GDAŃSK UNIVERSITY OF TECHNOLOGY
FACULTY OF MANAGEMENT AND ECONOMICS

TACIT KNOWLEDGE AWARENESS AND SHARING INFLUENCE ON INNOVATION

Wioleta Kucharska*, G. Scott Erickson**

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* Gdansk University of Technology, Faculty of Management and Economics, wioleta.kucharska@pg.edu.pl
** Ithaca College, Ithaca, NY, USA, gerickson@ithaca.edu (corresponding author)

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Abstract

This study measures the relationship between tacit knowledge and innovation in the Polish and US information technology (IT) industries. Large samples were obtained, allowing quantitative modeling not possible in many tacit knowledge studies focused on more qualitative analysis. Conceptually, the study identifies the potential sources of tacit knowledge (learning-by-doing and/or learning-by-interaction), individual tacit knowledge development leading to a willingness to share, and the consequent correlation to process and/or product/service innovation. The important role of critical thinking as a control variable in tacit knowledge development in individuals is also identified as is the connection of process innovation as a mediator between tacit knowledge sharing and product/service innovation.

The model is supported across both samples though with interesting differences across countries, particularly in sources of tacit knowledge (more learn-by-doing in the US), the link between awareness and sharing (stronger in US), and innovation (process as a full mediator in Poland, complementary in the US). The main theoretical contribution is empirical support for tacit knowledge's role in innovation, including the step-by-step details of how everything connects as well as details on how the model can differ by national context. The managerial implications include the care that must be taken to evaluate national circumstances and their potential impact on a firm's management of tacit knowledge.

Keywords
Tacit knowledge, knowledge awareness, knowledge sharing, innovation, IT industry, Poland, USA

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1. Introduction

Tacit knowledge has been a key topic in the study of knowledge management since its inception. Unlike explicit knowledge, tacit can be hard to recognize and define, hard to express, and consequently hard to measure. Even so, tacit knowledge has been much researched though often in a qualitative, mostly case-based manner. The importance of tacit knowledge to a firm's competitiveness merits a closer, more extendable quantitative approach.

This study surveys information technology professionals, providing quantitative empirical data on the sources of tacit knowledge, how it develops within the individual until they are willing and able to share it, and its impact on the firm's innovation. By using structural equation modeling, relationships between these levels of creation, development, and impact can be empirically evaluated. And by conducting the research across two dissimilar countries (Poland and the US), the context of the model can also be assessed.

As shown in the literature, quite a bit is known about tacit knowledge. But that understanding is often based on limited studies including only a single firm or a small sample. Part of the reason may be the vagueness of tacit knowledge itself—difficult to understand, difficult to explain to others, difficult to codify. Like tacit knowledge itself, its study lends itself to more qualitative approaches. But to the extent that tacit knowledge can be grasped intuitively by many who possess it, opportunities exist to study it in a more quantitatively rigorous manner. This study fills that gap. As noted, the study is also cross-country, another rarely employed approach but one offering particular opportunities for understanding tacit knowledge in different circumstances.

Specific hypotheses focus on the impact of the source of tacit knowledge, whether learning by doing or learning by interaction have more impact. Once the individual possesses tacit knowledge, does awareness drive the confidence and willingness to share it with others? Further, does critical thinking, as a control variable influence this development of the knowledge? What is the impact of tacit knowledge on innovation in the firm, does it differ by type (process innovation or product/service innovation), and is there a path from process to product innovation that mediates the outcome? Finally, do these relationships differ by country?

This paper will first consider theory surrounding tacit knowledge, both generally and in the more specific areas to be assessed. The conceptual model and related hypotheses will then be presented. Discussion continues with the methodology, including sampling strategy and measures. Analysis and results follow, including the critical thinking control variable and mediation analysis. Finally, the discussion concludes with theoretical and managerial implications as well as limitations and future research.

2. Theoretical Framework

The foundation for this study is built upon various key strands of research concerning tacit knowledge, strands which have not been fully connected in past work. Each is important and distinctive in its own applications but has not necessarily been linked to other important and distinctive work.

The overall view of tacit knowledge developed in this paper is from acquisition to impact on firm performance. That perspective needs some framing. This section focuses on the general concept of tacit knowledge before following sections discuss specific aspects in more detail.

Tacit knowledge has been a core idea in the realm of knowledge management and related disciplines since their beginning. Evolving out of sociology (Polanyi 1961), the differentiation between explicit and tacit knowledge was fundamental to understanding knowledge assets in organizations. Nonaka & Takeuchi (1995) focused on the distinction, contrasting codifiable, explainable explicit knowledge with hard-to-express, hard-to-share tacit knowledge. In order to leverage these knowledge assets, the distinction is important. Explicit is more amenable to capture by the organization and then shared by means of formal processes and procedures and/or information technology (Matson, Patiath & Shavers, 2003; Thomas, Kellogg & Erickson, 2001). Tacit, harder to identify and formalize is more likely to be managed in person-to-person manners such as apprenticeships, mentoring, and/or communities of practice (Brown & Duguid, 1991).

From the beginning, tacit knowledge as a concept has been hard to define because of its unstructured nature. While anecdotes and examples can help to illustrate how tacit is different from explicit, further amplification of the concept has not been a smooth process. Especially if the discussion is taken out of an either/or context and viewed as more of a continuum, with a specific piece of knowledge more tacit or more explicit. This view lines up well with Ackoff (1989) and others' DIKW hierarchy, ranging from structured, objective data through information, knowledge, and on to unstructured, subjective wisdom. A more recent formulation is the Cynefin framework (Kurtz & Snowden, 2003) focusing on environments with centralization of intangible assets and/or peripheral sharing. Based on these circumstances, the continuum can be revised as data/information, explicit knowledge, tacit knowledge, and insight/intelligence (Rothberg & Erickson, 2017).

When considered in this manner, explicit knowledge is degrees away from data/information, objective and codifiable. While tacit is differentiated from explicit, also by a matter of degrees, it is also closer to hard-to-define insight. In innovation studies, that creative spark, the eureka moment has proved extremely hard to not only describe but to develop in an organization beyond the initial inventor. But it is amenable to quantitative metrics. Tacit knowledge can have elements of this fuzziness or it may be closer to the explicit, structured end of the spectrum. In any event, it is considerably harder to describe, understand, and capture than is the case with more explicit knowledge.

2.1 Tacit knowledge

The opaque nature of tacit knowledge is reflected in its scholarship. Research has explored both its nature and its sources. Given its more subjective, unstructured nature, there is thought that tacit knowledge is more based on personal experience and reflection (Hau & Evangelista, 2007). Alternatively, to the extent that tacit knowledge can be shared with others, individuals must also be able to learn it through interaction (Insch, McIntyre & Dawley, 2008) , though perhaps not as much through structured mechanisms or formal training programs as might be the case with explicit.

Relatedly, there has also been a sense that tacit knowledge is more practical than theoretical, originating in activities rather than theory (Sternberg, et. al., 1995). To the extent it is grounded in experience, different versions of how it grows in individuals have been proposed. Nonaka (1994) suggested a cognitive component, including the experiential inputs needed, and a technical component including the learning skills to apply tacit knowledge, essentially preparation and execution. A more recent extension includes an effectuation component, the individual realizing they know something valuable (Jisr & Maamari, 2017), leading to socialization and sharing.

With tacit knowledge difficult to pin down definitionally, challenges in capturing how it is acquired and shared are not surprising. A lot of the work on tacit knowledge has been qualitative, often case studies, which are extremely useful for understanding situational details on its nature and management.

Significant work on explicit knowledge also uses qualitative approaches and specific examples , but, in addition, has been able to bring in more quantitative empirical approaches. As it is often more structured and formalized, explicit knowledge levels can be estimated by indicators such as education levels and training hours. Explication and sharing of explicit knowledge can be assessed through IT system usage statistics. Impact on the firm can be measured by standard financial indicators or innovation productivity. And, as explicit knowledge is fairly well-defined and understood by users, all of the above can and are measured through self-report scales as well.

Tacit knowledge poses more challenges with its less-defined nature and related concepts, but enough work has been done to allow something more quantitative to be executed in trying to understand its role in a similar process. In particular, while tacit knowledge content may be fuzzy and hard to communicate, the concept of tacit knowledge itself can be explained. Part of the reason tacit knowledge is so readily accepted as a phenomenon is that people recognize the idea from their own real-world experience. If so, it should be possible to measure it quantitatively through self-reports. Consider some of the details as laid out in the following sections.

2.2 Layers of tacit knowledge

Tacit knowledge, as noted earlier, is typically modeled as having progressive layers of development (acquisition, awareness, etc.) with some continued questions about when it is impactful. Do individuals need to be aware of their own knowledge in order to apply it effectively? Does awareness increase tacit knowledge's impact? Given how difficult it can be to express tacit knowledge, is something more than awareness necessary for sharing?

The earlier discussion defined tacit knowledge with specific levels of awareness, application, and social interaction, suggesting differing degrees of tacitness. Moving to more recent conceptualizations, Asher and Popper's (2019) "onion" model posits different layers of tacit knowledge and a description of knowledge as a matter of degree along a single axis—knowledge is more explicit at one end, moving to more tacit at the other end with elements of both making up the middle. From this perspective, tacit again has three aspects: a hidden practical layer, a reflective tacit layer, and a demonstrated tacit layer. These range from more explainable and closer to explicit knowledge to virtually impossible to explain but only demonstrable, at the furthest reaches of tacit knowledge (perhaps verging on the insight/intelligence concept developed in the fuller discussion on all intangible assets).

Similarly, Olaisen and Revang (2018) also argue for a three-level model, including representable knowing, non-represented knowing, and non-representable knowing. Again, representable knowing can be explained and is at the explicit end of things though requiring some degree of tacit interpretation for actual application. Non-represented is tacit knowledge not yet explicit but that could be. Non-representable is most tacit and cannot be made explicit. Issues of individual knowing versus organizational knowing are also explored, raising the question of whether the knowledge can be shared and if individuals are willing to share it. Their conclusion, based on an in-depth case study of a furniture manufacturer, is that all forms have the potential to be shared across the collective though recognition of the tacitness and use of appropriate techniques (e.g. observation) is important. A more quantitative approach could lend weight to these insights.

2.3 Sharing of tacit knowledge

Individuals possessing valuable tacit knowledge, especially if they recognize they have it, need to be willing to share it if the firm is to more fully benefit. Prior research has clarified a number of details concerning these circumstances. From one perspective, individual characteristics engender tacit development, workers not only develop deeper tacit understanding, ranging from situational (context-specific solutions), to standardized response (repeated solutions), to intuitive insight (Eraut, 2000) but also gain more confidence in the effectiveness of their knowledge. As individuals internalize their tacit learning, they gain both self-efficacy and a sense of expert power (Wipawayangkool & Teng, 2006a; 2006b). This confidence in their own knowledge and usefulness, combined with the recognition of fit to a given situation can lead to more willingness to apply their knowledge and/or share it with others. Individual willingness is key as sharing is an informal, voluntary act (Kucharska, & Kowalczyk, 2016, 2017) Senses of internal control (self-confidence) and external control (influence results) combined with strong social capital can influence the intention to share and push the individual toward completion (Göksel & Aydintan, 2017). In more practical terms, individuals will share rather than hoard knowledge when they are confident in what they know, that it will contribute, and that the organization will value their contribution. Both self-confidence and organizational acceptance can be important.

A related issue is the source of the tacit knowledge as it may influence awareness and sharing intention. As noted earlier, tacit is viewed as knowledge coming from practical experience, it is something recognized and then applied but it could come individual experience or from another sharing their experience. Tacit knowledge can be acquired first-hand through experience over time or more quickly from someone communicating and/or demonstrating knowledge person-to-person. Source has the potential to impact both recognition and explicability of tacit knowledge as well as the willingness and confidence to share it.

2.4 Tacit knowledge and innovation

Finally, returning to the question of why a deeper understanding of tacit matters, considerable research has been conducted into the relationship between knowledge, knowledge management, and firm performance (operational, financial). In particular, however, there is a suggested connection between tacit knowledge and innovation performance. Intuitively, this relationship makes a lot of sense. As noted earlier, tacit knowledge is more to the wisdom/insight end of the intangibles continuum. It would seem more likely to generate innovative ideas than explicit knowledge or data/information at the more incremental end of the continuum. Indeed, Liu & Han (2012), specifically associate tacit knowledge with creativity in innovation processes. Similarly, the empirical relationship between tacit knowledge and the "fuzzy front end" breakthrough ideas emphasized the role of sharing through tacit techniques such as stories and metaphor (Sakellariou, Karantinou & Goffin, 2017). In a precise set of circumstances (foreign-sourced tacit knowledge), Sheng (2019) was able to show that under the right conditions, tacit knowledge does contribute to product innovativeness. Finally, Ganguly, Talukdar & Chatterjee (2019) recently brought together some of the tacit characteristics we have discussed, including knowledge quality and knowledge sharing, and showed a correlation with innovation capabilities.

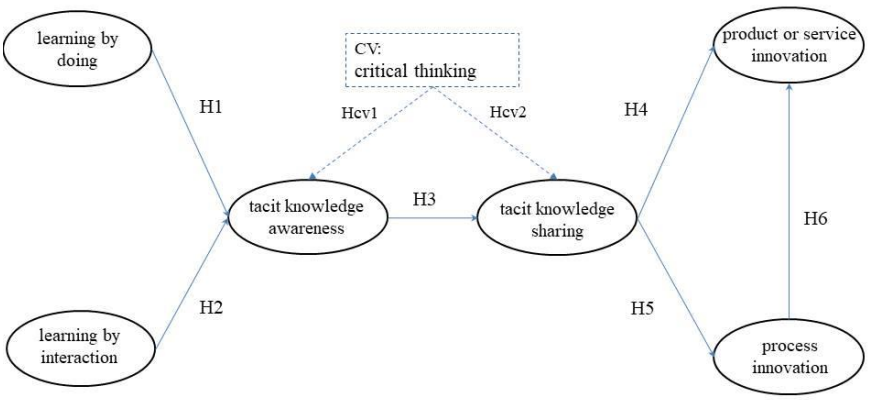
As suggested, a considerable literature has accumulated regarding tacit knowledge, its sources, its characteristics, and its relationship to organizational performance. Even so, there is still disagreement about how tacit knowledge and its characteristics can be operationalized for study. And while there are exceptions, much of the empirical work has been more qualitative or small sample, so there are calls to do more quantitative, bigger sample, more widely dispersed studies in order to better understand the

role of tacit knowledge, especially in supporting innovation (Sheng, 2019; Olaissen & Revang, 2018). This study starts to fill that gap.

3. Hypothesis Development

The theoretical model is illustrated in Figure 1, including the specific hypotheses. The bases for these hypotheses are described below.

Figure 1
Conceptual Model



3.1 Tacit knowledge development

As described above, tacit knowledge is almost always characterized as being highly personal, not necessarily something perceived consciously, and more difficult or even impossible to explicate or share. The literature has different versions, but several depict tacit as some mix of hidden/non-representable knowledge, recognized/representable, and demonstrable/represented (Asher & Popper, 2019; Olaisen & Revang, 2018). In our model, the focus is on tacit knowledge which can be recognized and then shared. Specifically, as individuals become aware of having learned something, they reflect upon it, reduce it to a form that can be communicated, and share.

Modeled in that way, the natural question is what allows individuals to move through those stages? The literature just reviewed noted how internalization can occur, how the individual can reflect upon what they are doing and/or what they know. With internalization comes self-efficacy and expert power (Wipawayangkool & Teng, 2006a; 2006b), building confidence in the value of the knowledge and the user's ability to judge when to apply it. This reflection and resulting depth of understanding can be characterized as critical thinking (Oswald & Mascarenhas, 2019). To better understand the link between tacit knowledge awareness and tacit knowledge sharing, this study directly investigates the direct connection between awareness and sharing as well as the potential intervening variable of critical thinking.

3.2 Tacit knowledge sources

Before this process of tacit knowledge awareness to tacit knowledge sharing happens, the individual needs to acquire the knowledge. As detailed in the literature described above, tacit knowledge comes from personal learning, specifically through first-hand experiences or person-to-person sharing, referred to as learning by doing or learning by interacting (Muñoz, Mosey & Binks, 2015; Eraut, 2000). Learners may or may not be conscious of the learning but once possessed, the process of awareness, internalization, and then sharing can begin.

That circumstance begs the question about whether the learning source impacts how that process happens. Does learning by doing raise awareness and potential sharing? Some previous research suggests learning by doing does lead to self-recognition of new knowledge (Zou & Lees, 2016; Insch, et. al., 2008) and suggests the following hypothesis:

H1. Learning by doing fosters tacit knowledge awareness.

Alternatively, does learning by interacting raise awareness and potential sharing? Previous literature again provides some evidence that learning by interaction can also engender knowledge recognition (Oswald, et. al., 2019; Leonared & Insch, 2010; Brachos, et. al., 2007). Consequently, a second hypothesis, complementary to the first, can also by advanced.

H2. Learning by interaction fosters tacit knowledge awareness.

Further, once the precursors for the hypothesized model are in place, the theorized relationships developed in the previous section can be explored. Specifically, if individuals become aware of their tacit knowledge, are they more likely to participate in knowledge sharing in the organization? Confidence in their own understanding and belief in the benefits to others of their tacit knowledge may lead to more sharing behavior. As detailed above, internalization and self-efficacy make sharing more likely and can be tied to tacit knowledge awareness.

H3. Tacit knowledge awareness influences tacit knowledge sharing.

As also detailed above, critical thinking may be an extraneous variable influencing both tacit awareness and tacit sharing. As a control variable (Nielsen & Raswant, 2018), it may be important to a full representation of the model. Critical thinking, essentially self-reflection on the knowledge, may increase awareness:

Hcv1. Critical thinking positively influences tacit knowledge awareness.

Critical thinking may also create the self-efficacy and confidence leading to more sharing. When confident of adding value, based on reflection, individuals may be more inclined to share.

Hcv2: Critical thinking positively influences tacit knowledge sharing.

3.3 Innovation

Once tacit knowledge is acquired and recognized by the individual, it can be applied to their work and/or shared with others. The underlying justification for interest in managing this knowledge is the impact on

organizational performance. This could be operational (efficiency, quality), financial (profitability, ROI), or some other desired outcome (competitiveness). One common indicator is improved innovation performance. Similar to other concepts discussed in this paper, innovation can be viewed in a number of ways, but product vs. process innovation is a common one (Eidizadeh, Salehzadeh & Esfahami, 2017; Jimenez-Jimenez & Sanz-Valle, 2011; Jimenez-Jimenez,Sanz-Valle & Hernandez-Espallardo, 2008; Manu, 1992).

Product innovation relates to the development and introduction of new products, both goods and services. For clarity in notation, this variable is referred to in this paper as product/service innovation. Process innovation, as the name suggests, has more to do with operational processes, the manufacturing of the good or the execution of the service. As discussed earlier, there is a sense in the literature that effective knowledge management, particularly of tacit knowledge, can help to generate innovation (Sheng, 2019; Kodama, 2019; Jisr & Maamari, 2017; Sakellariou, Karantinou & Goffin, 2017; Goffin & Koners, 2011; Goffin, et. al., 2010; Brachos et al., 2006). In particular, tacit knowledge, on the more subjective and unstructured side of intangible assets may be particularly linked with customer-facing product and service innovation.

H4. Tacit knowledge sharing positively influences product or service innovation.

But tacit knowledge is also linked with more incremental, process-based improvements. And from the perspective of employees, these may be the innovations they are most likely to experience first-hand and see in their workplace.

H5. Tacit knowledge sharing positively influences process innovation.

Either type of innovation is possible, but the more incremental innovations often seen in process innovation may lead to the sometimes more substantive product/service innovations. A buildup of improvements in operational processes can lead to new products and services as well.

H6. Process innovation positively influences product or service innovation.

3.4 Nationality

Given all the individual, social, and cultural aspects of developing and sharing knowledge, a frequent area of study in the field concerns how national differences affect management. That includes some of the specific literature forming the basis of this study, including the acquisition, recognition, and sharing of tacit knowledge (Sheng, 2019; Lee, et. al., 2008; Subramanian & Venkatraman, 2001).

This study includes two different samples, from the US and from Poland. The former, of course, is a highly developed, mature economy while the latter is fast-growing and still developing. No further hypotheses are advanced but the discussion will report on national differences in support of the hypotheses already described.

4. Method

4.1 Samples and data collection

Scale validation requires a minimum of two separate samples (Meek, et. al., 2019; de Vellis, 2017) to verify the reliability and validity of the proposed scales. Accordingly, the sampling plan here included independent samples of information technology (IT) professionals in Poland (n = 350) and the US (n = 379). The complexity of the study required high quality sampling procedures though given the population size and dispersion, simple random sampling would have been challenging. Accordingly, sampling administration was online and executed by survey partners Qualtrics (US) and ASM (Poland). The partners used panel-based quota sampling, providing necessary randomness with reasonable efficiency.

Survey execution took two months (January - February 2020). The questionnaire included filter questions to establish minimum work experience and status as a "knowledge worker". Respondents were also prompted with a short explanation of the meaning of "tacit knowledge". The core of the survey, excluding classification items, used a seven-point Likert scale to assess intensity of feeling. Data management was straightforward. Only fully completed questionnaires with SD>0.4 were included.

Table 2 presents the sample characteristics. Where comparable, the sample generally matched the underlying populations (jobs, gender) of both countries (Polish Yearbook, 2017; Bureau of Labor Statistics, 2020). While some differences were apparent in the underlying populations, they were not significant enough to justify varying the quota targets. The Polish quota structure was used as a pattern for samples for both countries.

Table 1
Sample Characteristics

Characteristic	Poland (n = 350)	USA (n = 379)
C-suite	3%	3%
Top managers	7%	7%
Middle managers	23%	23%
Professionals	67%	67%
Company size		
Micro (<10 employees)	3%	2%
Small (10-50 employees)	77%	6%
Medium (51-250 employees)	11%	25%
Large (>250 employees)	8%	66%
Age		
18-24	1%	2%
25-34	19%	27%
35-44	49%	50%
45-54	21%	16%
55-64	9%	6%
65 and over	2%	1%
Gender		
Female	50%	49%
Male	50%	50%
Other	0	1%

KMO	.838	.908
Harman single factor test	23%	33%
Total Variance Explained	65%	73%
Common Method Bias	24%	48%

4.2 Measurement metrics

In assessing sample quality, invariance was reviewed using the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO test) and Harman single factor tests. The samples come from two countries, so the invariance tests of adequacy are needed to verify the measurement instrument operates properly across the different populations. As will be discussed, the scales were developed by the authors based on items and terminology from the literature. Consequently, these scales must be validated and nationally invariant. As indicated in Table 2, the agreement of the scales with the constructs was assessed with multi-group confirmatory factor analysis (MCFA) (Byrne, 2016). Both sample sizes are above 300, so the more liberal model global fit indices (CFI, RMSEA) were applied (Chen, 2007). The measured change in model fit is around 0.01 or less for CFI and 0.015 or less in for RMSEA, confirming national invariance (Raudenska, 2020; Byrne, 2016; Chen, 2007). The table also reports alternative fit indicators, all of which show a similar pattern.

Referring back to Table 1, the KMO test of for sample adequacy was .838 for Poland and .908 for the US, confirming the good quality of the samples (Hair, 2010; Kaiser, 1974). The Harman single factor tests came out at 23% (Poland) and 33% (US) indicating no single factor is predominant (Podsakoff & Organ, 1986). All samples achieved an accepted level of Common Method Bias (CMB), namely 24% for Poland and 48% for the US, confirming good sample quality and enabling further analysis.

Table 2
Invariance Measurement

MCFA models	**AGFI**	**GFI**	**CFI**	**TLI**	**RMSEA**
Unconstrained model	.876	.902	.939	.929	.036
Loading measurement equality, measurement model (Δ)	.871 (.005)	.894 (.008)	.931 (.008)	.923 (.006)	.038 (.002)
Factor covariances equality, structural model (Δ)	.859 (.012)	.884 (.010)	.915 (.016)	.905 (.014)	.042 (.004)

4.3 Measurement constructs

As noted in the literature review, tacit knowledge has not been subjected to large sample, quantitative studies to the same degree as other areas in knowledge management, including explicit knowledge. Even so, some guidance from the literature does exist, including related validated scales and frequent emphasis on key components of constructs.

Sources of knowledge are hinted at in previous constructs, including those related to metacognition and expert power (Wipawayangkool & Teng, 2006a; 2006b) and the cognitive and social aspects of student learning environments (Insch, McIntyre & Dawley, 2008). Those items, combined with key words from less quantitative literature such as “expert knowledge” and “practical experience” (Olaisen & Revang, 2018), “learning by doing” (McLeod, et. al., 2006), and “practical experience in a relevant context” (Lam,

1998), led to the learning by doing and learning by interaction constructs and items included in the instrument. Details are included in the appendix.

Critical thinking, in a number of ways, links directly to existing quantitative work. These sources again include Wipawayangkool & Teng's (2006a; 2006b) mental models, efficiency, and automaticity constructs. Deliberative tasks based on reflection are also behind Insch, McIntyre & Dawley's (2008) cognitive and technical constructs. Supplemented again with specific terminology such as "constructive thinking" (Oswald & Mascarenhas, 2018), critical thinking construct items were also included.

The tacit knowledge constructs, awareness and sharing, are a bit more straightforward as directly applicable constructs are available in the literature. Recognizing valuable personal knowledge as tacit is reflected in Sheng's (2019) foreign tacit knowledge construct while both Ganguli, Talukdar & Chatterjee (2019) and Wipawayangkool & Teng (2006a; 2006b) have sharing constructs (termed "personalization" in the latter). As adapted to this study, these comprise the tacit knowledge awareness and tacit knowledge sharing construct items.

The innovation constructs are mixed. The product/service innovation concept is well-established in the literature, and items to establish the organization's perceived success in product or service innovation are readily available from both the Sheng (2019) and the Ganguli, Talukdar & Chatterjee (2019) frameworks already mentioned. These are adapted for the product or service innovation context. Process innovation is more problematic as it is a concept more focused on incremental improvements in the individual worker's job environment. Consequently, the items are from the perspective of the work group and its receptivity to improvements and change, constant topics in the broader knowledge management literature.

4.4 Measurement Model

After positive verification of samples and questionnaire quality, Confirmatory Factor Analysis (CFA) was conducted to assess the convergent and discriminant validity of the empirical results, based on the theoretical model presented in Figure 1. CFA was completed separately for Poland and USA. In addition, the critical thinking (CT) control variable was imputed by mean value from the obtained scale measures. Measured constructs reached indicator loadings (standardized) above the reference level of >0.6 (Hair, et. al, 2010; Fornell & Larcker, 1981). Internal consistency of the constructs was assessed using Cronbach's alpha and a critical level >0.7 (Francis, 2001), average variance extracted (AVE) was assessed with a test statistic >0.5,and composite reliability >0.7 (Byrne, 2016; Hair et al., 2010), all establishing scale validity.

Discriminant validity was assessed by comparing the AVE square root against correlations with other constructs (deVellis, 2017; Hu & Bentler, 1999; Fornell & Larcker, 1981). Results, from IBM SPSS AMOS software, are presented in Table 3. All AVE's were appropriately larger with the key exception of the process innovation and product/service innovation constructs. For Poland, the AVE square root is larger but only barely, suggesting the possibility of collinearity. For US, the AVE is larger than one correlation (barely) but not the other. Again, collinearity is suggested. But that is actually an interesting result itself, especially because it differs in magnitude across the two samples. The result will be explored in more detail in the mediation results.

Table 3
Means, Standard Deviations, and Bivariate Correlations (Poland/US)

Construct	Critical Thinking	Learn by Interaction	Learn by Doing	Tacit Know Awareness	Tacit Know Sharing	Process Innovation	Prod/Serv Innovation
Learn by Interaction	.237/ .468	**.716/ .705**					
Learn by Doing	.403/ .402	.323/ .705	**.727/ .707**				
Tacit Know Awareness	.349/ .413	.339/ .552	.342/ .697	**.712/ .801**			
Tacit Know Sharing	.136/ .299	.132/ 0.4	.133/ .492	.389/ .724	**.723/ .748**		
Process Innovation	.04/ .107	.04/ .143	.04/ .176	.117/ .259	.3/ .357	**.737/ .930**	
Prod/Serv Innovation	.039/ .133	.038/ .178	.038/ .218	.112/ .322	.288/ .444	.725/ .922	**.729/ .790**
Mean	6.50/ 5.94	5.84/ 6.07	6.37/ 6.30	6.12/ 6.18	5.90/ 6.18	5.44/ 5.95	5.60/ 5.60
Standard Deviation	0.71/ 1.30	1.09/ 0.98	0.84/ 0.91	0.90/ 0.98	1.07/ 0.98	1.23/ 1.15	1.05/ 1.12
Cronbach's α	.71/ .73	.74/ .71	.74/ .73	.76/ .77	.73/ .79	.82/ .86	.80/ .87
Composite Reliability		.76/ .75	.77/ .75	.75/ .84	.76/ .79	.83/ .86	.82/ .87
Aver Var Extracted		.51/ .50	.53/ .50	.51/ .64	.52/ .56	.54/ .61	.53/ .62

5. Analysis and Results

5.1 Model Results

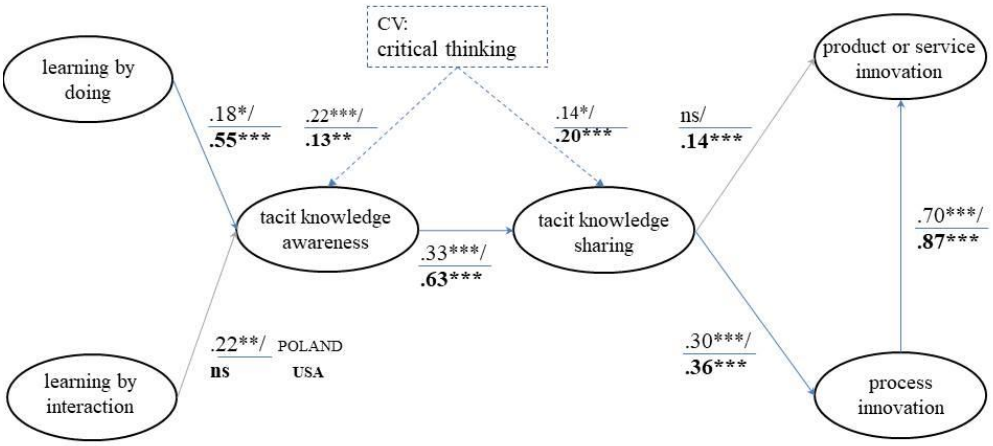
The results confirm the basic framework of the model, including the key elements of learning, tacit knowledge awareness, tacit knowledge sharing, and innovation. The R^2 for the Polish sample and the full model (with the control variable, critical thinking) is .53, a very good result. For the US sample, the R^2 is even better, .86, with the factors explaining over 86% of the variation in innovation in the firm. The Polish sample explains 53% of variation, still quite a good outcome.

The structural equation modeling results are shown in Figure 2. As noted, specific path coefficients are identified from the Polish sample in normal font and from the US sample in **bold font**. Further, t-statistics were used to test for significance, with results as shown. These results are also included according to relevant hypotheses and model variations in Table 4. Models are presented both with without the control variable (Aguinis & Vandenberg, 2014; Carlson & Wu, 2012). Other pertinent information is included, according to the procedure suggested by Becker et al. (2016). Based on these results, the models are a good fit with the data. Further, the national results are similar both with and

without the control variable (CV), but models B and D with the CV better fit the data for both the Polish and US samples and so are visualized in the figure.

In the full model with CV (model D), the US sample suggests learning by doing has a considerable effect on tacit knowledge awareness (H1, .57, p<.001) but showed no significant relationship between learning by interaction and tacit knowledge awareness (H2). All the other correlations are clear and significant, showing relationships between tacit knowledge awareness and tacit knowledge sharing (H3, .63, p<.001), between tacit sharing and product/service innovation (H4, .14, p<.001), between tacit sharing and process innovation (H5, .36, p<.001), and between process innovation and product/service innovation (H6, .87, p<.001). The model without the control variable (model C) shows very similar results in the US sample, with comparable magnitudes and significance levels.

Figure 2
Conceptual Model Results



Polish results vs. **USA results**
***p < .001 **p<.01 *p<.05

The full model for the Polish sample (Model B) shows a different pattern, especially regarding the early hypotheses. Both learning by doing (H1, .18, p<.05) and learning by interaction (H2, .22, p<.01) have a relationship with tacit knowledge awareness. As was the case with the US, a clear connection exists between tacit knowledge awareness and tacit knowledge sharing (H3, .33, p<.001), tacit knowledge sharing and process innovation (H5, .30, p<.001), and process innovation and product/service innovation (H6, .70, p<.001). Interestingly, the tacit knowledge sharing and product/service innovation relationship (H4) is not significant.

Table 4
Relationship between Tacit Knowledge Sources, Tacit Knowledge Development, and Innovation, by Country, with and without Critical Thinking as a Control Variable

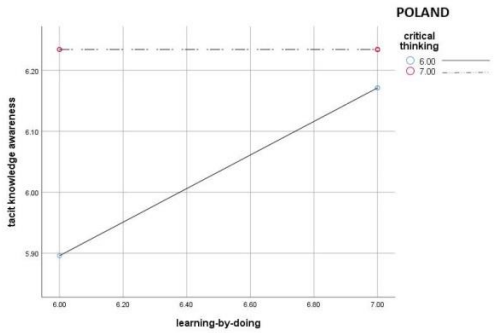
Information Technology (IT) Professionals				
Country	Poland		USA	
CV critical thinking	Model A without CV	Model B with CV	Model C without CV	Model D with CV
H1	.17**	.18*	.57***	.55***
H2	.16*	.22**	.ns	Ns
H3	.37***	.33***	.72***	.63***
H4	ns	ns	.13***	.14***
H5	.30***	.30***	.36***	.36***
H6	.70***	.70***	.87***	.87***
Hcv1		.21***		.13**
Hcv2		.14*		.20***
Tacit Knowledge Sharing to Process Innovation to Product/Service Innovation	full mediation	full mediation	complementary mediation	complementary mediation
$\chi 2$	378.81(163)	375.159(179)	550.07(163)	558.62(179)
CMIN/df	2.32	2.1	3.37	3.12
RMSEA	.062	.056	.079	.075
CFI	.913	.924	.903	.907
TLI	.899	.910	.887	.891

5.2 Control Variable Effects

As noted, the control variable, critical thinking, was included for both samples with results noted in the previous figure and table. Going back to Table 3, critical thinking shows a higher mean in the Polish sample than in the US (6.50 v.s 5.94) as well as less variation (standard deviation of 0.71 vs. 1.30). For the Polish sample, critical thinking does have a relationship with tacit knowledge sharing (Hcv1, .21, $p<.001$), more so than what is seen in the US (.14, $p<.05$), though both are significant. That is reversed for the relationship between critical thinking and tacit knowledge awareness (Hcv2, .13, $p<.01$ for Poland, .20, $p<.001$ for US).

Figures 3, 4, and 5 show the interaction visuals (Hayes, 2018). Critical thinking moderates the effect of learning by doing on tacit knowledge awareness for both countries. Critical thinking moderates the effect of learning by interaction on tacit knowledge awareness, but only for Poland (the US results were not significant). Finally, critical thinking moderates the effect of tacit knowledge awareness on tacit knowledge sharing for both countries.

Figures 3a, 3b
Interaction Effect of Critical Thinking on the Effect of Learning by Doing on Tacit Knowledge Awareness



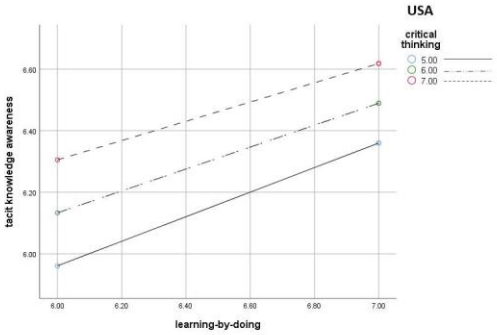
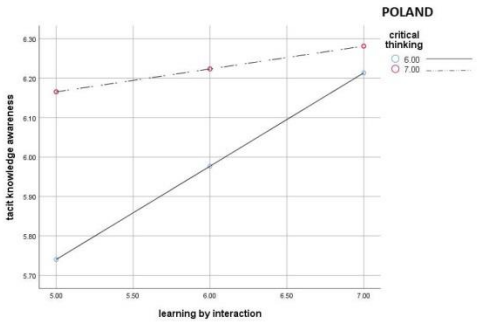
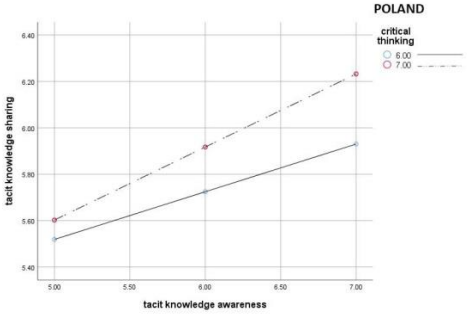
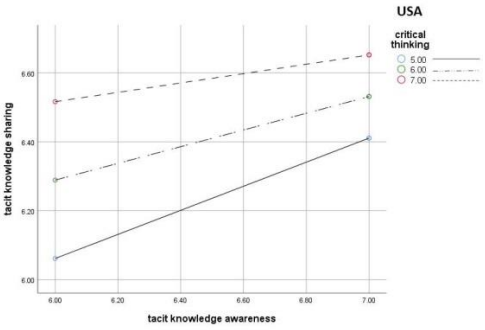


Figure 4
Interaction Effect of Critical Thinking on the Effect of Learning by Interaction on Tacit Knowledge Awareness



Figures 5a, 5b
Interaction Effect of Critical Thinking on the Effect of Tacit Knowledge Awareness on Tacit Knowledge Sharing





5.2 Mediation Effects

The mediation results suggest US tacit knowledge sharing leads directly to external product/service innovation while process innovations support product/service innovations (complementary mediation). In Poland, on the other hand, product/service innovation is apparently not connected to tacit knowledge sharing except through process innovation (full mediation). This difference is one of many seen between the two samples, but an important one supported clearly by the data.

The mediation results also provide some explanation for the possible collinearity seen in the discriminant validity results mentioned earlier. In the results from both countries' samples, there may be some question about whether the respondents fully recognize the academic distinction between product and process innovation. Indeed, as noted in the conceptual development, the product/service innovation perspective is generally from a high level, that of strategic planning and/or observing the creation and execution of new offerings. Process innovation is more from the perspective of the operational employees and the improvements they initiate and see every day. If the two concepts are not well-defined for the respondents, weak discriminant validity could affect the full and complementary mediation results.

Table 5
Mediation Analysis

Mediation	**Effects**			**Mediation type observed**
	country	**direct**	**indirect**	
Tacit Knowledge Sharing to Process Innovation to Product/Service Innovation	Poland	.08 (ns)	.21 (***)	full
	US	.14 (**)	.31 (***)	complementary

6 Discussion

6.1 Theoretical Implications

In short, the basic conceptualization is confirmed with a substantive sample. Individuals obtain tacit knowledge, become aware of it and more confident in its value. They then demonstrate a willingness to share it with others, leveraging the value of their knowledge even further. The result is innovation, including both process and product/service innovation. Tacit knowledge awareness and tacit knowledge sharing are both complimented by critical thinking on the part of employees. And, finally, product/service innovation may be directly influenced by knowledge sharing or may be indirectly influenced through mediation by the process innovation variable though the respondents are not necessarily clear about the distinction between product/service and process innovation. Sources of tacit knowledge vary and there are differences in magnitude and significance of the correlations in the different country samples, but the empirical data support the overall model in both cases.

The results from the two countries are similar in a number of ways but also show some key differences. The US IT professionals tend to learning by doing, not so much learning by interaction. They develop tacit knowledge by direct experience rather than sharing by others. The learning by doing has a strong impact on their awareness of possessing valuable tacit knowledge. The awareness has a strong

influence on their tacit knowledge sharing—which probably needs to be communicated through learning by doing as opposed to just telling (learning by interacting), though the overlap between the two types of learning could use more exploration. Critical thinking contributes to both awareness and sharing. The knowledge sharing leads to both process and product/service innovations, though the process innovations then have a strong connection to the product/service innovations.

The Polish IT professionals report both learning by doing and learning by interaction, suggesting more sharing in the knowledge acquisition process and that source of tacit knowledge can vary by nation. Those learnings lead to tacit knowledge awareness and then on to knowledge sharing, more straightforward than in the US sample as interaction is more important to gaining the knowledge in the first place. Sharing leads to process innovation and only then, indirectly, to product innovation. Critical thinking is an influence on both awareness and sharing.

In common between both samples is the clear link between some kind of learning and awareness. Particularly strong in the US is learning by doing and thereby gaining some awareness of possessing useful tacit knowledge. Related to the literature, this suggests that the tacit knowledge is something more than hidden or non-representable (Asher & Popper, 2019; Olaisen & Revang, 2018), that knowledge holders have reflected upon their learning, including through critical thinking, recognized what they know, and recognized the usefulness. The linkage is a bit weaker in the Polish study and also includes more social learning by interaction, but the idea of reflection and recognition is similar across both countries.

From tacit knowledge awareness to knowledge sharing is a step also apparent in both samples though again stronger in the US. Critical thinking is once more an influence. In previous studies, an individual's reflection on tacit knowledge and its usefulness internalizes the learnings (Oswald & Mascarenhas, 2019) and helps to instill confidence, a sense of expert power leading to a willingness to share with others (Wipawayangkool & Teng, 2006a; 2006b). An aspect of personal, individual confidence may be present and a perhaps a reason why the US tacit awareness/tacit sharing correlation shows a higher magnitude.

In both samples, process innovation is linked more strongly to knowledge sharing than is product/service innovation, though the link between process and product/service innovation is significant and substantial. The idea that product/service innovation flows from tacit knowledge sharing, even if indirectly, is confirmed by the mediation results. This likely makes sense, but, as noted earlier, the weakness of discriminant validity, especially in the US sample, raises some questions. As noted, the respondents may not see a distinction between the everyday process improvements close at hand and the more dramatic product/service innovations launched by the firm as a whole. Or the two are so closely related in practice, as somewhat suggested by the results, that they are perceived as one in the same. Although tacit knowledge is seen to have an important role in product/service innovation, especially the "fuzzy front end" (Sakellariou, Karantinou & Goffin, 2017) when knowledge is more unstructured and creative ideas are generated, those duties are more often the responsibility of the R&D department. The workers in these samples are not R&D scientists and engineers but are largely IT middle managers and professionals. IT lends itself to a lot of problem solving and operational solutions, more of the incremental process improvements taking place on a daily basis. While those can and do add up to more disruptive product/service innovations, those are not necessarily part of the work right in front of the respondents (from which they learn). Instead, the more disruptive innovations are more often outcomes of their collective knowledge funneled through R&D's new product development process.

6.2 Managerial Implications

The theoretical process of obtaining, recognizing, sharing, and innovating through tacit knowledge is validated. But, as noted, important distinctions are apparent between the two samples, between Poland and the US suggesting that context may be important in managing tacit knowledge. The two nations were chosen, in large part, because of the differences in economic maturity, with the US highly developed and Poland a fast-growing but still developing economy. Even though the sample was constructed to ensure similar representation by company position from both countries (C-suite, top managers, middle managers, professionals), size of company was not controlled, another potential variable affecting applications of tacit knowledge. The Polish sample has majority responses from small firms (77%) while the US sample has quite a large percentage from medium (25%) and large (66%) firms. To the extent that middle managers and professionals may have very different duties in a very large rather than a small firm, there could be an impact on the model results. Smaller firms may enable more learning by interaction, with more working together across functions. Or not, smaller firms could have less sharing of task-related tacit knowledge if departments are smaller or non-existent—there may simply be less workers at a comparable level with whom to share. And the age-old question about innovation tending to come from small or large firms, as well as the nature of the innovation (product/service vs. process) could also be a factor. The mediation result concerning process having a greater role in product innovation in Poland as well as the lack of discriminant validity may very well have something to do with the size of the company, its innovation strategy (pioneering, incremental, etc.), and its innovation capabilities. These results may also be affected by the industry itself, information technology, and how innovation proceeds in developing hardware, software, or consulting offerings.

But probably even more potentially important to the differences between the countries' samples would be the cultures of the countries themselves. The international business literature is full of country comparisons based on cultural differences. Probably the best-known are the Hofstede indices (Hofstede, 1980). The original four indices include power distance, individualism/collectivism, uncertainty avoidance, and masculine/feminine. To these four have been added long-term/short-term orientation and indulgence/restraint.

The Hofstede indices can provide an initial reading on how national cultures differ. Obviously, dependence on a single metric without reference to more regional or local differences can be dangerous, but as a broad indicator suggesting directions for further research, the indices can be useful. Recent readings on the two countries in question include (Hofstede Insights, 2020):

- Power distance (Poland 68, USA 40)
- Individualism (Poland 60, USA 91)
- Masculinity (Poland 64, USA 62)
- Uncertainty avoidance (Poland 93, USA 46)
- Long-term orientation (Poland 38, USA 26)
- Indulgence (Poland 29, USA 68)

As seen, considerable differences are apparent between the countries on a number of the indicators. In particular, the Polish are much more respectful of hierarchy and authority (power distance), both cultures are individualistic though the US is more so (individualism), Poles much prefer settled

environments (uncertainty avoidance), and the US is less restrained (indulgence). These aspects might explain some of the differences in the study and its potential for wider applicability. In particular, some of the literature suggests that tacit knowledge progresses through stages as it becomes better understood and more sharable. The holder of the knowledge, in reflecting on it, gains self-assurance in their own expert power and the value of the knowledge, moving on to confidently share it with others. In doing so, the individual has to be willing to act as an individual—even though sharing is group-oriented, the willingness to stand out and advise others shows individual self-confidence. Further, research has indicated that informal networks often develop within organizations based on knowledge sources (different from formal reporting structures), so effective knowledge sharing also depends, to some degree on less respect for established hierarchies. Implicit in this, as well as in the attitude toward risk-taking innovation (especially product/service), is comfort with facing uncertainty and risk.

It is always a little risky to make broad conclusions based on the Hofstede Indices, and they have their critics. They are very general, can have broad differences within a given nation, and should probably be supported by additional, in-depth, qualitative data. But as a first pass, they are certainly suggestive that part of the differences in the sample results may be based on national culture differences as well as some of the other factors discussed. Consequently, applying the results in a specific national environment should be done with care. The evidence suggests that results can be different, depending on the circumstances.

6.3 Limitations and Future Research Directions

The study does have limitations. It is conducted only in a given industry, information technology. In addition, the sample profile has recognizable patterns in terms of size distribution of firms. Finally, the study is conducted in two different types of nations, but only two.

In particular, the study points to some key divergences between the two samples from Poland and the USA. There are readily apparent differences between the countries, from economic maturity to national culture. Additionally, the samples highlight differences in the distribution of companies by size and, by implication, the level of responsibility of respondents even if, nominally, they hold similar positions. Any or all of these could have something to do with the prominent differences in results: primary sources of tacit knowledge (learning by doing vs. learning by interaction) as well as the path to product/service innovation. Magnitudes and correlations also differ somewhat, even if results are emphatically significant in both samples.

These results suggest that something might be going on in the environment that can impact tacit knowledge's development, sharing, and influence on innovation. Literature has often focused on variables that might leverage knowledge's effect or that might make knowledge management systems more or less successful (e.g. organizational culture). Here, given what we know about the study, the differences in national economic maturity, national culture, firm characteristics including size, particular aspects of the IT industry, and, potentially, other variables may be responsible for the disparate outcomes.

Consequently, considerable opportunities exist for further research. There are key findings here in terms of sources of tacit knowledge, their correlation with the development of tacit knowledge and willingness to share, and then the impact on innovation. The results indicate that any and all of these relationships may vary by context. Additional research can explore how much the choice of industry matters. Information technology has very clear types of knowledge used in creating and improving

software, hardware, and integrative offerings which may be more or less tacit than what is found in other industries. IT also has distinct innovation outputs, much of it incremental or problem-solving (more process-oriented) though also including product/service introductions. Other industries may not show the same patterns and examining them would clarify the quantitative model surrounding tacit knowledge as presented here.

Similarly, samples with a different representation of company sizes would also provide more evidence as to what is behind the results presented here. In smaller firms, employees often have a wider range of duties while those in larger firms can specialize. Further, foreign subsidiaries (present, to some degree in the Polish sample) could also impact the generation and use of local tacit knowledge. Studying those aspects of organizational environments could again provide a deeper understanding of the workings of tacit knowledge and innovation.

Each of those areas for additional research can and should include the perceived distinction between process and product/service innovation. As indicated, innovation is a key and significant output of the model the results also suggest some lack of clarity on the difference between the two. That could be a flaw in the instrument, of course, though some of the items had been validated in past studies. Or it could be differences based on how innovation is pursued in the IT industry and/or in companies of different size. In any event, additional research into the findings is warranted.

Finally, of course, this study includes only Poland and the US. Results from other countries, including those in the EU or other developed nations as well as in developing economies not explored at all in this study, could also help to clarify these results and provide guidance on the nature of tacit knowledge and its management in different national contexts. Further, just as qualitative research can be a guide to subsequent quantitative studies, follow-on qualitative work could be useful in uncovering some of the reasons behind what was seen in this study. In particular, conclusions suggested by blunt tools such as the Hofstede indices could be explored in more detail by probing workers from different countries about the how's and why's of the more quantitative results.

7 Conclusion

The obvious conclusion is that tacit knowledge has a recognizable role in innovation that can be managed effectively to motivate the learning, critical thinking, and sharing that leads to improvements. This study clarified and attached quantitative data to the relationship between tacit knowledge creation and innovation. In doing so, it demonstrated the differences between the sources of tacit knowledge (learning by doing and learning by interaction) and the correlation of source with tacit knowledge awareness and then sharing. The study also captured the impact of critical thinking by individuals on their awareness of the tacit knowledge they hold as well as on their intention and willingness to share it. Finally, the study captured how sharing tacit knowledge leads to process or product/service innovation, either directly or with product/service innovation mediated by process innovation.

The study is unique in making these quantitative connections based on two sizable samples from different countries with dramatically different contexts, economic, social, and otherwise. As such, it provides unique empirical evidence on these relationships between tacit knowledge, innovation, and everything in between.

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Appendix

Table 6
Constructs and Items

Construct	**Items** **(Authors' compilation based on sources noted)**
Learning by doing (learning from own work experience)	• I learn more effectively when I am actually performing tasks • task-related practical experience lets me better understand things • the more I do, the more ideas I have • I rely on my own experience for learning
Learning by interaction (learning from others work experiences)	• I learn faster when I work with others • feedback helps me learn • I can learn when I observe how others do • colleagues' anecdotes, stories and examples help me learn
Critical thinking	• making sense of things is important to me • I learn from constructive questioning • I like to evaluate my work and find out better solutions on my own
Tacit knowledge awareness	• I can create and explain new ideas or insights • even if my idea is hard to explain, I am able to express it or demonstrate it • sometimes I am absolutely sure about a new idea but find it difficult to express • as I have accumulated experience, I find it is easier to express
Tacit knowledge sharing	• I share knowledge learned from my own experience • I have the opportunity to learn from others' experiences • colleagues share new ideas with me • colleagues include me in discussions about best practices
Process innovation	• we constantly improve the way we work • we are good at managing changes • we are highly disposed to introduce new methods and procedures • we are highly disposed to accept new rules
Product or service innovation	• we provide competitively superior innovations to our clients • our innovations are perceived positively by our clients • we are better than competitors at introducing innovations • I am proud of our innovations

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Gdańsk University of Technology, Faculty of Management and Economics

Narutowicza 11/12, (premises at ul. Traugutta 79)

80-233 Gdańsk, phone: 58 347-18-99 Fax 58 347-18-61

www.zie.pg.edu.pl