400	Total Count of Course	Total Average of VAR 8	Total StdDev of VAR 8
									StdDev of VAR 8	Count of Course	Average of VAR 8	StdDev of VAR 8
FE2	247	4.87	1.60									
SE1	22	5.77	1.19							121	5.92	1.22
AQN	29	5.90	1.14	13	5.54	1.27				22	5.77	1.19
COR				3	6.33	1.15				42	5.79	1.18
CME	13	6.08	1.04	71	5.76	1.16				3	6.33	1.15
FPM	121	5.83	1.09							84	5.81	1.15
TEV	11	5.82	1.08							121	5.83	1.09
FCN	46	6.07	0.95							11	5.82	1.08
CMA	12	5.75	0.87	22	6.41	0.85				46	6.07	0.95
IND	17	6.76	0.44							34	6.18	0.90
BCE	2	7.00	0.00							17	6.76	0.44
Grand Total	9696	5.48	1.41	5783	5.52	1.48	587	5.67		2	7.00	0.00

Table 51. I Have Learned New Knowledge/Skills from this Training.

Course	100			200			300			Total Count of Course	Total Average of VAR 9	Total StdDev of VAR 9_2
	Count of Course	Average of VAR 9	StdDev of VAR 9_2	Count of Course	Average of VAR 9	StdDev of VAR 9_2	Count of Course	Average of VAR 9	StdDev of VAR 9_2		Total Average of VAR 9	Total StdDev of VAR 9_2
CMC	600	5.58	1.56							600	5.58	1.56
FE2	1069	5.16	1.56							1069	5.16	1.56
SYS				872	5.04	1.46				872	5.04	1.46
ISA	1941	5.50	1.44	201	6.02	1.23				2142	5.55	1.43
PMT				930	5.44	1.38	642	5.32	1.43	1572	5.39	1.40
ACQ	9292	5.75	1.38	4608	5.53	1.42				13900	5.67	1.40
ENG	4459	5.57	1.37	915	5.24	1.46				5374	5.51	1.40
CMQ	952	5.69	1.35	902	5.65	1.41				1854	5.67	1.38
CMI	314	5.54	1.41	235	5.67	1.31				549	5.59	1.37
LOG	4585	5.64	1.32	4592	5.67	1.37				9177	5.66	1.35
EVM	1559	5.75	1.34							1559	5.75	1.34
STM	1014	5.52	1.33							1014	5.52	1.33
BCF	1575	5.74	1.34	303	5.67	1.24				1878	5.73	1.33
SBP	684	5.85	1.28	166	5.61	1.42				850	5.81	1.31
CMA	93	5.81	1.30							93	5.81	1.30

Table 51. I Have Learned New Knowledge/Skills from this Training (continued)

PQM	1652	5.67	1.26	812	5.53	1.32				2464	5.63	1.28
CON	8515	5.88	1.22	4878	5.76	1.33				13393	5.83	1.26
CME				100	5.60	1.26				100	5.60	1.26
TST	1438	5.77	1.23							1438	5.77	1.23
RQM	928	5.80	1.20							928	5.80	1.20
Grand Total	40670	5.70	1.34	19514	5.60	1.39	642	5.32	1.43	60826	5.67	1.36

APPENDIX C. PRINCIPAL COMPONENT ANALYSIS AND FACTOR ANALYSIS

C.1 OVERVIEW

Appendix C contains tables supporting Principal Component Analysis and Factor analysis. The analysis was achieved through the Real Options Valuation's Risk Simulator 2021 software application (ROV/RS) tools (Mun, 2021).

C.2 PCA-FA

Appendix C

Table 52. Principal Component Analysis/ Factor Analysis for ACQ/CON/PMT Self-paced Courses Post-course Surveys

Correlation Matrix

	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8	VAR9	VAR10	VAR11	VAR12	VAR13	VAR14	VAR15
VAR1	1.0000	-0.0733	-0.0735	0.3393	0.7831	0.3992	0.8034	0.7443	0.4347	0.6365	0.5581	0.6839	0.6909	0.6051	0.6894
VAR2	-0.0733	1.0000	0.3866	0.0482	-0.0369	0.0016	-0.0317	0.0076	0.0148	-0.0377	-0.0861	-0.0778	-0.0267	-0.0291	-0.0046
VAR3	-0.0735	0.3866	1.0000	0.0712	-0.0304	0.1320	-0.0270	0.0119	0.0472	-0.0288	-0.0884	-0.0958	-0.0619	-0.0594	-0.0580
VAR4	0.3393	0.0482	0.0712	1.0000	0.4804	0.7650	0.4237	0.4260	0.8869	0.4682	0.2513	0.2901	0.3345	0.3255	0.2939
VAR5	0.7831	-0.0369	-0.0304	0.4804	1.0000	0.5446	0.9432	0.8392	0.5588	0.7785	0.6005	0.6940	0.7225	0.6519	0.7085
VAR6	0.3992	0.0016	0.1320	0.7650	0.5446	1.0000	0.5024	0.5157	0.7759	0.4625	0.3251	0.3910	0.4300	0.4185	0.3830
VAR7	0.8034	-0.0317	-0.0270	0.4237	0.9432	0.5024	1.0000	0.8514	0.5162	0.7506	0.6300	0.7056	0.7369	0.6673	0.6988
VAR8	0.7443	0.0076	0.0119	0.4260	0.8392	0.5157	0.8514	1.0000	0.4871	0.6823	0.5382	0.6661	0.6938	0.6043	0.6643
VAR9	0.4347	0.0148	0.0472	0.8869	0.5588	0.7759	0.5162	0.4871	1.0000	0.5064	0.2955	0.3399	0.3793	0.3405	0.3306
VAR10	0.6365	-0.0377	-0.0288	0.4682	0.7785	0.4625	0.7506	0.6823	0.5064	1.0000	0.5534	0.6336	0.6910	0.6584	0.6408
VAR11	0.5581	-0.0861	-0.0884	0.2513	0.6005	0.3251	0.6300	0.5382	0.2955	0.5534	1.0000	0.7021	0.6887	0.7401	0.7375
VAR12	0.6839	-0.0778	-0.0958	0.2901	0.6940	0.3910	0.7056	0.6661	0.3399	0.6336	0.7021	1.0000	0.8959	0.8154	0.7988
VAR13	0.6909	-0.0267	-0.0619	0.3345	0.7225	0.4300	0.7369	0.6938	0.3793	0.6910	0.6887	0.8959	1.0000	0.8895	0.8050
VAR14	0.6051	-0.0291	-0.0594	0.3255	0.6519	0.4185	0.6673	0.6043	0.3405	0.6584	0.7401	0.8154	0.8895	1.0000	0.7745
VAR15	0.6894	-0.0046	-0.0580	0.2939	0.7085	0.3830	0.6988	0.6643	0.3306	0.6408	0.7375	0.7988	0.8050	0.7745	1.0000

Eigenvalues and Eigenvectors

Eigenvalue	8.3084	1.9559	1.3198	0.7812	0.6216	0.3836	0.3750	0.2849	0.2217	0.2028	0.1655	0.1575	0.1014	0.0712	0.0494
Proportion	0.5539	0.1304	0.0880	0.0521	0.0414	0.0256	0.0250	0.0190	0.0033	0.0047	0.0068	0.0148	0.0135	0.0105	0.0110
Cum Proportion	0.5539	0.6843	0.7723	0.8244	0.8658	0.8914	0.9164	0.9354	0.9387	0.9434	0.9502	0.9650	0.9785	0.9890	1.0000

Eigenvectors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
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VAR1	-0.2855	-0.0843	0.0085	-0.3559	-0.0013	-0.3597	-0.0460	-0.6119	-0.0105	0.4478	0.2565	-0.0452	-0.0887	0.0005	0.0478
VAR2	0.0146	0.2023	-0.6878	0.0179	-0.6819	-0.0412	0.0385	0.0402	-0.0171	0.0963	-0.0136	-0.0754	-0.0054	0.0132	0.0085
VAR3	0.0138	0.2844	-0.6317	-0.0144	0.7016	0.0473	0.0152	-0.1334	-0.0438	-0.0678	-0.0166	0.0182	0.0039	0.0063	0.0083
VAR4	-0.1961	0.5108	0.1861	0.2019	-0.1098	0.0639	0.0386	-0.2254	-0.0826	-0.3014	0.1291	0.1682	-0.6287	-0.1218	-0.0642
VAR5	-0.3152	0.0230	0.0079	-0.3450	-0.0060	0.0583	0.1012	0.1592	-0.0449	-0.0090	-0.4743	0.1834	-0.1497	0.0368	0.6764
VAR6	-0.2201	0.4313	0.1218	0.2014	0.1251	-0.2515	-0.1330	0.4604	0.3189	0.5109	-0.0239	-0.1874	-0.0328	-0.0378	-0.0249
VAR7	-0.3139	-0.0190	-0.0192	-0.3616	0.0063	-0.0167	0.1256	0.1747	-0.2245	0.0383	-0.3667	0.1684	-0.0357	-0.0403	-0.7111
VAR8	-0.2955	0.0180	-0.0518	-0.3777	0.0065	-0.1708	-0.0782	0.4018	-0.0076	-0.4219	0.6102	-0.0534	0.0988	0.0644	0.0561
VAR9	-0.2166	0.4823	0.2046	0.0907	-0.0902	-0.0253	0.0763	-0.2653	-0.1609	-0.1159	-0.0280	0.6984	0.1527	0.0373	
VAR10	-0.2858	0.0153	0.0098	-0.1425	-0.0241	0.8343	0.0296	-0.0804	0.2429	0.1683	0.1587	-0.2782	0.0269	0.0124	-0.0538
VAR11	-0.2598	-0.2124	-0.0398	0.3284	0.0689	-0.0946	0.7922	0.0789	-0.1951	0.0573	0.1301	-0.2246	-0.0163	-0.1296	0.0691
VAR12	-0.2953	-0.2117	-0.0539	0.2148	0.0245	-0.1189	-0.3381	-0.0748	-0.1389	-0.2375	-0.2605	-0.6014	-0.1888	0.3770	-0.0358
VAR13	-0.3063	-0.1752	-0.0898	0.2192	-0.0066	0.0401	-0.3939	-0.0087	-0.1892	-0.0329	-0.0231	0.0406	0.1693	-0.7678	0.0726
VAR14	-0.2896	-0.1813	-0.0904	0.3763	0.0112	0.1461	-0.1778	0.0922	-0.2418	0.2412	0.2067	0.5544	0.0236	0.4519	0.0190
VAR15	-0.2917	-0.1914	-0.1124	0.1640	-0.0272	-0.1541	0.0978	-0.1695	0.7701	-0.2847	-0.1347	0.2535	0.0937	0.0149	-0.1020

Unrotated Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.8229	-0.1179	0.0097	-0.3146	-0.0010	-0.2228	-0.0282	-0.3266	-0.0050	0.2016	0.1044	-0.0179	-0.0283	0.0001	0.0106
VAR2	0.0420	0.2830	-0.7901	0.0158	-0.5376	-0.0255	0.0236	0.0215	-0.0081	0.0434	-0.0055	-0.0299	-0.0017	0.0035	0.0019
VAR3	0.0396	0.3977	-0.7257	-0.0127	0.5531	0.0293	0.0093	-0.0712	-0.0206	-0.0305	-0.0067	0.0072	0.0013	0.0017	0.0018
VAR4	-0.5652	0.7144	0.2138	0.1785	-0.0865	0.0396	0.0236	-0.1203	-0.0389	-0.1357	0.0525	0.0668	-0.2002	-0.0325	-0.0143
VAR5	-0.9086	0.0322	0.0091	-0.3049	-0.0048	0.0361	0.0620	0.0850	-0.0212	-0.0040	-0.1929	0.0728	-0.0477	0.0098	0.1503
VAR6	-0.6344	0.6032	0.1400	0.1780	0.0986	-0.1558	-0.0814	0.2458	0.1501	0.2301	-0.0097	-0.0744	-0.0104	-0.0101	-0.0055
VAR7	-0.9047	-0.0265	-0.0221	-0.3196	0.0050	-0.0103	0.0769	0.0933	-0.1057	0.0172	-0.1492	0.0668	-0.0114	-0.0108	-0.1580
VAR8	-0.8516	0.0252	-0.0595	-0.3338	0.0051	-0.1058	-0.0479	0.2145	-0.0036	-0.1900	0.2482	-0.0212	0.0315	0.0172	0.0125
VAR9	-0.6244	0.6745	0.2350	0.0801	-0.0711	-0.0157	0.0468	-0.1416	-0.0854	-0.0724	-0.0471	-0.0111	0.2224	0.0408	0.0083
VAR10	-0.8237	0.0215	0.0113	-0.1260	-0.0190	0.5168	0.0182	-0.0429	0.1144	0.0758	0.0646	-0.1104	0.0086	0.0033	-0.0120
VAR11	-0.7488	-0.2970	-0.0457	0.2902	0.0544	-0.0586	0.4851	0.0421	-0.0919	0.0258	0.0529	-0.0891	-0.0052	-0.0346	0.0154
VAR12	-0.8512	-0.2960	-0.0619	0.1899	0.0193	-0.0737	-0.2070	-0.0399	-0.0654	-0.1069	-0.1060	-0.2387	-0.0601	0.1006	-0.0080
VAR13	-0.8828	-0.2450	-0.1031	0.1937	-0.0052	0.0248	-0.2412	-0.0046	-0.0891	-0.0148	-0.0094	0.0161	0.0539	-0.2049	0.0161
VAR14	-0.8348	-0.2535	-0.1039	0.3326	0.0089	0.0905	-0.1089	0.0492	-0.1139	0.1086	0.0841	0.2200	0.0075	0.1206	0.0042
VAR15	-0.8407	-0.2677	-0.1292	0.1449	-0.0214	-0.0955	0.0599	-0.0905	0.3626	-0.1282	-0.0548	0.1006	0.0298	0.0040	-0.0227

Varimax Rotated Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.4007	0.1820	0.0438	-0.5822	-0.0404	0.1070	0.1147	-0.6548	0.0934	0.0214	0.0304	-0.0177	0.0055	-0.0054	0.0025
VAR2	0.0172	0.0186	-0.9799	0.0100	0.1953	-0.0087	-0.0245	0.0147	0.0037	-0.0051	0.0017	0.0033	-0.0007	0.0002	-0.0003
VAR3	0.0466	0.0540	-0.1973	0.0075	0.9771	-0.0053	-0.0215	0.0140	-0.0063	0.0229	0.0026	0.0028	-0.0004	0.0004	-0.0002
VAR4	-0.1215	0.9505	-0.0319	-0.1461	0.0231	0.0972	0.0392	-0.0273	0.0324	-0.0229	0.0301	0.0049	-0.2112	0.0059	0.0024
VAR5	-0.3813	0.3073	0.0190	-0.8009	-0.0148	0.1934	0.1354	-0.0955	0.0961	0.0550	-0.0953	-0.0150	0.0011	0.0014	0.1779
VAR6	-0.2111	0.7449	0.0211	-0.2306	0.0987	0.0425	0.0563	-0.0301	0.0400	0.5732	0.0328	-0.0055	0.0014	-0.0010	0.0026
VAR7	-0.4008	0.2485	0.0125	-0.8245	-0.0076	0.1496	0.1718	-0.1203	0.0443	0.0432	-0.0848	-0.0023	0.0151	-0.0008	-0.1413
VAR8	-0.3674	0.2508	-0.0174	-0.7606	0.0198	0.1068	0.0914	-0.1011	0.0772	0.0776	0.4248	-0.0203	-0.0033	-0.0072	-0.0037
VAR9	-0.1211	0.9195	-0.0044	-0.2436	0.0077	0.0901	0.0590	-0.0882	0.0184	-0.0044	0.0044	-0.0158	0.2455	-0.0101	-0.0015
VAR10	-0.4098	0.2884	0.0195	-0.4550	-0.0109	0.7173	0.1180	-0.0851	0.0658	0.0238	0.0256	-0.0067	0.0019	-0.0029	0.0028
VAR11	-0.5393	0.1094	0.0486	-0.2744	-0.0403	0.0973	0.7695	-0.0756	0.0969	0.0264	0.0176	-0.0116	0.0024	-0.0023	0.0025
VAR12	-0.8245	0.1308	0.0470	-0.3477	-0.0479	0.0855	0.1469	-0.1258	0.0704	0.0372	0.0399	-0.3534	0.0054	0.0059	0.0028
VAR13	-0.8650	0.1674	0.0014	-0.3614	-0.0247	0.1359	0.0992	-0.1065	0.0414	0.0420	0.0425	0.0302	0.0118	-0.2160	0.0002
VAR14	-0.8703	0.1626	0.0037	-0.2566	-0.0214	0.1489	0.2099	-0.0568	0.0200	0.0639	0.0169	0.1986	-0.0108	0.1898	0.0019
VAR15	-0.6558	0.1224	-0.0208	-0.3693	-0.0255	0.1233	0.2467	-0.1417	0.5639	0.0419	0.0347	-0.0173	-0.0000	-0.0039	0.0045

Sum of Squares	3.7525	2.7411	1.0087	3.1089	1.0112	0.6892	0.8210	0.5358	0.3677	0.3513	0.2056	0.1670	0.1055	0.0829	0.0517
Rank	1	3	5	2	4	7	6	8	9	10	11	12	13	14	15

Varimax Rotated Factor Loadings (Ranked)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.4007	-0.5822	0.1820	-0.0404	0.0438	0.1147	0.1070	-0.6548	0.0934	0.0214	0.0304	-0.0177	0.0055	-0.0054	0.0025
VAR2	0.0172	0.0100	0.0186	0.1953	-0.9799	-0.0245	-0.0087	0.0147	0.0037	-0.0051	0.0017	0.0033	-0.0007	0.0002	-0.0003
VAR3	0.0466	0.0075	0.0540	0.9771	-0.1973	-0.0215	-0.0053	0.0140	-0.0063	0.0229	0.0026	0.0028	-0.0004	0.0004	-0.0002
VAR4	-0.1215	-0.1461	0.9505	0.0231	-0.0319	0.0392	0.0972	-0.0273	0.0324	-0.0229	0.0301	0.0049	-0.2112	0.0059	0.0024
VAR5	-0.3813	-0.8009	0.3073	-0.0148	0.0190	0.1354	0.1934	-0.0955	0.0961	0.0550	-0.0953	-0.0150	0.0011	0.0014	0.1779

VAR6	-0.2111	-0.2306	0.7449	0.0987	0.0211	0.0563	0.0425	-0.0301	0.0400	0.5732	0.0328	-0.0055	0.0014	-0.0010	0.0026
VAR7	-0.4008	-0.8245	0.2485	-0.0076	0.0125	0.1718	0.1496	-0.1203	0.0443	0.0432	-0.0848	-0.0023	0.0151	-0.0008	-0.1413
VAR8	-0.3674	-0.7606	0.2508	0.0198	-0.0174	0.0914	0.1068	-0.1011	0.0772	0.0776	0.4248	-0.0203	-0.0033	-0.0072	-0.0037
VAR9	-0.1211	-0.2436	0.9195	0.0077	-0.0044	0.0590	0.0901	-0.0882	0.0184	-0.0044	0.0044	-0.0158	0.2455	-0.0101	-0.0015
VAR10	-0.4098	-0.4550	0.2884	-0.0109	0.0195	0.1180	0.7173	-0.0851	0.0658	0.0238	0.0256	-0.0067	0.0019	-0.0029	0.0028
VAR11	-0.5393	-0.2744	0.1094	-0.0403	0.0486	0.7695	0.0973	-0.0756	0.0969	0.0264	0.0176	-0.0116	0.0024	-0.0023	0.0025
VAR12	-0.8245	-0.3477	0.1308	-0.0479	0.0470	0.1469	0.0855	-0.1258	0.0704	0.0372	0.0399	-0.3534	0.0054	0.0059	0.0028
VAR13	-0.8650	-0.3614	0.1674	-0.0247	0.0014	0.0992	0.1359	-0.1065	0.0414	0.0420	0.0425	0.0302	0.0118	-0.2160	0.0002
VAR14	-0.8703	-0.2566	0.1626	-0.0214	0.0037	0.2099	0.1489	-0.0568	0.0200	0.0639	0.0169	0.1986	-0.0108	0.1898	0.0019
VAR15	-0.6558	-0.3693	0.1224	-0.0255	-0.0208	0.2467	0.1233	-0.1417	0.5639	0.0419	0.0347	-0.0173	-0.0000	-0.0039	0.0045

Sum of Squares	3.7525	3.1089	2.7411	1.0112	1.0087	0.8210	0.6892	0.5358	0.3677	0.3513	0.2056	0.1670	0.1055	0.0829	0.0517
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Proportion	25.02%	20.73%	18.27%	6.74%	6.72%	5.47%	4.59%	3.57%	2.45%	2.34%	1.37%	1.11%	0.70%	0.55%	0.34%
Cum Proportion	25.02%	45.74%	64.02%	70.76%	77.48%	82.96%	87.55%	91.12%	93.57%	95.92%	97.29%	98.40%	99.10%	99.66%	100.00%

Factor Score Coefficients

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	0.1205	0.1451	-0.0519	0.0129	-0.0220	-0.0030	-0.0113	-1.7805	-0.2001	0.0917	0.0013	0.1517	-0.2068	0.0921	0.1576
VAR2	0.0075	0.0042	-0.0218	-0.2149	-1.0678	0.0634	0.0289	-0.0658	-0.0912	0.1055	-0.0497	-0.0975	0.0321	0.0247	0.0351
VAR3	-0.0436	0.0060	-0.0239	1.0752	0.2128	0.0193	-0.0031	-0.0393	0.0116	-0.1785	-0.0372	-0.0289	0.0220	0.0084	0.0357
VAR4	0.0040	0.1088	0.6006	-0.0155	0.0163	0.0005	-0.1429	0.0103	0.0328	-0.7182	-0.0123	-0.0330	-2.1042	-0.0808	-0.1735
VAR5	0.1085	-0.6528	-0.0521	-0.0015	0.0016	-0.0563	-0.2466	0.4077	-0.0769	-0.0713	-0.8161	0.0512	-0.1044	0.0500	3.1651
VAR6	0.0817	0.1158	0.0549	-0.0504	-0.0178	0.0199	0.0313	-0.0737	-0.0039	1.7573	-0.1092	-0.0695	-0.0671	-0.1013	-0.0934
VAR7	0.1258	-0.7915	-0.0619	-0.0026	0.0030	-0.0583	-0.2800	0.4789	-0.0544	-0.0589	-1.0790	0.0358	-0.1932	0.0918	-3.1085
VAR8	0.1386	-0.3931	-0.0643	-0.0079	0.0058	-0.0157	-0.1663	0.2922	-0.0762	-0.0998	1.9639	0.0916	0.0713	0.1671	0.1167
VAR9	-0.0001	0.1304	0.5218	-0.0129	0.0121	-0.0053	-0.1168	0.0188	0.0471	-0.6274	0.0887	0.0222	2.2899	0.1354	0.0268
VAR10	0.1607	0.2293	-0.1020	-0.0007	-0.0134	-0.0117	1.6605	-0.0504	-0.0370	0.1530	0.1496	-0.2010	0.0518	-0.0154	-0.2335
VAR11	0.2146	0.1398	-0.0188	0.0147	-0.0326	1.5412	-0.0147	-0.0330	-0.3524	0.0195	0.1609	-0.0594	-0.0594	-0.4386	0.2212
VAR12	-0.4275	0.1283	-0.0034	0.0176	-0.0032	-0.2163	-0.0969	0.0911	-0.3243	-0.0639	-0.0647	-2.1729	-0.0305	0.8947	-0.0418
VAR13	-0.5687	0.1397	-0.0016	0.0177	0.0055	-0.2642	-0.1454	0.0932	-0.3826	-0.0805	-0.0471	0.8723	-0.0172	-2.8256	0.1245
VAR14	-0.6202	0.1569	0.0020	0.0173	0.0063	-0.2799	-0.1462	0.0653	-0.3964	-0.0905	0.0321	1.0698	0.1673	2.0396	0.1136
VAR15	-0.0123	0.1018	-0.0088	0.0112	0.0187	-0.1917	-0.0651	0.1428	1.9793	-0.0544	-0.0747	0.1603	0.1119	0.0543	-0.3400

Factor Analysis

Correlation Matrix

	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8	VAR9	VAR10	VAR11	VAR12	VAR13	VAR14	VAR15
VAR1	1.0000	-0.0733	-0.0735	0.3393	0.7831	0.3992	0.8034	0.7443	0.4347	0.6365	0.5581	0.6839	0.6909	0.6051	0.6894
VAR2	-0.0733	1.0000	0.3866	0.0482	-0.0369	0.0016	-0.0317	0.0076	0.0148	-0.0377	-0.0861	-0.0778	-0.0267	-0.0291	-0.0046
VAR3	-0.0735	0.3866	1.0000	0.0712	-0.0304	0.1320	-0.0270	0.0119	0.0472	-0.0288	-0.0884	-0.0958	-0.0619	-0.0594	-0.0580
VAR4	0.3393	0.0482	0.0712	1.0000	0.4804	0.7650	0.4237	0.4260	0.8869	0.4682	0.2513	0.2901	0.3345	0.3255	0.2939
VAR5	0.7831	-0.0369	-0.0304	0.4804	1.0000	0.5446	0.9432	0.8392	0.5588	0.7785	0.6005	0.6940	0.7225	0.6519	0.7085
VAR6	0.3992	0.0016	0.1320	0.7650	0.5446	1.0000	0.5024	0.5157	0.7759	0.4625	0.3251	0.3910	0.4300	0.4185	0.3830
VAR7	0.8034	-0.0317	-0.0270	0.4237	0.9432	0.5024	1.0000	0.8514	0.5162	0.7506	0.6300	0.7056	0.7369	0.6673	0.6988
VAR8	0.7443	0.0076	0.0119	0.4260	0.8392	0.5157	0.8514	1.0000	0.4871	0.6823	0.5382	0.6661	0.6938	0.6043	0.6643
VAR9	0.4347	0.0148	0.0472	0.8869	0.5588	0.7759	0.5162	0.4871	1.0000	0.5064	0.2955	0.3399	0.3793	0.3405	0.3306
VAR10	0.6365	-0.0377	-0.0288	0.4682	0.7785	0.4625	0.7506	0.6823	0.5064	1.0000	0.5534	0.6336	0.6910	0.6584	0.6408
VAR11	0.5581	-0.0861	-0.0884	0.2513	0.6005	0.3251	0.6300	0.5382	0.2955	0.5534	1.0000	0.7021	0.6887	0.7401	0.7375
VAR12	0.6839	-0.0778	-0.0958	0.2901	0.6940	0.3910	0.7056	0.6661	0.3399	0.6336	0.7021	1.0000	0.8959	0.8154	0.7988
VAR13	0.6909	-0.0267	-0.0619	0.3345	0.7225	0.4300	0.7369	0.6938	0.3793	0.6910	0.6887	0.8959	1.0000	0.8895	0.8050
VAR14	0.6051	-0.0291	-0.0594	0.3255	0.6519	0.4185	0.6673	0.6043	0.3405	0.6584	0.7401	0.8154	0.8895	1.0000	0.7745
VAR15	0.6894	-0.0046	-0.0580	0.2939	0.7085	0.3830	0.6988	0.6643	0.3306	0.6408	0.7375	0.7988	0.8050	0.7745	1.0000

Eigenvalues and Eigenvectors

Eigenvalue	8.3084	1.9559	1.3198	0.7812	0.6216	0.3836	0.3750	0.2849	0.2217	0.2028	0.1655	0.1575	0.1014	0.0712	0.0494
Proportion	0.5539	0.1304	0.0880	0.0521	0.0414	0.0256	0.0250	0.0190	0.0033	0.0047	0.0068	0.0148	0.0135	0.0105	0.0110
Cum Proportion	0.5539	0.6843	0.7723	0.8244	0.8658	0.8914	0.9164	0.9354	0.9387	0.9434	0.9502	0.9650	0.9785	0.9890	1.0000

Eigenvectors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.2855	-0.0843	0.0085	-0.3559	-0.0013	-0.3597	-0.0460	-0.6119	-0.0105	0.4478	0.2565	-0.0452	-0.0887	0.0005	0.0478
VAR2	0.0146	0.2023	-0.6878	0.0179	-0.6819	-0.0412	0.0385	0.0402	-0.0171	0.0963	-0.0136	-0.0754	-0.0054	0.0132	0.0085
VAR3	0.0138	0.2844	-0.6317	-0.0144	0.7016	0.0473	0.0152	-0.1334	-0.0438	-0.0678	-0.0166	0.0182	0.0039	0.0063	0.0083
VAR4	-0.1961	0.5108	0.1861	0.2019	-0.1098	0.0639	0.0386	-0.2254	-0.0826	-0.3014	0.1291	0.1682	-0.6287	-0.1218	-0.0642
VAR5	-0.3152	0.0230	0.0079	-0.3450	-0.0060	0.0583	0.1012	0.1592	-0.0449	-0.0090	-0.4743	0.1834	-0.1497	0.0368	0.6764
VAR6	-0.2201	0.4313	0.1218	0.2014	0.1251	-0.2515	-0.1330	0.4604	0.3189	0.5109	-0.0239	-0.1874	-0.0328	-0.0378	-0.0249
VAR7	-0.3139	-0.0190	-0.0192	-0.3616	0.0063	-0.0167	0.1256	0.1747	-0.2245	0.0383	-0.3667	0.1684	-0.0357	-0.0403	-0.7111
VAR8	-0.2955	0.0180	-0.0518	-0.3777	0.0065	-0.1708	-0.0782	0.4018	-0.0076	-0.4219	0.6102	-0.0534	0.0988	0.0644	0.0561
VAR9	-0.2166	0.4823	0.2046	0.0907	-0.0902	-0.0253	0.0763	-0.2653	-0.1814	-0.1609	-0.1159	-0.0280	0.6984	0.1527	0.0373
VAR10	-0.2858	0.0153	0.0098	-0.1425	-0.0241	0.8343	0.0296	-0.0804	0.2429	0.1683	0.1587	-0.2782	0.0269	0.0124	-0.0538
VAR11	-0.2598	-0.2124	-0.0398	0.3284	0.0689	-0.0946	0.7922	0.0789	-0.1951	0.0573	0.1301	-0.2246	-0.0163	-0.1296	0.0691
VAR12	-0.2953	-0.2117	-0.0539	0.2148	0.0245	-0.1189	-0.3381	-0.0748	-0.1389	-0.2375	-0.2605	-0.6014	-0.1888	0.3770	-0.0358
VAR13	-0.3063	-0.1752	-0.0898	0.2192	-0.0066	0.0401	-0.3939	-0.0087	-0.1892	-0.0329	-0.0231	0.0406	0.1693	-0.7678	0.0726
VAR14	-0.2896	-0.1813	-0.0904	0.3763	0.0112	0.1461	-0.1778	0.0922	-0.2418	0.2412	0.2067	0.5544	0.0236	0.4519	0.0190
VAR15	-0.2917	-0.1914	-0.1124	0.1640	-0.0272	-0.1541	0.0978	-0.1695	0.7701	-0.2847	-0.1347	0.2535	0.0937	0.0149	-0.1020

Unrotated Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.8229	-0.1179	0.0097	-0.3146	-0.0010	-0.2228	-0.0282	-0.3266	-0.0050	0.2016	0.1044	-0.0179	-0.0283	0.0001	0.0106
VAR2	0.0420	0.2830	-0.7901	0.0158	-0.5376	-0.0255	0.0236	0.0215	-0.0081	0.0434	-0.0055	-0.0299	-0.0017	0.0035	0.0019
VAR3	0.0396	0.3977	-0.7257	-0.0127	0.5531	0.0293	0.0093	-0.0712	-0.0206	-0.0305	-0.0067	0.0072	0.0013	0.0017	0.0018
VAR4	-0.5652	0.7144	0.2138	0.1785	-0.0865	0.0396	0.0236	-0.1203	-0.0389	-0.1357	0.0525	0.0668	-0.2002	-0.0325	-0.0143
VAR5	-0.9086	0.0322	0.0091	-0.3049	-0.0048	0.0361	0.0620	0.0850	-0.0212	-0.0040	-0.1929	0.0728	-0.0477	0.0098	0.1503
VAR6	-0.6344	0.6032	0.1400	0.1780	0.0986	-0.1558	-0.0814	0.2458	0.1501	0.2301	-0.0097	-0.0744	-0.0104	-0.0101	-0.0055
VAR7	-0.9047	-0.0265	-0.0221	-0.3196	0.0050	-0.0103	0.0769	0.0933	-0.1057	0.0172	-0.1492	0.0668	-0.0114	-0.0108	-0.1580
VAR8	-0.8516	0.0252	-0.0595	-0.3338	0.0051	-0.1058	-0.0479	0.2145	-0.0036	-0.1900	0.2482	-0.0212	0.0315	0.0172	0.0125
VAR9	-0.6244	0.6745	0.2350	0.0801	-0.0711	-0.0157	0.0468	-0.1416	-0.0854	-0.0724	-0.0471	-0.0111	0.2224	0.0408	0.0083
VAR10	-0.8237	0.0215	0.0113	-0.1260	-0.0190	0.5168	0.0182	-0.0429	0.1144	0.0758	0.0646	-0.1104	0.0086	0.0033	-0.0120
VAR11	-0.7488	-0.2970	-0.0457	0.2902	0.0544	-0.0586	0.4851	0.0421	-0.0919	0.0258	0.0529	-0.0891	-0.0052	-0.0346	0.0154
VAR12	-0.8512	-0.2960	-0.0619	0.1899	0.0193	-0.0737	-0.2070	-0.0399	-0.0654	-0.1069	-0.1060	-0.2387	-0.0601	0.1006	-0.0080
VAR13	-0.8828	-0.2450	-0.1031	0.1937	-0.0052	0.0248	-0.2412	-0.0046	-0.0891	-0.0148	-0.0094	0.0161	0.0539	-0.2049	0.0161
VAR14	-0.8348	-0.2535	-0.1039	0.3326	0.0089	0.0905	-0.1089	0.0492	-0.1139	0.1086	0.0841	0.2200	0.0075	0.1206	0.0042
VAR15	-0.8407	-0.2677	-0.1292	0.1449	-0.0214	-0.0955	0.0599	-0.0905	0.3626	-0.1282	-0.0548	0.1006	0.0298	0.0040	-0.0227

Varimax Rotated Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.4007	0.1820	0.0438	-0.5822	-0.0404	0.1070	0.1147	-0.6548	0.0934	0.0214	0.0304	-0.0177	0.0055	-0.0054	0.0025
VAR2	0.0172	0.0186	-0.9799	0.0100	0.1953	-0.0087	-0.0245	0.0147	0.0037	-0.0051	0.0017	0.0033	-0.0007	0.0002	-0.0003
VAR3	0.0466	0.0540	-0.1973	0.0075	0.9771	-0.0053	-0.0215	0.0140	-0.0063	0.0229	0.0026	0.0028	-0.0004	0.0004	-0.0002
VAR4	-0.1215	0.9505	-0.0319	-0.1461	0.0231	0.0972	0.0392	-0.0273	0.0324	-0.0229	0.0301	0.0049	-0.2112	0.0059	0.0024
VAR5	-0.3813	0.3073	0.0190	-0.8009	-0.0148	0.1934	0.1354	-0.0955	0.0961	0.0550	-0.0953	-0.0150	0.0011	0.0014	0.1779
VAR6	-0.2111	0.7449	0.0211	-0.2306	0.0987	0.0425	0.0563	-0.0301	0.0400	0.5732	0.0328	-0.0055	0.0014	-0.0010	0.0026
VAR7	-0.4008	0.2485	0.0125	-0.8245	-0.0076	0.1496	0.1718	-0.1203	0.0443	0.0432	-0.0848	-0.0023	0.0151	-0.0008	-0.1413
VAR8	-0.3674	0.2508	-0.0174	-0.7606	0.0198	0.1068	0.0914	-0.1011	0.0772	0.0776	0.4248	-0.0203	-0.0033	-0.0072	-0.0037
VAR9	-0.1211	0.9195	-0.0044	-0.2436	0.0077	0.0901	0.0590	-0.0882	0.0184	-0.0044	0.0044	-0.0158	0.2455	-0.0101	-0.0015
VAR10	-0.4098	0.2884	0.0195	-0.4550	-0.0109	0.7173	0.1180	-0.0851	0.0658	0.0238	0.0256	-0.0067	0.0019	-0.0029	0.0028
VAR11	-0.5393	0.1094	0.0486	-0.2744	-0.0403	0.0973	0.7695	-0.0756	0.0969	0.0264	0.0176	-0.0116	0.0024	-0.0023	0.0025
VAR12	-0.8245	0.1308	0.0470	-0.3477	-0.0479	0.0855	0.1469	-0.1258	0.0704	0.0372	0.0399	-0.3534	0.0054	0.0059	0.0028
VAR13	-0.8650	0.1674	0.0014	-0.3614	-0.0247	0.1359	0.0992	-0.1065	0.0414	0.0420	0.0425	0.0302	0.0118	-0.2160	0.0002
VAR14	-0.8703	0.1626	0.0037	-0.2566	-0.0214	0.1489	0.2099	-0.0568	0.0200	0.0639	0.0169	0.1986	-0.0108	0.1898	0.0019
VAR15	-0.6558	0.1224	-0.0208	-0.3693	-0.0255	0.1233	0.2467	-0.1417	0.5639	0.0419	0.0347	-0.0173	-0.0000	-0.0039	0.0045

Sum of Squares	3.7525	2.7411	1.0087	3.1089	1.0112	0.6892	0.8210	0.5358	0.3677	0.3513	0.2056	0.1670	0.1055	0.0829	0.0517
Rank	1	3	5	2	4	7	6	8	9	10	11	12	13	14	15

Varimax Rotated Factor Loadings (Ranked)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	-0.4007	-0.5822	0.1820	-0.0404	0.0438	0.1147	0.1070	-0.6548	0.0934	0.0214	0.0304	-0.0177	0.0055	-0.0054	0.0025
VAR2	0.0172	0.0100	0.0186	0.1953	-0.9799	-0.0245	-0.0087	0.0147	0.0037	-0.0051	0.0017	0.0033	-0.0007	0.0002	-0.0003
VAR3	0.0466	0.0075	0.0540	0.9771	-0.1973	-0.0215	-0.0053	0.0140	-0.0063	0.0229	0.0026	0.0028	-0.0004	0.0004	-0.0002

VAR4	-0.1215	-0.1461	0.9505	0.0231	-0.0319	0.0392	0.0972	-0.0273	0.0324	-0.0229	0.0301	0.0049	-0.2112	0.0059	0.0024
VAR5	-0.3813	-0.8009	0.3073	-0.0148	0.0190	0.1354	0.1934	-0.0955	0.0961	0.0550	-0.0953	-0.0150	0.0011	0.0014	0.1779
VAR6	-0.2111	-0.2306	0.7449	0.0987	0.0211	0.0563	0.0425	-0.0301	0.0400	0.5732	0.0328	-0.0055	0.0014	-0.0010	0.0026
VAR7	-0.4008	-0.8245	0.2485	-0.0076	0.0125	0.1718	0.1496	-0.1203	0.0443	0.0432	-0.0848	-0.0023	0.0151	-0.0008	-0.1413
VAR8	-0.3674	-0.7606	0.2508	0.0198	-0.0174	0.0914	0.1068	-0.1011	0.0772	0.0776	0.4248	-0.0203	-0.0033	-0.0072	-0.0037
VAR9	-0.1211	-0.2436	0.9195	0.0077	-0.0044	0.0590	0.0901	-0.0882	0.0184	-0.0044	0.0044	-0.0158	0.2455	-0.0101	-0.0015
VAR10	-0.4098	-0.4550	0.2884	-0.0109	0.0195	0.1180	0.7173	-0.0851	0.0658	0.0238	0.0256	-0.0067	0.0019	-0.0029	0.0028
VAR11	-0.5393	-0.2744	0.1094	-0.0403	0.0486	0.7695	0.0973	-0.0756	0.0969	0.0264	0.0176	-0.0116	0.0024	-0.0023	0.0025
VAR12	-0.8245	-0.3477	0.1308	-0.0479	0.0470	0.1469	0.0855	-0.1258	0.0704	0.0372	0.0399	-0.3534	0.0054	0.0059	0.0028
VAR13	-0.8650	-0.3614	0.1674	-0.0247	0.0014	0.0992	0.1359	-0.1065	0.0414	0.0420	0.0425	0.0302	0.0118	-0.2160	0.0002
VAR14	-0.8703	-0.2566	0.1626	-0.0214	0.0037	0.2099	0.1489	-0.0568	0.0200	0.0639	0.0169	0.1986	-0.0108	0.1898	0.0019
VAR15	-0.6558	-0.3693	0.1224	-0.0255	-0.0208	0.2467	0.1233	-0.1417	0.5639	0.0419	0.0347	-0.0173	-0.0000	-0.0039	0.0045

Sum of Squares	3.7525	3.1089	2.7411	1.0112	1.0087	0.8210	0.6892	0.5358	0.3677	0.3513	0.2056	0.1670	0.1055	0.0829	0.0517
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Proportion	25.02%	20.73%	18.27%	6.74%	6.72%	5.47%	4.59%	3.57%	2.45%	2.34%	1.37%	1.11%	0.70%	0.55%	0.34%
Cum Proportion	25.02%	45.74%	64.02%	70.76%	77.48%	82.96%	87.55%	91.12%	93.57%	95.92%	97.29%	98.40%	99.10%	99.66%	100.00%

Factor Score Coefficients

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14	Factor 15
VAR1	0.1205	0.1451	-0.0519	0.0129	-0.0220	-0.0030	-0.0113	-1.7805	-0.2001	0.0917	0.0013	0.1517	-0.2068	0.0921	0.1576
VAR2	0.0075	0.0042	-0.0218	-0.2149	-1.0678	0.0634	0.0289	-0.0658	-0.0912	0.1055	-0.0497	-0.0975	0.0321	0.0247	0.0351
VAR3	-0.0436	0.0060	-0.0239	1.0752	0.2128	0.0193	-0.0031	-0.0393	0.0116	-0.1785	-0.0372	-0.0289	0.0220	0.0084	0.0357
VAR4	0.0040	0.1088	0.6006	-0.0155	0.0163	0.0005	-0.1429	0.0103	0.0328	-0.7182	-0.0123	-0.0330	-2.1042	-0.0808	-0.1735
VAR5	0.1085	-0.6528	-0.0521	-0.0015	0.0016	-0.0563	-0.2466	0.4077	-0.0769	-0.0713	-0.8161	0.0512	-0.1044	0.0500	3.1651
VAR6	0.0817	0.1158	0.0549	-0.0504	-0.0178	0.0199	0.0313	-0.0737	-0.0039	1.7573	-0.1092	-0.0695	-0.0671	-0.1013	-0.0934
VAR7	0.1258	-0.7915	-0.0619	-0.0026	0.0030	-0.0583	-0.2800	0.4789	-0.0544	-0.0589	-1.0790	0.0358	-0.1932	0.0918	-3.1085
VAR8	0.1386	-0.3931	-0.0643	-0.0079	0.0058	-0.0157	-0.1663	0.2922	-0.0762	-0.0998	1.9639	0.0916	0.0713	0.1671	0.1167
VAR9	-0.0001	0.1304	0.5218	-0.0129	0.0121	-0.0053	-0.1168	0.0188	0.0471	-0.6274	0.0887	0.0222	2.2899	0.1354	0.0268
VAR10	0.1607	0.2293	-0.1020	-0.0007	-0.0134	-0.0117	1.6605	-0.0504	-0.0370	0.1530	0.1496	-0.2010	0.0518	-0.0154	-0.2335
VAR11	0.2146	0.1398	-0.0188	0.0147	-0.0326	1.5412	-0.0147	-0.0330	0.0195	0.1609	-0.0594	-0.0594	-0.4386	0.2212	
VAR12	-0.4275	0.1283	-0.0034	0.0176	-0.0032	-0.2163	-0.0969	0.0911	-0.3243	-0.0639	-0.0647	-2.1729	-0.0305	0.8947	-0.0418
VAR13	-0.5687	0.1397	-0.0016	0.0177	0.0055	-0.2642	-0.1454	0.0932	-0.3826	-0.0805	-0.0471	0.8723	-0.0172	-2.8256	0.1245
VAR14	-0.6202	0.1569	0.0020	0.0173	0.0063	-0.2799	-0.1462	0.0653	-0.3964	-0.0905	0.0321	1.0698	0.1673	2.0396	0.1136
VAR15	-0.0123	0.1018	-0.0088	0.0112	0.0187	-0.1917	-0.0651	0.1428	1.9793	-0.0544	-0.0747	0.1603	0.1119	0.0543	-0.3400

Principal Component Analysis/ Factor Analysis for All Courses Post-course Surveys with Additional Explicit Variable

Correlation Matrix

	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8	VAR9	VAR10	VAR11	VAR12	VAR13	VAR14
VAR1	1.0000	0.3317	0.4197	0.3913	0.6631	0.7253	0.7045	0.6648	0.6364	0.5940	0.5634	-0.0524	0.0100	-0.2421
VAR2	0.3317	1.0000	0.8029	0.8319	0.5369	0.4683	0.4453	0.3192	0.3040	0.2988	0.5148	-0.1054	-0.0195	-0.0492
VAR3	0.4197	0.8029	1.0000	0.8439	0.5986	0.5511	0.5310	0.3850	0.3660	0.3567	0.5532	-0.1079	-0.0130	-0.0713
VAR4	0.3913	0.8319	0.8439	1.0000	0.6126	0.5481	0.5286	0.3775	0.3615	0.3543	0.5774	-0.0977	-0.0036	-0.0703
VAR5	0.6631	0.5369	0.5986	0.6126	1.0000	0.8864	0.7882	0.6320	0.6053	0.5786	0.8075	-0.0521	0.0507	-0.1285
VAR6	0.7253	0.4683	0.5511	0.5481	0.8864	1.0000	0.8177	0.6804	0.6529	0.6201	0.7475	-0.0503	0.0328	-0.1399
VAR7	0.7045	0.4453	0.5310	0.5286	0.7882	0.8177	1.0000	0.6545	0.6174	0.5861	0.7044	-0.0426	0.0426	-0.1392
VAR8	0.6648	0.3192	0.3850	0.3775	0.6320	0.6804	0.6545	1.0000	0.8527	0.7719	0.6341	0.0085	0.0799	-0.2364
VAR9	0.6364	0.3040	0.3660	0.3615	0.6053	0.6529	0.6174	0.8527	1.0000	0.8338	0.6242	0.0134	0.0915	-0.2567
VAR10	0.5940	0.2988	0.3567	0.3543	0.5786	0.6201	0.5861	0.7719	0.8338	1.0000	0.6201	0.0073	0.0826	-0.2329
VAR11	0.5634	0.5148	0.5532	0.5774	0.8075	0.7475	0.7044	0.6341	0.6242	0.6201	1.0000	-0.0479	0.0864	-0.1456
VAR12	-0.0524	-0.1054	-0.1079	-0.0977	-0.0521	-0.0503	-0.0426	0.0085	0.0134	0.0073	-0.0479	1.0000	0.3536	-0.0337
VAR13	0.0100	-0.0195	-0.0130	-0.0036	0.0507	0.0328	0.0426	0.0799	0.0915	0.0826	0.0864	0.3536	1.0000	-0.2320
VAR14	-0.2421	-0.0492	-0.0713	-0.0703	-0.1285	-0.1399	-0.1392	-0.2364	-0.2567	-0.2329	-0.1456	-0.0337	-0.2320	1.0000

Eigenvalues and Eigenvectors

Eigenvalue	7.0093	1.8397	1.3096	0.9353	0.6745	0.5957	0.4091	0.2418	0.2194	0.2043	0.1880	0.1470	0.1297	0.0966
Proportion	0.5007	0.1314	0.0935	0.0668	0.0482	0.0425	0.0292	0.0069	0.0093	0.0105	0.0173	0.0134	0.0146	0.0157
Cum Proportion	0.5007	0.6321	0.7256	0.7924	0.8406	0.8831	0.9124	0.9193	0.9285	0.9390	0.9563	0.9697	0.9843	1.0000

Eigenvectors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
VAR1	-0.2934	0.1488	-0.1523	-0.0229	0.2253	0.2660	0.6455	0.5503	-0.0008	-0.1415	0.0299	-0.0659	0.0205	0.0370
VAR2	-0.2441	-0.4316	0.2466	-0.1040	-0.2196	-0.0001	0.0634	0.1216	-0.1232	-0.0814	-0.7038	0.3129	0.0116	-0.0202
VAR3	-0.2698	-0.3896	0.2119	-0.0883	-0.1439	0.0344	0.1697	-0.0980	0.1022	0.0900	0.6456	0.4751	0.0240	0.0279
VAR4	-0.2705	-0.3991	0.2339	-0.0799	-0.1469	0.0120	0.0364	-0.0596	0.0343	0.0061	0.1033	-0.8145	-0.0401	-0.0543
VAR5	-0.3360	-0.0388	-0.0090	0.1363	0.3293	0.0318	-0.2564	0.0481	-0.0830	0.4229	-0.0615	-0.0143	-0.0042	0.7069
VAR6	-0.3365	0.0308	-0.0758	0.1419	0.3182	0.0821	-0.0537	-0.1181	-0.0070	0.5226	-0.0928	0.0492	-0.0324	-0.6707
VAR7	-0.3222	0.0341	-0.0659	0.1333	0.3254	0.1008	0.0905	-0.6114	0.2800	-0.5205	-0.1259	0.0342	0.0541	0.0748
VAR8	-0.3055	0.2608	-0.1290	0.0121	-0.2855	-0.0852	0.0995	-0.2333	-0.6224	-0.0785	0.0710	0.0128	-0.5187	0.0311
VAR9	-0.3004	0.2858	-0.1255	-0.0177	-0.3812	-0.1337	0.0262	-0.0980	-0.1352	0.0795	-0.0007	-0.0441	0.7822	0.0147
VAR10	-0.2892	0.2674	-0.1231	-0.0098	-0.4134	-0.1740	-0.0806	0.1333	0.6858	0.1109	-0.0909	0.0209	-0.3331	0.0443
VAR11	-0.3200	-0.0066	0.0168	0.0917	0.1379	-0.1464	-0.5946	0.4384	-0.1088	-0.4655	0.1859	0.0460	0.0362	-0.1900
VAR12	0.0232	0.2887	0.5547	0.4713	-0.2211	0.5732	-0.0890	0.0225	0.0051	-0.0133	0.0086	0.0080	0.0019	-0.0040
VAR13	-0.0251	0.3020	0.6389	-0.0215	0.2587	-0.6165	0.2278	0.0120	0.0035	-0.0198	-0.0107	-0.0009	-0.0048	-0.0064
VAR14	0.0873	-0.2847	-0.2062	0.8285	-0.1035	-0.3529	0.2046	0.0668	-0.0079	-0.0156	0.0096	-0.0126	0.0134	0.0063

Unrotated Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
VAR1	-0.7767	0.2018	-0.1743	-0.0221	0.1851	0.2053	0.4129	0.2706	-0.0004	-0.0640	0.0130	-0.0252	0.0074	0.0115
VAR2	-0.6462	-0.5854	0.2821	-0.1005	-0.1803	-0.0001	0.0405	0.0598	-0.0577	-0.0368	-0.3052	0.1200	0.0042	-0.0063
VAR3	-0.7143	-0.5285	0.2425	-0.0854	-0.1181	0.0266	0.1086	-0.0482	0.0479	0.0407	0.2799	0.1822	0.0086	0.0087
VAR4	-0.7162	-0.5414	0.2677	-0.0773	-0.1207	0.0093	0.0233	-0.0293	0.0161	0.0028	0.0448	-0.3123	-0.0144	-0.0169
VAR5	-0.8897	-0.0527	-0.0103	0.1318	0.2704	0.0245	-0.1640	0.0237	-0.0389	0.1912	-0.0267	-0.0055	-0.0015	0.2197
VAR6	-0.8909	0.0418	-0.0868	0.1372	0.2613	0.0633	-0.0344	-0.0581	-0.0033	0.2362	-0.0403	0.0189	-0.0117	-0.2084
VAR7	-0.8531	0.0463	-0.0754	0.1289	0.2672	0.0778	0.0579	-0.3007	0.1311	-0.2353	-0.0546	0.0131	0.0195	0.0233
VAR8	-0.8088	0.3537	-0.1477	0.0117	-0.2345	-0.0657	0.0636	-0.1147	-0.2915	-0.0355	0.0308	0.0049	-0.1868	0.0097
VAR9	-0.7953	0.3877	-0.1436	-0.0172	-0.3131	-0.1032	0.0167	-0.0482	-0.0633	0.0359	-0.0003	-0.0169	0.2817	0.0046
VAR10	-0.7658	0.3626	-0.1409	-0.0095	-0.3395	-0.1343	-0.0515	0.0656	0.3212	0.0501	-0.0394	0.0080	-0.1200	0.0138
VAR11	-0.8471	-0.0089	0.0192	0.0886	0.1133	-0.1130	-0.3803	0.2156	-0.0510	-0.2104	0.0806	0.0176	0.0130	-0.0590
VAR12	0.0615	0.3916	0.6348	0.4558	-0.1816	0.4424	-0.0569	0.0111	0.0024	-0.0060	0.0037	0.0030	0.0007	-0.0013
VAR13	-0.0665	0.4096	0.7311	-0.0207	0.2124	-0.4758	0.1457	0.0059	0.0017	0.0089	-0.0046	-0.0003	-0.0017	-0.0020
VAR14	0.2312	-0.3862	-0.2360	0.8013	-0.0850	-0.2724	0.1309	0.0329	-0.0037	-0.0070	0.0042	-0.0048	0.0048	0.0020

Varimax Rotated Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
VAR1	-0.4185	-0.1807	-0.0404	-0.1166	0.3666	0.0201	0.7879	-0.0809	0.0249	-0.1182	0.0102	-0.0089	0.0010	0.0010
VAR2	-0.1233	-0.9245	-0.0646	-0.0010	0.1577	0.0161	0.0548	-0.0357	0.0086	-0.0832	-0.2511	0.1629	-0.0008	-0.0001
VAR3	-0.1637	-0.8694	-0.0680	-0.0112	0.2199	0.0129	0.1137	-0.0818	0.0161	-0.0811	0.3605	0.0873	0.0022	-0.0055
VAR4	-0.1565	-0.8813	-0.0585	-0.0117	0.2328	0.0066	0.0695	-0.0741	0.0228	-0.1087	0.0097	-0.3438	0.0040	0.0014
VAR5	-0.3427	-0.3745	-0.0464	-0.0221	0.8019	-0.0260	0.1648	-0.0646	0.0111	-0.1552	0.0091	-0.0164	0.0012	0.2002
VAR6	-0.4077	-0.2970	-0.0468	-0.0249	0.7732	-0.0056	0.2437	-0.1197	0.0189	-0.0905	0.0199	-0.0108	0.0012	-0.2494
VAR7	-0.3732	-0.2861	-0.0335	-0.0288	0.5447	-0.0141	0.2814	-0.6074	0.0437	-0.1723	0.0106	-0.0135	0.0064	0.0036
VAR8	-0.8493	-0.1638	-0.0357	-0.0806	0.2765	-0.0257	0.1910	-0.1221	-0.2292	-0.1128	0.0113	-0.0127	-0.2236	-0.0030
VAR9	-0.8910	-0.1499	-0.0373	-0.0966	0.2408	-0.0334	0.1498	-0.0753	-0.0268	-0.1027	0.0075	-0.0090	0.2725	0.0012
VAR10	-0.8372	-0.1491	-0.0386	-0.0806	0.2305	-0.0281	0.1184	-0.0489	0.4212	-0.1188	0.0077	-0.0032	-0.0831	0.0047
VAR11	-0.4036	-0.3490	-0.0526	-0.0353	0.5130	-0.0521	0.0689	-0.0594	0.0379	-0.6597	0.0042	-0.0067	-0.0001	0.0218

VAR12	-0.0669	0.0475	0.9798	-0.0076	-0.0115	-0.1787	-0.0289	0.0119	-0.0033	0.0115	-0.0032	0.0028	-0.0003	0.0007
VAR13	-0.0571	0.0028	0.1782	-0.1145	0.0135	-0.9753	-0.0096	-0.0049	0.0026	-0.0184	-0.0004	-0.0016	0.0003	0.0001
VAR14	0.1505	0.0224	0.0006	0.9790	-0.0384	0.1139	-0.0583	0.0099	-0.0075	0.0180	-0.0010	0.0011	-0.0014	-0.0000

Sum of Squares	3.0741	2.9263	1.0180	1.0111	2.2517	1.0032	0.8893	0.4343	0.2361	0.5746	0.1941	0.1533	0.1312	0.1028
Rank	1	2	4	5	3	6	7	9	10	8	11	12	13	14

Varimax Rotated Factor Loadings (Ranked)

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
VAR1	-0.4185	-0.1807	0.3666	-0.0404	-0.1166	0.0201	0.7879	-0.1182	-0.0809	0.0249	0.0102	-0.0089	0.0010	0.0010
VAR2	-0.1233	-0.9245	0.1577	-0.0646	-0.0010	0.0161	0.0548	-0.0832	-0.0357	0.0086	-0.2511	0.1629	-0.0008	-0.0001
VAR3	-0.1637	-0.8694	0.2199	-0.0680	-0.0112	0.0129	0.1137	-0.0811	-0.0818	0.0161	0.3605	0.0873	0.0022	-0.0055
VAR4	-0.1565	-0.8813	0.2328	-0.0585	-0.0117	0.0066	0.0695	-0.1087	-0.0741	0.0228	0.0097	-0.3438	0.0040	0.0014
VAR5	-0.3427	-0.3745	0.8019	-0.0464	-0.0221	-0.0260	0.1648	-0.1552	-0.0646	0.0111	0.0091	-0.0164	0.0012	0.2002
VAR6	-0.4077	-0.2970	0.7732	-0.0468	-0.0249	-0.0056	0.2437	-0.0905	-0.1197	0.0189	0.0199	-0.0108	0.0012	-0.2494
VAR7	-0.3732	-0.2861	0.5447	-0.0335	-0.0288	-0.0141	0.2814	-0.1723	-0.6074	0.0437	0.0106	-0.0135	0.0064	0.0036
VAR8	-0.8493	-0.1638	0.2765	-0.0357	-0.0806	-0.0257	0.1910	-0.1128	-0.1221	-0.2292	0.0113	-0.0127	-0.2236	-0.0030
VAR9	-0.8910	-0.1499	0.2408	-0.0373	-0.0966	-0.0334	0.1498	-0.1027	-0.0753	-0.0268	0.0075	-0.0090	0.2725	0.0012
VAR10	-0.8372	-0.1491	0.2305	-0.0386	-0.0806	-0.0281	0.1184	-0.1188	-0.0489	0.4212	0.0077	-0.0032	-0.0831	0.0047
VAR11	-0.4036	-0.3490	0.5130	-0.0526	-0.0353	-0.0521	0.0689	-0.6597	-0.0594	0.0379	0.0042	-0.0067	-0.0001	0.0218
VAR12	-0.0669	0.0475	-0.0115	0.9798	-0.0076	-0.1787	-0.0289	0.0115	0.0119	-0.0033	-0.0032	0.0028	-0.0003	0.0007
VAR13	-0.0571	0.0028	0.0135	0.1782	-0.1145	-0.9753	-0.0096	-0.0184	-0.0049	0.0026	-0.0004	-0.0016	0.0003	0.0001
VAR14	0.1505	0.0224	-0.0384	0.0006	0.9790	0.1139	-0.0583	0.0180	0.0099	-0.0075	-0.0010	0.0011	-0.0014	-0.0000

Sum of Squares	3.0741	2.9263	2.2517	1.0180	1.0111	1.0032	0.8893	0.5746	0.4343	0.2361	0.1941	0.1533	0.1312	0.1028
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Proportion	21.96%	20.90%	16.08%	7.27%	7.22%	7.17%	6.35%	4.10%	3.10%	1.69%	1.39%	1.10%	0.94%	0.73%
Cum Proportion	21.96%	42.86%	58.94%	66.21%	73.44%	80.60%	86.95%	91.06%	94.16%	95.85%	97.23%	98.33%	99.27%	100.00%

Factor Score Coefficients

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
VAR1	0.1712	0.0321	-0.2748	0.0452	0.0556	-0.0246	1.5135	-0.2065	0.3962	0.0866	-0.0856	-0.0659	0.0510	0.1828
VAR2	0.0046	-0.5299	-0.1591	0.0136	0.0008	-0.0057	0.0093	0.1276	0.0188	-0.0209	-1.4275	1.1612	-0.0102	-0.0847
VAR3	0.0207	-0.3721	-0.1526	0.0192	-0.0009	-0.0042	-0.0042	0.0647	0.0161	-0.0090	1.7937	0.8634	0.0089	0.0028
VAR4	0.0249	-0.3593	-0.1619	0.0219	-0.0014	0.0018	-0.0023	0.0628	0.0339	0.0237	-0.2132	-2.1445	0.0016	-0.0821
VAR5	0.0993	0.0803	1.0160	-0.0097	-0.0096	-0.0053	-0.2485	0.6846	0.5123	-0.0356	-0.0162	0.0675	-0.0088	2.1505
VAR6	0.0903	0.0817	0.8035	-0.0027	-0.0077	-0.0012	-0.2041	0.3932	0.4068	0.0120	-0.0508	0.0310	0.0136	-2.3041
VAR7	0.1348	0.0793	-0.1003	0.0267	-0.0105	0.0081	-0.0633	-0.0278	-1.8683	0.1652	-0.1143	0.0721	0.1029	0.2157
VAR8	-0.5364	0.0073	-0.1765	-0.0464	0.0526	0.0101	-0.1435	0.1083	-0.0317	-1.2082	0.0114	-0.0420	-1.5907	0.0637
VAR9	-0.5600	0.0173	-0.1817	-0.0466	0.0637	0.0124	-0.1635	0.1447	0.0435	-0.4868	-0.0049	-0.0023	2.1346	0.0738
VAR10	-0.3746	0.0238	-0.1148	-0.0283	0.0495	0.0107	-0.1454	0.2003	0.1028	1.6696	-0.0067	0.0224	-0.7466	0.0855
VAR11	0.1335	0.1065	-0.1292	0.0235	-0.0063	0.0292	-0.0908	-1.8010	0.2118	-0.0703	0.0510	0.0770	0.0393	-0.2914
VAR12	-0.0300	-0.0603	0.0217	1.0580	-0.0161	0.1976	0.0035	-0.0329	0.0153	0.0063	0.0106	0.0156	0.0035	-0.0048
VAR13	0.0305	-0.0145	-0.0299	-0.1922	0.1232	-1.0791	0.0732	0.0658	0.0061	0.0032	-0.0049	0.0034	-0.0094	-0.0332
VAR14	-0.0927	0.0069	-0.0461	-0.0178	1.0560	-0.1235	0.1329	-0.0162	0.0334	0.0027	0.0024	-0.0166	0.0279	0.0222

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APPENDIX D. REGRESSION ANALYSIS

Table 53. Beginning Regression

Basic Econometrics Analysis Report

Regression Statistics	
R-Squared (Coefficient of Determination)	0.9749
Adjusted R-Squared	0.9749
Multiple R (Multiple Correlation Coefficient)	0.9874
Standard Error of the Estimates (SEy)	0.1912
Number of Observations	19818

The R-Squared or Coefficient of Determination indicates that 0.97 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.97 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results										
	Intercept	VAR2	VAR3	VAR5	VAR6	LN(VAR11)	VAR1*VAR2	VAR1*VAR3	VAR1*VAR5	VAR1*VAR14
Coefficients	1.9957	-0.0215	-0.0297	-0.1500	0.0643	0.0470	0.0060	0.0259	0.0353	0.1104
Standard Error	0.0250	0.0016	0.0067	0.0060	0.0029	0.0121	0.0003	0.0011	0.0009	0.0009
t-Statistic	79.8073	-13.2606	-4.4581	-24.9296	22.0722	3.8975	22.2877	23.6501	39.3182	122.7838
p-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
Lower 5%	1.9467	-0.0247	-0.0428	-0.1618	0.0586	0.0234	0.0055	0.0237	0.0336	0.1087
Upper 95%	2.0447	-0.0183	-0.0166	-0.1382	0.0700	0.0706	0.0065	0.0280	0.0371	0.1122

	VAR2*VAR12	VAR3*VAR5	VAR3*VAR6	VAR3*VAR12	VAR11*VAR12	VAR11*VAR13	VAR12*VAR14	LN(VAR2*VAR12)	LN(VAR3*VAR12)	LN(VAR3*VAR14)
Coefficients	-0.0019	-0.0106	-0.0161	0.0108	0.0231	-0.0228	-0.0699	-0.0072	1.2156	-1.2907
Standard Error	0.0003	0.0012	0.0012	0.0012	0.0008	0.0006	0.0007	0.0044	0.0135	0.0141
t-Statistic	-6.4341	-8.7828	-13.8308	8.9662	27.9124	-37.9795	-93.4764	-1.6447	90.2329	-91.6918
p-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1000	0.0000	0.0000
Lower 5%	-0.0024	-0.0129	-0.0184	0.0084	0.0215	-0.0240	-0.0713	-0.0157	1.1892	-1.3183
Upper 95%	-0.0013	-0.0082	-0.0138	0.0132	0.0247	-0.0216	-0.0684	0.0014	1.2420	-1.2631

	LN(VAR13*VAR14)
Coefficients	0.4983
Standard Error	0.0110

t-Statistic	45.0982
p-Value	0.0000
Lower 5%	0.4766
Upper 95%	0.5199

Degrees of Freedom

Degrees of Freedom for Regression	20
Degrees of Freedom for Residual	19797
Total Degrees of Freedom	19817

Hypothesis Test

Critical t-Statistic (99% confidence with df of 19797)	2.5761
Critical t-Statistic (95% confidence with df of 19797)	1.9601
Critical t-Statistic (90% confidence with df of 19797)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	28089.51	1404.48	38424.52	0.0000	Critical F-statistic (99% confidence with df of 20 and 19797)	1.8792
Residual	723.61	0.04			Critical F-statistic (95% confidence with df of 20 and 19797)	1.5711
Total	28813.12				Critical F-statistic (90% confidence with df of 20 and 19797)	1.4210

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Regression Statistics

R-Squared (Coefficient of Determination)	0.6283
Adjusted R-Squared	0.6280
Multiple R (Multiple Correlation Coefficient)	0.7926
Standard Error of the Estimates (SEy)	0.8036
Number of Observations	20396

The R-Squared or Coefficient of Determination indicates that 0.63 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.63 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	EN	DG	S	BD	CA	CW	DI	EL	ET
Coefficients	0.8695	-0.0108	-0.0698	-0.1183	0.1095	0.2641	0.3223	0.2204	-0.2457	-0.1172
Standard Error	0.0347	0.0034	0.0063	0.0390	0.0105	0.0412	0.0110	0.0073	0.0421	0.0078
t-Statistic	25.0717	-3.1488	-11.0851	-3.0320	10.4068	6.4140	29.1965	30.3883	-5.8295	-15.1207
p-Value	0.0000	0.0016	0.0000	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lower 5%	0.8015	-0.0175	-0.0822	-0.1948	0.0889	0.1834	0.3007	0.2061	-0.3283	-0.1324
Upper 95%	0.9375	-0.0041	-0.0575	-0.0418	0.1301	0.3448	0.3440	0.2346	-0.1631	-0.1020
	AJ	AN	BI	DK	FV					
Coefficients	0.0363	0.1185	0.0826	0.0213	0.0811					
Standard Error	0.0065	0.0100	0.0114	0.0102	0.0079					
t-Statistic	5.5838	11.8403	7.2170	2.0787	10.2977					
p-Value	0.0000	0.0000	0.0000	0.0377	0.0000					
Lower 5%	0.0235	0.0989	0.0602	0.0012	0.0657					
Upper 95%	0.0490	0.1381	0.1050	0.0414	0.0966					

Degrees of Freedom

Degrees of Freedom for Regression	14
Degrees of Freedom for Residual	20381
Total Degrees of Freedom	20395

Hypothesis Test

Critical t-Statistic (99% confidence with df of 20381)	2.5761
Critical t-Statistic (95% confidence with df of 20381)	1.9601
Critical t-Statistic (90% confidence with df of 20381)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	22245.37	1588.95	2460.57	0.0000	Critical F-statistic (99% confidence with df of 14 and 20381)	2.0824
Residual	13161.37	0.65			Critical F-statistic (95% confidence with df of 14 and 20381)	1.6923
Total	35406.74				Critical F-statistic (90% confidence with df of 14 and 20381)	1.5049

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

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Regression Statistics	
R-Squared (Coefficient of Determination)	0.5505
Adjusted R-Squared	0.5504
Multiple R (Multiple Correlation Coefficient)	0.7420
Standard Error of the Estimates (SEy)	0.8684
Number of Observations	12938

The R-Squared or Coefficient of Determination indicates that 0.55 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.55 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results			
	Intercept	BD	CW
Coefficients	1.5271	0.1234	0.6128
Standard Error	0.0349	0.0123	0.0131
t-Statistic	43.7917	10.0574	46.8446
p-Value	0.0000	0.0000	0.0000
Lower 5%	1.4588	0.0994	0.5872
Upper 95%	1.5955	0.1475	0.6384

Degrees of Freedom

Degrees of Freedom for Regression	2
Degrees of Freedom for Residual	12935
Total Degrees of Freedom	12937

Hypothesis Test

Critical t-Statistic (99% confidence with df of 12935)	2.5762
Critical t-Statistic (95% confidence with df of 12935)	1.9601
Critical t-Statistic (90% confidence with df of 12935)	1.6450

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	11946.67	5973.34	7920.57	0.0000	Critical F-statistic (99% confidence with df of 2 and 12935)	4.6068
Residual	9754.99	0.75			Critical F-statistic (95% confidence with df of 2 and 12935)	2.9964
Total	21701.67				Critical F-statistic (90% confidence with df of 2 and 12935)	2.3030

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (Ho) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (Ha) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

300 Series ACQ/CON/PMT Self-paced Post-course Knowledge Transfer versus Longer-term Relevance Factor Regression

Regression Statistics	
R-Squared (Coefficient of Determination)	0.6513
Adjusted R-Squared	0.6485
Multiple R (Multiple Correlation Coefficient)	0.8070
Standard Error of the Estimates (SEy)	0.8239
Number of Observations	252

The R-Squared or Coefficient of Determination indicates that 0.65 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.65 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	BD	CW
Coefficients	0.6541	0.2345	0.6031
Standard Error	0.2263	0.1152	0.1157
t-Statistic	2.8899	2.0353	5.2114
p-Value	0.0042	0.0429	0.0000
Lower 5%	0.2083	0.0076	0.3751
Upper 95%	1.0999	0.4613	0.8310

Degrees of Freedom

Degrees of Freedom for Regression	2
Degrees of Freedom for Residual	249
Total Degrees of Freedom	251

Hypothesis Test

Critical t-Statistic (99% confidence with df of 249)	2.5957
Critical t-Statistic (95% confidence with df of 249)	1.9695
Critical t-Statistic (90% confidence with df of 249)	1.6510

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	315.71	157.85	232.57	0.0000	Critical F-statistic (99% confidence with df of 2 and 249)	4.6914
Residual	169.01	0.68			Critical F-statistic (95% confidence with df of 2 and 249)	3.0321
Total	484.71				Critical F-statistic (90% confidence with df of 2 and 249)	2.3240

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

100 Series ACQ/CON/PMT Self-paced Post-course Knowledge Transfer versus Near-term Relevance Factor Regression

Regression Statistics

R-Squared (Coefficient of Determination)	0.2097
Adjusted R-Squared	0.2095
Multiple R (Multiple Correlation Coefficient)	0.4580
Standard Error of the Estimates (SEy)	1.1515
Number of Observations	12938

The R-Squared or Coefficient of Determination indicates that 0.21 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.21 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	S	CA	EL
Coefficients	4.6794	-0.3400	1.4795	0.8486
Standard Error	0.0220	0.0698	0.0733	0.0751
t-Statistic	213.0932	-4.8721	20.1712	11.3042
p-Value	0.0000	0.0000	0.0000	0.0000
Lower 5%	4.6363	-0.4767	1.3357	0.7014
Upper 95%	4.7224	-0.2032	1.6232	0.9957

Degrees of Freedom

Degrees of Freedom for Regression	3
Degrees of Freedom for Residual	12934
Total Degrees of Freedom	12937

Hypothesis Test

Critical t-Statistic (99% confidence with df of 12934)	2.5762
Critical t-Statistic (95% confidence with df of 12934)	1.9601
Critical t-Statistic (90% confidence with df of 12934)	1.6450

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	4551.36	1517.12	1144.14	0.0000	Critical F-statistic (99% confidence with df of 3 and 12934)	3.7831
Residual	17150.31	1.33			Critical F-statistic (95% confidence with df of 3 and 12934)	2.6056
Total	21701.67				Critical F-statistic (90% confidence with df of 3 and 12934)	2.0842

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (Ho) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (Ha) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

300 Series ACQ/CON/PMT Self-paced Post-course Knowledge Transfer versus Near-term Relevance Factor Regression

Regression Statistics	
R-Squared (Coefficient of Determination)	0.2157
Adjusted R-Squared	0.2062
Multiple R (Multiple Correlation Coefficient)	0.4644
Standard Error of the Estimates (SEy)	1.2381
Number of Observations	252

The R-Squared or Coefficient of Determination indicates that 0.22 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.21 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results				
	Intercept	S	CA	EL
Coefficients	4.4071	-1.4760	0.9811	2.4420
Standard Error	0.1619	0.6357	0.4278	0.5935
t-Statistic	27.2150	-2.3220	2.2932	4.1148
p-Value	0.0000	0.0210	0.0227	0.0001
Lower 5%	4.0881	-2.7280	0.1385	1.2731
Upper 95%	4.7260	-0.2240	1.8237	3.6110

Degrees of Freedom

Degrees of Freedom for Regression	3
Degrees of Freedom for Residual	248
Total Degrees of Freedom	251

Hypothesis Test

Critical t-Statistic (99% confidence with df of 248)	2.5958
Critical t-Statistic (95% confidence with df of 248)	1.9696
Critical t-Statistic (90% confidence with df of 248)	1.6510

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	104.53	34.84	22.73	0.0000	Critical F-statistic (99% confidence with df of 3 and 248)	3.8615
Residual	380.18	1.53			Critical F-statistic (95% confidence with df of 3 and 248)	2.6410
Total	484.71				Critical F-statistic (90% confidence with df of 3 and 248)	2.1060

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

ACQ/CON/PMT Self-paced Post-course Surveys Averaged at Course Level Auto Econometrics

Regression Statistics

R-Squared (Coefficient of Determination)	0.8520
Adjusted R-Squared	0.8214
Multiple R (Multiple Correlation Coefficient)	0.9230
Standard Error of the Estimates (SEy)	0.0938
Number of Observations	71

The R-Squared or Coefficient of Determination indicates that 0.85 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.82 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	var2	var4	var5	var7	var8	var13	ln(var2)	ln(var4)	ln(var6)
Coefficients	10.4830	-21.5450	15.3468	0.7257	7.2047	-0.1371	0.7832	125.1041	-87.9395	-0.5606
Standard Error	10.9010	5.5096	5.6001	0.1048	2.4793	0.0609	0.2970	31.4204	32.6613	0.1606
t-Statistic	0.9616	-3.9105	2.7404	6.9260	2.9059	-2.2499	2.6368	3.9816	-2.6925	-3.4915
p-Value	0.3402	0.0002	0.0081	0.0000	0.0052	0.0283	0.0107	0.0002	0.0093	0.0009
Lower 5%	-11.3378	-32.5736	4.1369	0.5160	2.2418	-0.2590	0.1886	62.2094	-153.3181	-0.8820
Upper 95%	32.3038	-10.5163	26.5566	0.9355	12.1677	-0.0151	1.3778	187.9988	-22.5608	-0.2392
	ln(var7)	ln(var9)	ln(var13)							
Coefficients	-45.7222	1.0169	-3.0828							
Standard Error	14.4438	0.5958	1.0835							
t-Statistic	-3.1655	1.7066	-2.8454							
p-Value	0.0025	0.0932	0.0061							
Lower 5%	-74.6347	-0.1758	-5.2516							
Upper 95%	-16.8096	2.2096	-0.9141							

Degrees of Freedom		Hypothesis Test	
Degrees of Freedom for Regression	12	Critical t-Statistic (99% confidence with df of 58)	2.6633
Degrees of Freedom for Residual	58	Critical t-Statistic (95% confidence with df of 58)	2.0017
Total Degrees of Freedom	70	Critical t-Statistic (90% confidence with df of 58)	1.6716

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	2.94	0.24	27.83	0.0000	Critical F-statistic (99% confidence with df of 12 and 58)	2.5075
Residual	0.51	0.01			Critical F-statistic (95% confidence with df of 12 and 58)	1.9233
Total	3.45				Critical F-statistic (90% confidence with df of 12 and 58)	1.6613

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Regression Statistics

R-Squared (Coefficient of Determination)	0.8707
Adjusted R-Squared	0.8408
Multiple R (Multiple Correlation Coefficient)	0.9331
Standard Error of the Estimates (SEy)	0.1040
Number of Observations	81

The R-Squared or Coefficient of Determination indicates that 0.87 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.84 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	var1	var2	var3	var5	var6	ln(var3)	var1*var2	var1*var3	var1*var4
Coefficients	21.2654	-49.8318	-4.7250	50.6042	-1.8490	-33.4813	-7.7211	10.7519	-38.2956	-6.5665
Standard Error	7.4769	8.9254	0.9241	15.6516	0.7277	6.6842	2.4945	2.2386	13.9330	1.5032
t-Statistic	2.8442	-5.5832	-5.1132	3.2332	-2.5410	-5.0090	-3.0953	4.8029	-2.7486	-4.3683
p-Value	0.0059	0.0000	0.0000	0.0019	0.0134	0.0000	0.0029	0.0000	0.0077	0.0000
Lower 5%	6.3331	-67.6570	-6.5706	19.3458	-3.3022	-46.8306	-12.7029	6.2810	-66.1217	-9.5686
Upper 95%	36.1978	-32.0066	-2.8795	81.8626	-0.3957	-20.1320	-2.7393	15.2227	-10.4695	-3.5643
	var1*var6	var2*var3	var2*var5	var3*var4	ln(var1*var2)	ln(var4*var6)				
Coefficients	44.1660	-6.2031	0.3640	3.4080	7.2750	7.5170				
Standard Error	10.6465	2.0256	0.1389	1.4508	1.8039	1.6692				
t-Statistic	4.1484	-3.0623	2.6214	2.3491	4.0329	4.5034				
p-Value	0.0001	0.0032	0.0109	0.0219	0.0001	0.0000				
Lower 5%	22.9035	-10.2485	0.0867	0.5106	3.6723	4.1834				
Upper 95%	65.4286	-2.1577	0.6413	6.3053	10.8776	10.8506				

Degrees of Freedom		Hypothesis Test	
Degrees of Freedom for Regression	15	Critical t-Statistic (99% confidence with df of 65)	2.6536
Degrees of Freedom for Residual	65	Critical t-Statistic (95% confidence with df of 65)	1.9971
Total Degrees of Freedom	80	Critical t-Statistic (90% confidence with df of 65)	1.6686

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	4.74	0.32	29.17	0.0000	Critical F-statistic (99% confidence with df of 15 and 65)	2.3270
Residual	0.70	0.01			Critical F-statistic (95% confidence with df of 15 and 65)	1.8231
Total	5.44				Critical F-statistic (90% confidence with df of 15 and 65)	1.5943

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Table 54. Regression for Explicit

All Independent Variables Regression Analysis Report

Regression Statistics	
R-Squared (Coefficient of Determination)	0.6236
Adjusted R-Squared	0.6236
Multiple R (Multiple Correlation Coefficient)	0.7897
Standard Error of the Estimates (SEy)	0.7904
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.62 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.62 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results										
	Intercept	S	CA	EL	BD	CW	DI	AN	BI	DK
Coefficients	1.1943	-0.0848	0.3040	-0.2877	0.0644	0.3132	0.2347	0.1945	0.0999	0.0601
Standard Error	0.0230	0.0204	0.0209	0.0222	0.0056	0.0058	0.0039	0.0055	0.0065	0.0056
t-Statistic	51.9545	-4.1654	14.5729	-12.9681	11.6031	53.9477	60.0684	35.3311	15.3561	10.7656
p-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lower 5%	1.1492	-0.1247	0.2631	-0.3312	0.0536	0.3018	0.2270	0.1837	0.0872	0.0491
Upper 95%	1.2394	-0.0449	0.3449	-0.2442	0.0753	0.3246	0.2423	0.2053	0.1127	0.0710
	ET	AD	ES	EXPL						
Coefficients	-0.1111	-0.0128	-0.0630	-0.2888						
Standard Error	0.0042	0.0020	0.0034	0.0070						
t-Statistic	-26.5633	-6.5227	-18.5663	-41.5081						
p-Value	0.0000	0.0000	0.0000	0.0000						
Lower 5%	-0.1193	-0.0166	-0.0696	-0.3024						
Upper 95%	-0.1029	-0.0089	-0.0563	-0.2752						

Degrees of Freedom		Hypothesis Test	
Degrees of Freedom for Regression	13	Critical t-Statistic (99% confidence with df of 64999)	2.5759
Degrees of Freedom for Residual	64999	Critical t-Statistic (95% confidence with df of 64999)	1.9600
Total Degrees of Freedom	65012	Critical t-Statistic (90% confidence with df of 64999)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	67281.80	5175.52	8284.68	0.0000	Critical F-statistic (99% confidence with df of 13 and 64999)	2.1301
Residual	40605.52	0.62			Critical F-statistic (95% confidence with df of 13 and 64999)	1.7203
Total	107887.32				Critical F-statistic (90% confidence with df of 13 and 64999)	1.5241

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (Ho) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (Ha) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus 6 Knowledge Friction Factors Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.5857
Adjusted R-Squared	0.5857
Multiple R (Multiple Correlation Coefficient)	0.7653
Standard Error of the Estimates (SEy)	0.8292
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.59 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.59 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	AD	ES	F1	F2	F3	F4
Coefficients	1.0861	-0.0116	-0.0771	-0.2909	0.4018	-0.1558	0.4847

Standard Error	0.0237	0.0021	0.0035	0.0073	0.0045	0.0146	0.0039
t-Statistic	45.8197	-5.6449	-21.7514	-39.8824	89.6826	-10.6943	123.6010
p-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lower 5%	1.0396	-0.0156	-0.0840	-0.3052	0.3931	-0.1843	0.4770
Upper 95%	1.1325	-0.0076	-0.0701	-0.2766	0.4106	-0.1272	0.4924

Degrees of Freedom

Degrees of Freedom for Regression	6
Degrees of Freedom for Residual	65006
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65006)	2.5759
Critical t-Statistic (95% confidence with df of 65006)	1.9600
Critical t-Statistic (90% confidence with df of 65006)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	63193.49	10532.25	15318.88	0.0000	Critical F-statistic (99% confidence with df of 6 and 65006)	2.8023
Residual	44693.82	0.69			Critical F-statistic (95% confidence with df of 6 and 65006)	2.0987
Total	107887.32				Critical F-statistic (90% confidence with df of 6 and 65006)	1.7742

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (Ho) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (Ha) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus Explicit Knowledge Friction Factor Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.0586
Adjusted R-Squared	0.0586
Multiple R (Multiple Correlation Coefficient)	0.2421
Standard Error of the Estimates (SEy)	1.2499
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.06 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.06 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	EXPL
Coefficients	6.3339	-0.6578

Standard Error	0.0084	0.0103
t-Statistic	754.6312	-63.6209
p-Value	0.0000	0.0000
Lower 5%	6.3174	-0.6781
Upper 95%	6.3503	-0.6376

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	6323.41	6323.41	4047.61	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	101563.91	1.56			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	107887.32				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus Clarity Knowledge Friction Factor Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.4553
Adjusted R-Squared	0.4553
Multiple R (Multiple Correlation Coefficient)	0.6748
Standard Error of the Estimates (SEy)	0.9508
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.46 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.46 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

Intercept	F2
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Coefficients	0.7190	0.8427
Standard Error	0.0225	0.0036
t-Statistic	31.8998	233.1095
p-Value	0.0000	0.0000
Lower 5%	0.6748	0.8356
Upper 95%	0.7631	0.8497

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	49120.65	49120.65	54340.03	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	58766.67	0.90			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416

Total

107887.32

Critical F-statistic (90% confidence with df of 1 and 65011)

2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus Near Relevance Knowledge Friction Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.1645
Adjusted R-Squared	0.1645
Multiple R (Multiple Correlation Coefficient)	0.4056
Standard Error of the Estimates (SEy)	1.1775
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.16 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.16 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	F3
Coefficients	4.9376	1.8496
Standard Error	0.0097	0.0163
t-Statistic	509.9221	113.1266
p-Value	0.0000	0.0000
Lower 5%	4.9186	1.8175
Upper 95%	4.9566	1.8816

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	17744.85	17744.85	12797.64	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	90142.47	1.39			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	107887.32				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (Ho) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (Ha) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus Longer-term Relevance Knowledge Friction Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.5092
Adjusted R-Squared	0.5092
Multiple R (Multiple Correlation Coefficient)	0.7136
Standard Error of the Estimates (SEy)	0.9025
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.51 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.51 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	F4
Coefficients	1.8758	0.6925
Standard Error	0.0159	0.0027
t-Statistic	118.0030	259.6952
p-Value	0.0000	0.0000
Lower 5%	1.8447	0.6873
Upper 95%	1.9070	0.6978

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	54933.56	54933.56	67441.60	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	52953.76	0.81			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	107887.32				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H₀) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus Experience Knowledge Friction Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.0027
Adjusted R-Squared	0.0027
Multiple R (Multiple Correlation Coefficient)	0.0524
Standard Error of the Estimates (SEy)	1.2865
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.00 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.00 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	AD
Coefficients	6.0370	-0.0395
Standard Error	0.0114	0.0030
t-Statistic	529.8960	-13.3669
p-Value	0.0000	0.0000
Lower 5%	6.0146	-0.0453
Upper 95%	6.0593	-0.0337

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	295.70	295.70	178.67	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	107591.62	1.65			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	107887.32				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H₀) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Knowledge Transfer versus Certification/Education Knowledge Friction Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.0001
Adjusted R-Squared	0.0001
Multiple R (Multiple Correlation Coefficient)	0.0100
Standard Error of the Estimates (SEy)	1.2882
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.00 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.00 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	ES
Coefficients	5.8738	0.0128
Standard Error	0.0116	0.0050
t-Statistic	507.6773	2.5596
p-Value	0.0000	0.0105
Lower 5%	5.8511	0.0030
Upper 95%	5.8965	0.0226

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	10.87	10.87	6.55	0.0105	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	107876.45	1.66			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	107887.32				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (Ho) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (Ha) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Explicit Factor versus Clarity Factor Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.0665
Adjusted R-Squared	0.0665

Multiple R (Multiple Correlation Coefficient)	0.2580
Standard Error of the Estimates (SEy)	0.4580
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.07 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.07 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	F2
Coefficients	1.3879	-0.1186
Standard Error	0.0109	0.0017
t-Statistic	127.8193	-68.0744
p-Value	0.0000	0.0000
Lower 5%	1.3666	-0.1220
Upper 95%	1.4092	-0.1151

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	972.25	972.25	4634.13	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	13639.49	0.21			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	14611.74				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Explicit Factor Versus Longer-term Relevance Factor Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.0190
Adjusted R-Squared	0.0190
Multiple R (Multiple Correlation Coefficient)	0.1380
Standard Error of the Estimates (SEy)	0.4696
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.02 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.02 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	F4
Coefficients	0.9453	-0.0493
Standard Error	0.0083	0.0014
t-Statistic	114.2939	-35.5166
p-Value	0.0000	0.0000
Lower 5%	0.9291	-0.0520
Upper 95%	0.9615	-0.0466

Degrees of Freedom

Hypothesis Test

Degrees of Freedom for Regression	1	Critical t-Statistic (99% confidence with df of 65011)	2.5759
Degrees of Freedom for Residual	65011	Critical t-Statistic (95% confidence with df of 65011)	1.9600
Total Degrees of Freedom	65012	Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	278.12	278.12	1261.43	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	14333.62	0.22			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	14611.74				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

Explicit Factor versus Education/Cert Factor Regression Analysis Report

Regression Statistics

R-Squared (Coefficient of Determination)	0.0538
Adjusted R-Squared	0.0538
Multiple R (Multiple Correlation Coefficient)	0.2320
Standard Error of the Estimates (SEy)	0.4612
Number of Observations	65013

The R-Squared or Coefficient of Determination indicates that 0.05 of the variation in the dependent variable can be explained and accounted for by the independent variables in this regression analysis. However, in a multiple regression, the Adjusted R-Squared takes into account the existence of additional independent variables or regressors and adjusts this R-Squared value to a more accurate view of the regression's explanatory power. Hence, only 0.05 of the variation in the dependent variable can be explained by the regressors.

The Multiple Correlation Coefficient (Multiple R) measures the correlation between the actual dependent variable (Y) and the estimated or fitted (Y) based on the regression equation. This is also the square root of the Coefficient of Determination (R-Squared).

The Standard Error of the Estimates (SEy) describes the dispersion of data points above and below the regression line or plane. This value is used as part of the calculation to obtain the confidence interval of the estimates later.

Regression Results

	Intercept	ES
Coefficients	0.8855	-0.1088

Standard Error	0.0041	0.0018
t-Statistic	213.7809	-60.8052
p-Value	0.0000	0.0000
Lower 5%	0.8774	-0.1123
Upper 95%	0.8936	-0.1053

Degrees of Freedom

Degrees of Freedom for Regression	1
Degrees of Freedom for Residual	65011
Total Degrees of Freedom	65012

Hypothesis Test

Critical t-Statistic (99% confidence with df of 65011)	2.5759
Critical t-Statistic (95% confidence with df of 65011)	1.9600
Critical t-Statistic (90% confidence with df of 65011)	1.6449

The Coefficients provide the estimated regression intercept and slopes. For instance, the coefficients are estimates of the true; population b values in the following regression equation $Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n$. The Standard Error measures how accurate the predicted Coefficients are, and the t-Statistics are the ratios of each predicted Coefficient to its Standard Error.

The t-Statistic is used in hypothesis testing, where we set the null hypothesis (H_0) such that the real mean of the Coefficient = 0, and the alternate hypothesis (H_a) such that the real mean of the Coefficient is not equal to 0. A t-test is performed and the calculated t-Statistic is compared to the critical values at the relevant Degrees of Freedom for Residual. The t-test is very important as it calculates if each of the coefficients is statistically significant in the presence of the other regressors. This means that the t-test statistically verifies whether a regressor or independent variable should remain in the regression or it should be dropped.

The Coefficient is statistically significant if its calculated t-Statistic exceeds the Critical t-Statistic at the relevant degrees of freedom (df). The three main confidence levels used to test for significance are 90%, 95% and 99%. If a Coefficient's t-Statistic exceeds the Critical level, it is considered statistically significant. Alternatively, the p-Value calculates each t-Statistic's probability of occurrence, which means that the smaller the p-Value, the more significant the Coefficient. The usual significant levels for the p-Value are 0.01, 0.05, and 0.10, corresponding to the 99%, 95%, and 90% confidence levels.

The Coefficients with their p-Values highlighted in blue indicate that they are statistically significant at the 90% confidence or 0.10 alpha level, while those highlighted in red indicate that they are not statistically significant at any other alpha levels.

Analysis of Variance

	Sums of Squares	Mean of Squares	F-Statistic	p-Value	Hypothesis Test	
Regression	786.27	786.27	3697.27	0.0000	Critical F-statistic (99% confidence with df of 1 and 65011)	6.6353
Residual	13825.47	0.21			Critical F-statistic (95% confidence with df of 1 and 65011)	3.8416
Total	14611.74				Critical F-statistic (90% confidence with df of 1 and 65011)	2.7056

The Analysis of Variance (ANOVA) table provides an F-test of the regression model's overall statistical significance. Instead of looking at individual regressors as in the t-test, the F-test looks at all the estimated Coefficients' statistical properties. The F-Statistic is calculated as the ratio of the Regression's Mean of Squares to the Residual's Mean of Squares. The numerator measures how much of the regression is explained, while the denominator measures how much is unexplained. Hence, the larger the F-Statistic, the more significant the model. The corresponding p-Value is calculated to test the null hypothesis (H_0) where all the Coefficients are simultaneously equal to zero, versus the alternate hypothesis (H_a) that they are all simultaneously different from zero, indicating a significant overall regression model. If the p-Value is smaller than the 0.01, 0.05, or 0.10 alpha significance, then the regression is significant. The same approach can be applied to the F-Statistic by comparing the calculated F-Statistic with the critical F values at various significance levels.

APPENDIX E.

STRUCTURAL EQUATIONS MODEL: PARTIAL LEAST SQUARES MODELS

Table 55. Partial Least Squares Models

PARTIAL LEAST SQUARES MODELS

Model Inputs for All Courses: Each Averaged:

F1 CLA, F2 Rel L, F3 Rel G, F4 Cert, F5 KT

F1 CLA, F2 Rel L, F3 Rel G, F4 Cert

F1 CLA, F2 Rel L, F3 Rel G

F1 CLA, F2 Rel L

Structural Equation Model: Path Estimation (PLS)

Direct Effects Path

Dep. Var	VAR5		
R-Square	0.53335		
Disturbance	0.68312		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	1.78332	0.00383	
VAR1	-0.08199	0.73876	-0.05390
VAR2	-0.85585	0.04331	-0.26426
VAR3	0.86936	0.00002	0.95359
VAR4	-0.13267	0.00038	-0.33082

Partial Direct Effects Path 1

Dep. Var	VAR4		
R-Square	0.09452		
Disturbance	0.95157		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	-2.81522	0.16831	
VAR1	0.84753	0.31527	0.22346
VAR2	-0.39485	0.78348	-0.04889
VAR3	0.27528	0.66868	0.12110

Partial Direct Effects Path 2

Dep. Var	VAR3		
R-Square	0.82971		
Disturbance	0.41266		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	0.11082	0.77294	
VAR1	1.07516	0.00000	0.64441
VAR2	1.57454	0.00000	0.44323

Partial Direct Effects Path 3

Dep. Var	VAR2		
R-Square	0.14563		
Disturbance	0.92432		
Indep. Var	Coeff	P-Value	Std. Beta
Intercept	-0.30056	0.20841	
VAR1	0.17923	0.00102	0.38161

Total Effects

Dep. Var	VAR5		
Indep. Var	Coeff	P-Value	Std. Beta
VAR1	0.79203	0.00000	0.52070
VAR2	0.50787	0.15998	0.15682

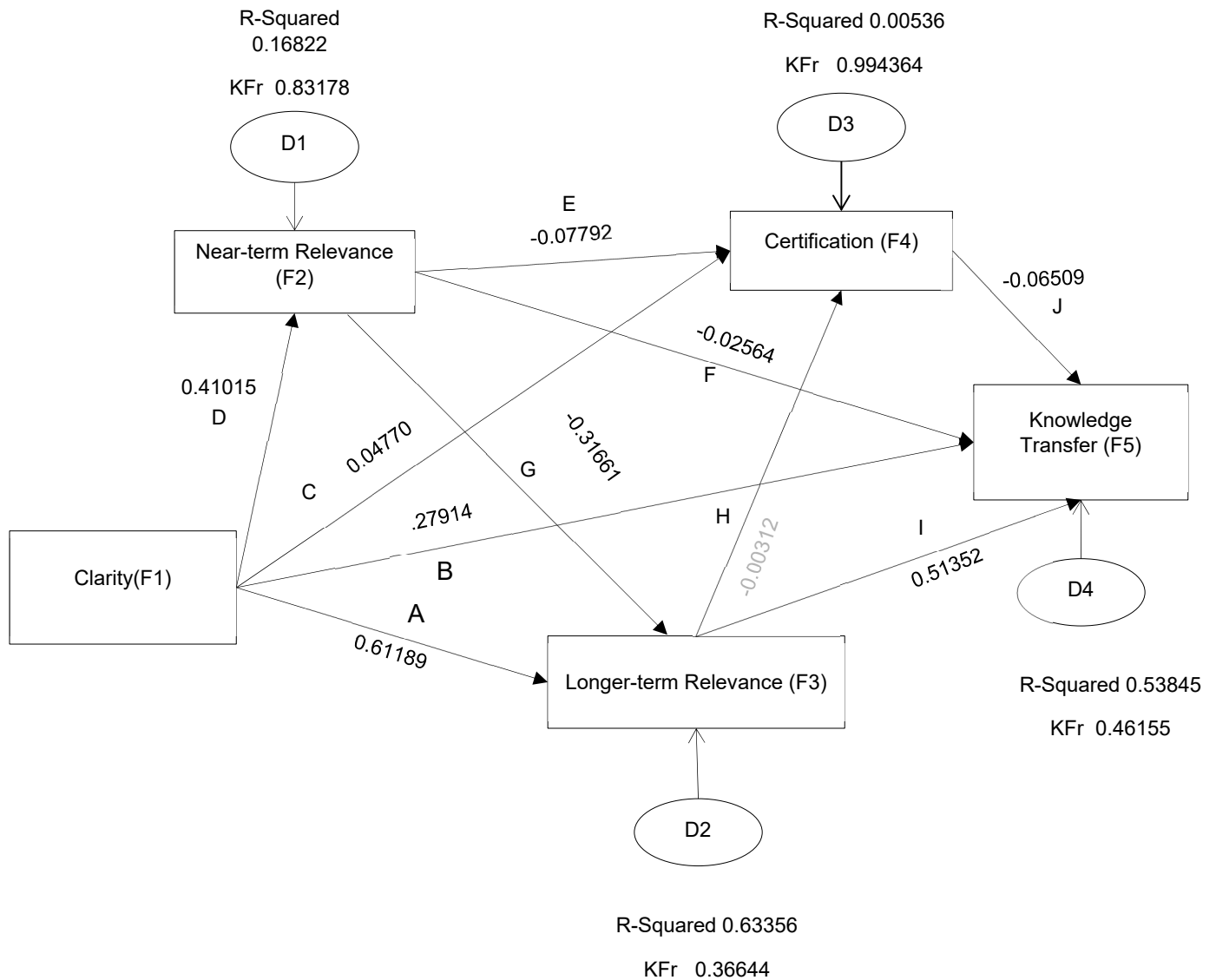
VAR3	0.83284	0.00011	0.91353
VAR4	-0.13267	0.00038	-0.33082

Summary Standardized Path Effects

Dep. Var	VAR5		
Indep. Var	Direct	Indirect	Total
VAR1	-0.05390	0.57461	0.52070
VAR2	-0.26426	0.42108	0.15682
VAR3	0.95359	-0.04006	0.91353
VAR4	-0.33082	0.00000	-0.33082

ACQ/CON/PNT

Courses



The model is adjusted to consider the strong impact of the *relevance* factor, and to reflect the Factor Analysis indicator that *relevance* acts as two separate factors. As stated earlier, the *experience* factor, which has shown very little explanatory power, and what little effect it has appears to be also captured in the stronger *certification* factor. On review, this makes sense, as the DAU Certification process requires a minimum number of years tenure to qualify for each level. For that reason, the *certification* factor is renamed *certification/experience*. The *experience* factor data used in the earlier treatments is removed. The aggregate of the direct and indirect paths provides the power of the model, while the individual paths provide the impact of each independent factor on dependent factor (F5). The direct effects on *knowledge transfer* (F5) are pathways B, F, I and J, from the four independent variables (*clarity* F1, *near-term relevance* F2, *longer-term relevance* F3, and *certification/experience* F4), which add together to provide 53 percent *knowledge transfer*. These factors also have indirect effects: Factor 1 has two valid indirect paths: AI and DF at 61 percent and -10 percent for an indirect effect of 51 percent. factors 2 and 3 do not have indirect impacts, and factor 1 does not directly impact factor 5 because their paths' p-value calculations determine that the links are not statistically significant. The full explanation of *knowledge transfer* and the inhibiting Knowledge Friction is the aggregation of all direct and indirect paths through the model to factor 5, which is that 53 percent of the knowledge is transferred (Mun, 2021). This instantiation removes *experience* from the model, as *certification* and *experience* have not been the major contributing factors, but *certification* has been nominally more influential and has an *experience* component in its explanation which is likely capturing the effects of the *experience* factor. For this reason the *certification* remains in the model to account for *certification* and *experience*. Also of note, this model lost some of its scope and granularity because of averaging of individual data for each of the courses in the DAU survey. The research tried to develop a triangulation to assure against macro-numerosity as discussed earlier, but the higher level of analysis (course verses individual) might not be supportable in this model.

Model Inputs

ACQ/CON/PNT:

VAR1; VAR2; VAR3; VAR4; VAR5

VAR1; VAR2; VAR3; VAR4

VAR1; VAR2; VAR3

VAR1; VAR2

F1 CLA, F2 Rel L, F3 Rel G, F4 Cert, F5 KT

F1 CLA, F2 Rel L, F3 Rel G,
F4 Cert

F1 CLA, F2 Rel L, F3 Rel G

F1 CLA, F2 Rel L

Structural Equation Model: Path Estimation (PLS)

Direct Effects

Path

Dep. Var

VAR5

R-Square 0.53845

Disturbance 0.67938

Indep. Var	Coeff	P-Value	Std. Beta
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Intercept	0.97342	0.00000	
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VAR1	0.32549	0.00000	0.27914
------	---------	---------	---------

VAR2	-0.11260	0.00002	-0.02564
------	----------	---------	----------

VAR3	0.53167	0.00000	0.51352
------	---------	---------	---------

VAR4	-0.08028	0.00000	-0.06509
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Partial Direct Effects Path 1

Dep. Var

VAR4

R-Square 0.00536

Disturbance 0.99731

Indep. Var	Coeff	P-Value	Std. Beta
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Intercept	1.65226	0.00000	
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VAR1	0.04509	0.00001	0.04770
------	---------	---------	---------

VAR2	-0.27744	0.00000	-0.07792
------	----------	---------	----------

VAR3	-0.00262	0.79355	-0.00312
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Partial Direct Effects Path 2

Dep.	Var			
VAR3				
R-Square		0.63356		
Disturbance		0.60534		
Indep. Var	Coeff	P-Value	Std. Beta	
Intercept	0.97094	0.00000		
VAR1	0.68913	0.00000	0.61189	
VAR2	1.34293	0.00000	0.31661	

Partial Direct Effects Path 3

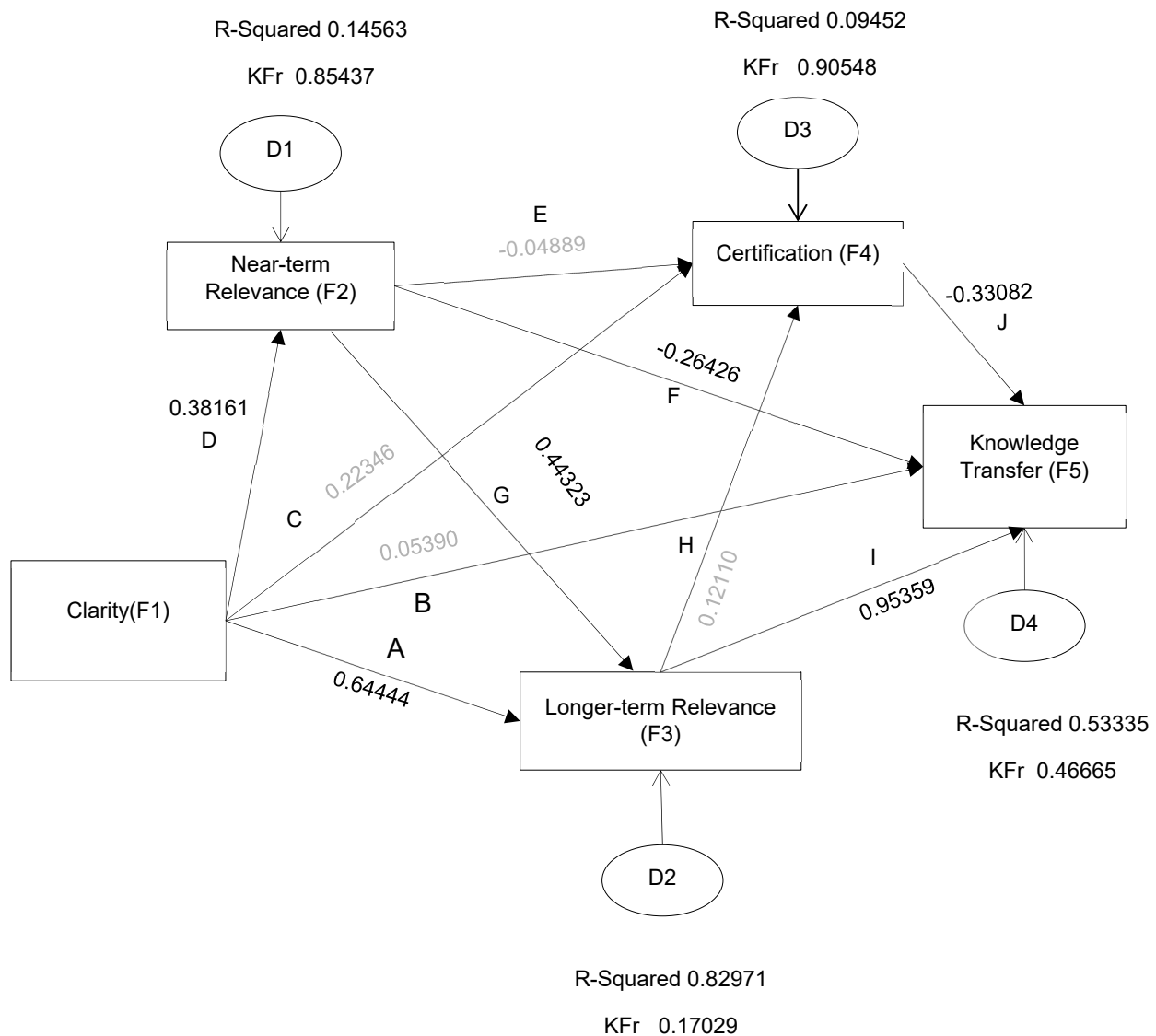
Dep.	Var			
VAR2				
R-Square		0.16822		
Disturbance		0.91202		
Indep. Var	Coeff	P-Value	Std. Beta	
Intercept	-0.09661	0.00000		
VAR1	0.10890	0.00000	0.41015	

Total Effects

Dep.	Var			
VAR5				
Indep. Var	Coeff	P-Value	Std. Beta	
VAR1	0.75636	0.00000	0.64864	
VAR2	0.62396	0.00000	0.14208	
VAR3	0.53188	0.00000	0.51372	
VAR4	-0.08028	0.00000	-0.06509	

Summary Standardized Path Effects

Dep.	Var			
VAR5				
Indep. Var	Direct	Indirect	Total	
VAR1	0.27914	0.36951	0.64864	
VAR2	-0.02564	0.16772	0.14208	
VAR3	0.51352	0.00020	0.51372	
VAR4	-0.06509	0.00000	-0.06509	



As explained in the research design section, the knowledge vectors flow in one direction. The aggregate of the direct and indirect paths provides the power of the model, while the individual paths provide the impact of each independent factor on dependent factor (F5). The direct effects on *knowledge transfer* (F5) are pathways B, F, I and J, from the four independent variables (*clarity* F1, *near-term relevance* F2, *longer-term relevance* F3, and *certification/experience* F4), which add together to provide 54 percent *knowledge transfer*. These factors also have indirect effects: Factor 3 indirectly impacts factor 5 at less than 1 percent through path HJ; factor 2 indirectly impacts factor 5 by 16 percent through paths EJ, GI, and GHJ; and factor 1 indirectly impacts factor 5 by 37 percent through paths AEJ, AF, AGI, AGHJ, BJ, DHJ, and DI. The full explanation of *knowledge transfer* and the inhibiting Knowledge Friction is the aggregation of all direct and

indirect paths through the model to Factor 5; which is that 65 percent of the knowledge is transferred (Mun, 2021).

This model articulates a few interesting observations. First, there is an increase of 11 percent in the explanative power of *knowledge transfer* and the associated amount of Knowledge Friction each factor can impose on that transfer. Second, the *clarity* factor greatly impacts both forms of the *relevance* factors and *knowledge transfer* factor; it has almost no impact on *certification* and *experience*. *certification* and *experience* in turn, has little impact on the *knowledge transfer* factor. Finally, per the p-Value (0.79: greater than 0.05), the *longer-term relevance* is not associated with the *certification and experience* factor. This final finding supports separating *near and longer-term relevance* into two separate factors and lends credence to the association of *longer-term relevance* with intrinsic motivation and self-betterment.

Another excursion is executed of the model, to challenge the selected framework of *clarity* (F1) leading to *relevance* (F2). *Relevance* and is combined and placed as the lead factor (F1). *Certification* is moved forward in the model (F2). *Clarity* is F3, and *Experience* is added as the last independent variable (F4). To try to draw out any masked impact of *certification* and *experience*, the data are mapped into blocks established by the two factors' low, medium and high rankings.

Relevance to KT with Low Experience

Direct Effects Path

Dep. Var: VAR5 Knowledge Transferred
R-Square 0.50830
Friction 0.49170

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	1.13634	0.00000	
Relevance	VAR1	0.78473	0.00000	0.17221
		-		-
Certification	VAR2	0.00430	0.85007	0.00180
Clarity	VAR3	0.72320	0.00000	0.61160
		-		-
Experience	VAR4	0.04230	0.08936	0.01632

Partial Direct Effects Path 1

Dep. Var: VAR4 Experience
R-Square 0.12073
Friction 0.87927

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	1.01394	0.00000	
		-		-
Relevance	VAR1	0.17841	0.00000	0.10149
Certification	VAR2	0.30490	0.00000	0.33130
Clarity	VAR3	0.01540	0.01462	0.03376

Partial Direct Effects Path 2

Dep. Var: VAR3 Clarity
R-Square 0.24061
Friction 0.75939

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	4.85838	0.00000	
Relevance	VAR1	1.89184	0.00000	0.49093
Certification	VAR2	0.02416	0.28542	0.01198

Partial Direct Effects Path 3

Dep. Var: VAR2 Certification

R-Square 0.00217
Friction 0.99783

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	1.30372	0.00000	
		-		-
Relevance	VAR1	0.08894	0.00029	0.04656

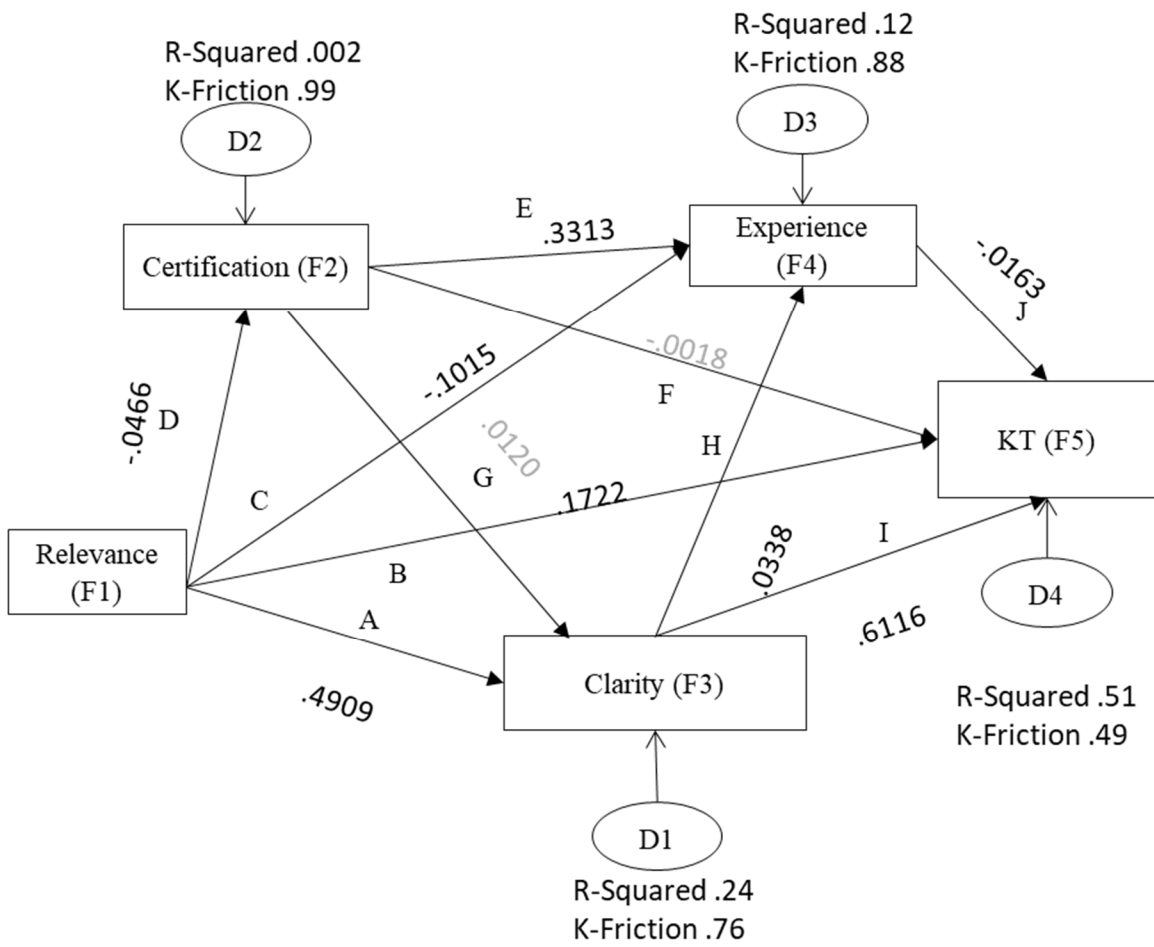
Total Effects

	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Coeff	P-Value	Std. Beta
Relevance	VAR1	2.15920	0.00000	0.47384
Certification	VAR2	0.00024	0.99301	0.00010
Clarity	VAR3	0.72254	0.00000	0.61104
Experience	VAR4	-0.04233	0.08936	-0.01633

Summary Standardized Path Effects

	Dep. Var	VAR5	Knowledge Transferred	
Var Name	Indep. Var	Direct	Indirect	Total
Relevance	VAR1	0.1722	0.3016	0.4738
Certification	VAR2	-0.0018	0.0019	0.0001
Clarity	VAR3	0.6116	-0.0006	0.6110
Experience	VAR4	-0.0163	0.0000	-0.0163

Relevance to KT with Low Certification/Experience



Direct Effects Path

Dep. Var: VAR5 Knowledge
Transferred
R-Square 0.47993
Friction 0.52007

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	1.52433	0.00000	
Relevance	VAR1	0.87027	0.00000	0.16986
		-		-
Certification	VAR2	0.08346	0.00045	0.05105
Clarity	VAR3	0.71899	0.00000	0.59986
		-		-
Experience	VAR4	0.12483	0.00214	0.04463

Partial Direct Effects Path 1

Dep. Var: VAR4 Experience
R-Square 0.01599
Friction 0.98401

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	3.32149	0.00000	
		-		-
Relevance	VAR1	0.10059	0.01275	0.05492
Certification	VAR2	0.06745	0.00000	0.11539
Clarity	VAR3	0.01029	0.27669	0.02401

Partial Direct Effects Path 2

Dep. Var: VAR3 Clarity
R-Square 0.19410
Friction 0.80590

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	4.77465	0.00000	
Relevance	VAR1	1.86917	0.00000	0.43729
Certification	VAR2	0.07056	0.00393	0.05173

Partial Direct Effects Path 3

Dep. Var: VAR2 Certification
R-Square 0.00002
Friction 0.99998

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	2.25304	0.00000	
Relevance	VAR1	0.01436	0.81844	0.00458

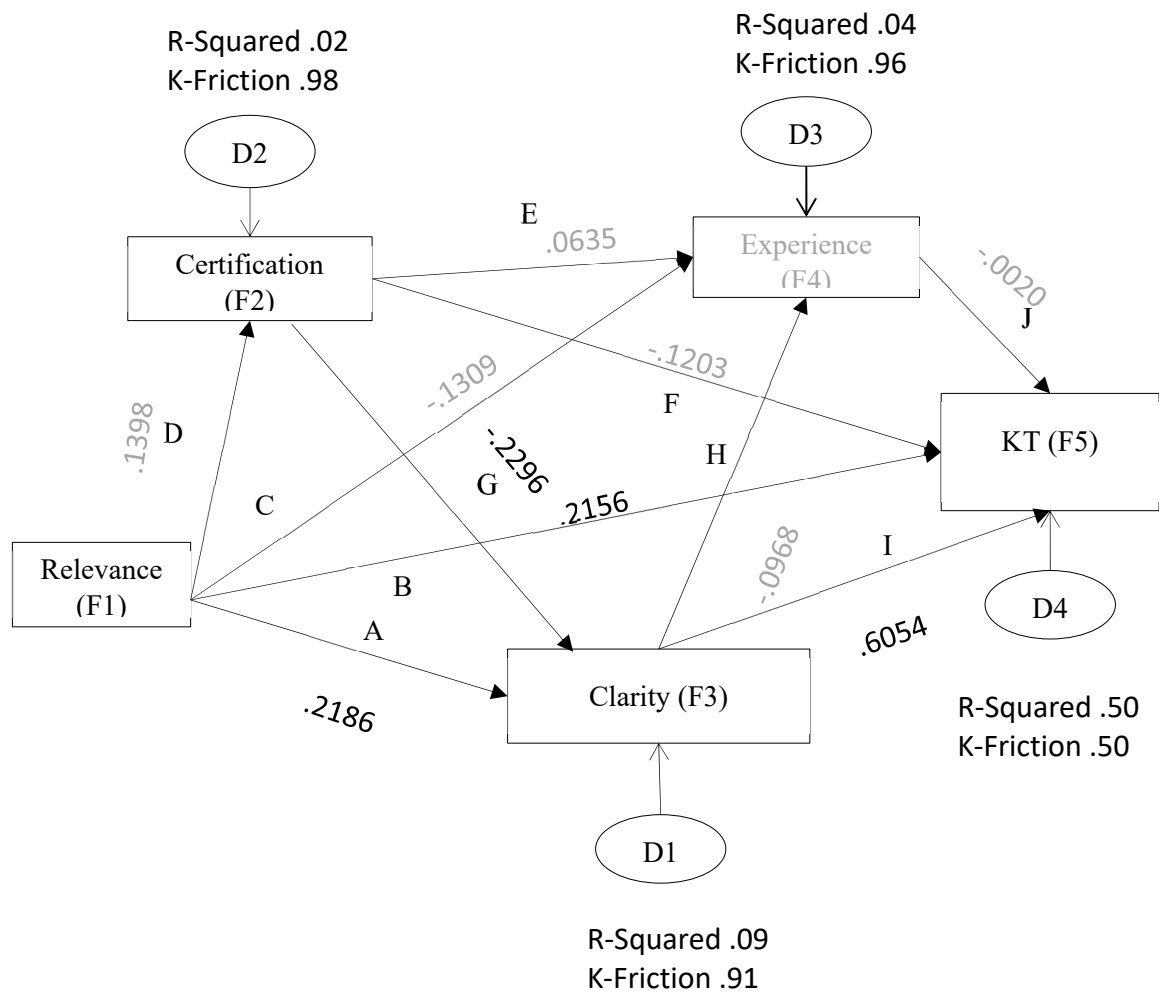
Total Effects

Var Name	Dep. Var	Indep. Var	Coeff	P-Value	Std. Beta
	VAR5				
Relevance	VAR1		2.22374	0.00000	0.43404
Certification	VAR2		-0.04124	0.16080	-0.02522
Clarity	VAR3		0.71771	0.00000	0.59879
Experience	VAR4		-0.12483	0.00214	-0.04463

Summary Standardized Path Effects

Var Name	Dep. Var	Indep. Var	Direct	Indirect	Total
	VAR5				
Relevance	VAR1		0.1699	0.2642	0.4340
Certification	VAR2		-0.0510	0.0258	-0.0252
Clarity	VAR3		0.5999	-0.0011	0.5988
Experience	VAR4		-0.0446	0.0000	-0.0446

Relevance to KT with Medium Certification/Experience



Direct Effects Path

Dep. Var: VAR5 Knowledge Transferred
R-Square 0.49837
Friction 0.50163

Var Name	Indep. Var	BETA	P-Value	Std. Beta
	Intercept	1.86784	0.25136	
Relevance	VAR1	1.08546	0.01983	0.21562
Certification	VAR2	-0.24043	0.18569	-0.12034
Clarity	VAR3	0.65095	0.00000	0.60537
Experience	VAR4	-0.00542	0.98179	-0.00202

Partial Direct Effects Path 1

Dep. Var: VAR4 Experience
R-Square 0.03539
Friction 0.96461

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	5.72731	0.00000	
Relevance	VAR1	-0.24538	0.29211	-0.13094
Certification	VAR2	0.04723	0.60915	0.06351
Clarity	VAR3	-0.03874	0.44007	-0.09678

Partial Direct Effects Path 2

Dep. Var: VAR3 Clarity
R-Square 0.08647
Friction 0.91353

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	6.68360	0.00000	
Relevance	VAR1	1.02333	0.06419	0.21858
Certification	VAR2	-0.42664	0.05215	-0.22963

Partial Direct Effects Path 3

Dep. Var: VAR2 Certification

R-Square 0.01954

Friction 0.98046

Var Name	Indep. Var	Coeff	P-Value	Std. Beta
	Intercept	3.04169	0.00000	
Relevance	VAR1	0.35226	0.24151	0.13980

Total Effects

Dep.		Knowledge
Var	VAR5	Transferred

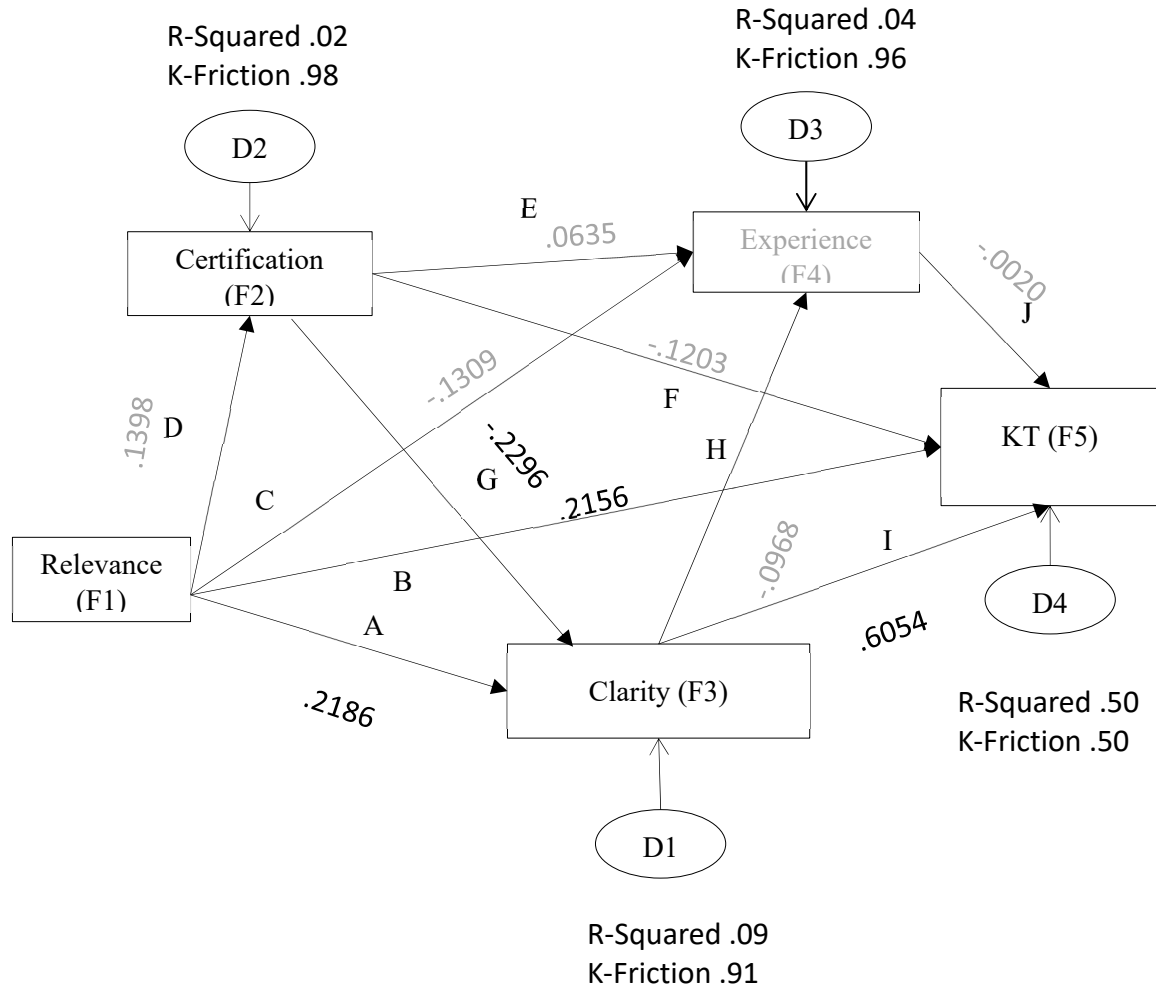
Var Name	Indep. Var	Coeff	P-Value	Std. Beta
Relevance	VAR1	1.57049	0.00764	0.31196
Certification	VAR2	-0.51850	0.02253	-0.25953
Clarity	VAR3	0.65116	0.00000	0.60557
Experience	VAR4	-0.00542	0.98179	-0.00203

Summary Standardized Path Effects

Dep.		Knowledge
Var	VAR5	Transferred

Var Name	Indep. Var	Direct	Indirect	Total
Relevance	VAR1	0.2156	0.0963	0.3120
Certification	VAR2	-0.1203	-0.1392	-0.2595
Clarity	VAR3	0.6054	0.0002	0.6056
Experience	VAR4	-0.0020	0.0000	-0.0020

Relevance to KT with High Certification/Experience



MODEL INPUTS:
 VAR1; VAR2; VAR3; VAR4; VAR5
 VAR1; VAR2; VAR3; VAR4
 VAR1; VAR2; VAR3
 VAR1; VAR2
 F1, F2, F3, F4, F5
 F1, F2, F3, F4
 F1, F2, F3
 F1, F2

STRUCTURAL EQUATION MODEL: PATH ESTIMATION (PLS)

DIRECT EFFECTS PATH			
DEP. VAR	VAR5		
R-SQUARE	0.58281		
DISTURBANCE	0.64591		
INDEP. VAR	COEFF	P-VALUE	STD. BETA
INTERCEPT	0.88607	0.00000	
VAR1	-0.25167	0.00000	-0.09482

VAR2	0.40067	0.00000	0.32104
VAR3	-0.13642	0.00000	-0.03010
VAR4	0.47982	0.00000	0.49747

PARTIAL DIRECT EFFECTS PATH 1

DEP. VAR	VAR4		
R-SQUARE	0.60652		
DISTURBANCE	0.62728		
INDEP. VAR	COEFF	P-VALUE	STD. BETA
INTERCEPT	0.51595	0.00000	
VAR1	0.07906	0.00000	0.02873
VAR2	0.69383	0.00000	0.53620
VAR3	1.87701	0.00000	0.39942

PARTIAL DIRECT EFFECTS PATH 2

DEP. VAR	VAR3		
R-SQUARE	0.15595		
DISTURBANCE	0.91872		
INDEP. VAR	COEFF	P-VALUE	STD. BETA
INTERCEPT	-0.17648	0.00000	
VAR1	0.02176	0.00000	0.03716
VAR2	0.11101	0.00000	0.40316

PARTIAL DIRECT EFFECTS PATH 3

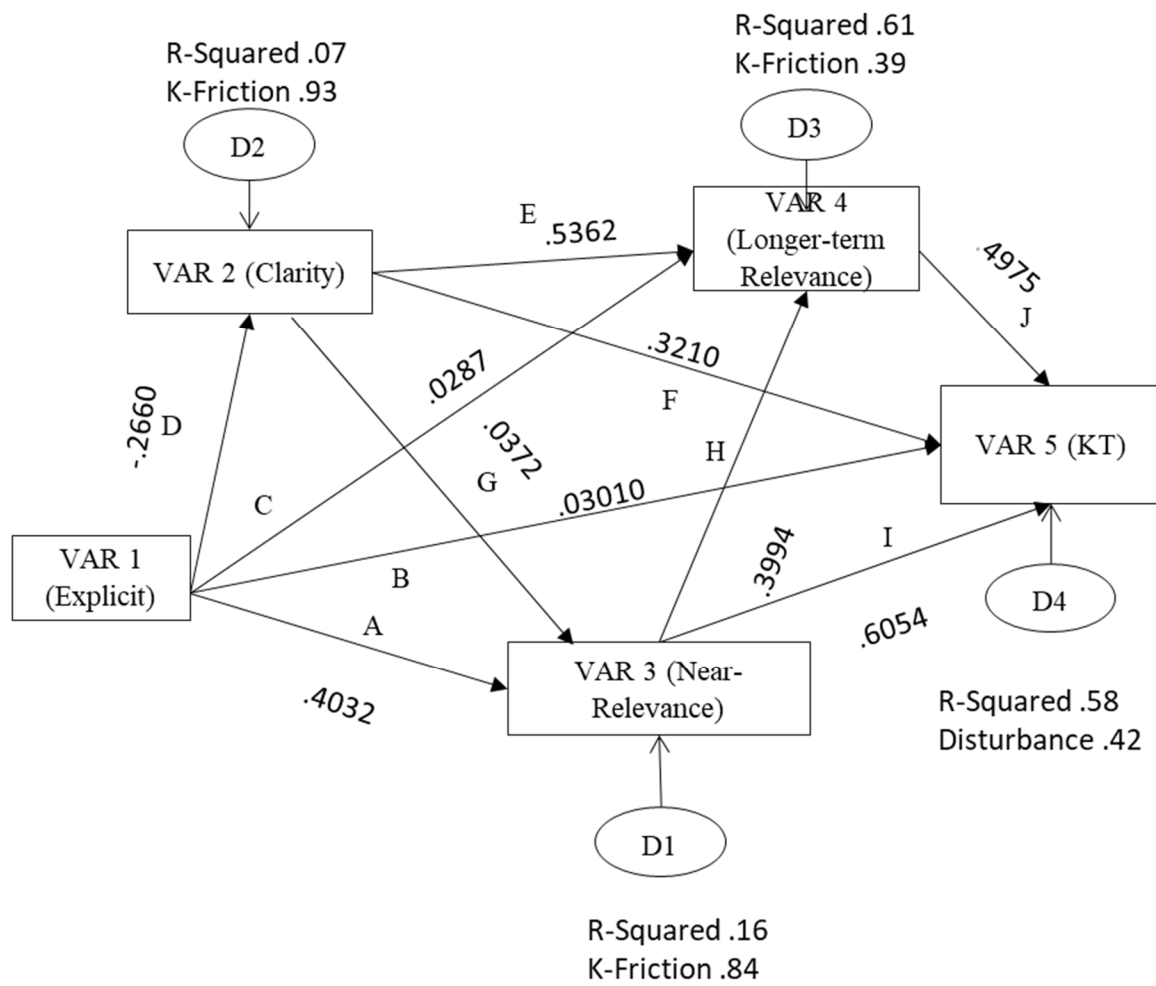
DEP. VAR	VAR2		
R-SQUARE	0.07077		
DISTURBANCE	0.96397		
INDEP. VAR	COEFF	P-VALUE	STD. BETA
INTERCEPT	6.51879	0.00000	
VAR1	-0.56570	0.00000	-0.26602

TOTAL EFFECTS

DEP. VAR	VAR5		
INDEP. VAR	COEFF	P-VALUE	STD. BETA
VAR1	-0.66009	0.00000	-0.24871
VAR2	0.81842	0.00000	0.65575
VAR3	0.76421	0.00000	0.16860
VAR4	0.47982	0.00000	0.49747

SUMMARY STANDARDIZED PATH EFFECTS

DEP. VAR	VAR5		
INDEP. VAR	DIRECT	INDIRECT	TOTAL
VAR1	-0.09482	-0.15389	-0.24871
VAR2	0.32104	0.33472	0.65575
VAR3	-0.03010	0.19870	0.16860
VAR4	0.49747	0.00000	0.49747



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