



Technology Readiness Among Upstream Actors in an Export-Linked Botanical Value Chain: Evidence from a Regency in West Kalimantan, Indonesia

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ABSTRACT

This study examines technology readiness among upstream actors in an export-linked, smallholder-based botanical value chain in a regency in West Kalimantan, Indonesia. Prior TRI studies largely focus on services, education, and urban MSMEs, leaving limited evidence on upstream export-linked value chains where first-mile constraints, trust boundaries, and traceability-related information exposure can shape technology perceptions. Using the Technology Readiness Index (TRI), this study addresses that gap by providing a baseline profile of readiness drivers and inhibitors to inform staged and trust-sensitive digitalization strategies. Primary data were collected in June 2025 through a cross-sectional field survey of 60 upstream actors recruited via purposive sampling. TRI was measured across four dimensions: optimism and innovativeness (drivers), and discomfort and insecurity (inhibitors). Reliability was assessed using Cronbach's alpha at the dimension level, with one ambiguous discomfort item excluded to improve internal consistency. Results indicate an ambivalent readiness configuration: optimism and innovativeness were high, while discomfort and insecurity were also high, reflecting substantial concerns related to difficulty, risk, and trust. The findings imply that upstream digitalization is shaped by a value-risk tension rather than perceived usefulness alone. Future research should validate TRI in similar upstream settings with larger samples and link readiness profiles to observed technology use and operational outcomes.

Keywords: technology readiness; digitalization; agricultural value chain; smallholder; West Kalimantan.

INTRODUCTION

Digital transformation is increasingly positioned as a practical pathway to improve the performance and resilience of agro-value chains, particularly in developing economies where upstream segments are dominated by smallholders and informal intermediaries. In such contexts, better coordination, information sharing, and logistics visibility are expected to strengthen flow efficiency and reduce avoidable losses across the chain. These improvements can also enable more consistent service levels to downstream markets (Christopher, 2016). In Indonesia, the urgency of digital agriculture is often framed around persistent value-chain bottlenecks, including fragmented actors, uneven information access, and limited integration between production, aggregation, and markets. These conditions make digital interventions attractive, yet challenging to implement at scale (World Bank, 2020).

At the same time, contemporary value-chain development increasingly emphasizes inclusivity. The objective is not only to raise efficiency, but also to improve participation and upgrading opportunities for upstream actors who are often structurally disadvantaged. Inclusive value-chain development highlights that innovation is rarely a single technology adoption event. Instead, it is a systems process involving institutions, coordination mechanisms, learning, and multi-actor adaptation across a chain (Devaux et al., 2018; Horton et al., 2022). However, inclusive innovation can be constrained when upstream actors lack practical capabilities to access, interpret, and act on information, particularly when digital channels become the dominant interface for production guidance, market information, traceability requirements, and buyer communication (Misaki et al., 2018). Without addressing these constraints, digitalization risks reinforcing existing asymmetries rather than reducing them.

This challenge is especially salient for export-oriented botanical commodities supplied by smallholders. In Kubu Raya Regency, West Kalimantan, local livelihoods in upstream communities are connected to the cultivation and harvesting of an endemic botanical leaf commodity that enters domestic and international value chains. Despite market potential, upstream operations commonly face coordination and quality-management issues that are difficult to resolve through conventional mechanisms alone. Examples include inconsistent grading practices, weak documentation, and limited visibility over inventory availability and delivery timing. In many commodity chains, such gaps can translate into avoidable transaction frictions and higher perceived risk for buyers. This, in turn, pressures upstream actors through stricter requirements and unstable purchasing patterns. Consequently, supply-chain transparency and credible information flows become increasingly important as market expectations shift toward verifiable production and product attributes (Fu et al., 2025). Technology options such as digital traceability platforms or blockchain-enabled transparency models are frequently proposed as solutions (Juneja, 2024).

Nevertheless, implementing digital supply-chain solutions cannot be assumed to succeed simply because the technology exists or because downstream actors demand it. Evidence from agricultural technology adoption research suggests that adoption outcomes are shaped by heterogeneous conditions at the farm level and in the surrounding ecosystem, including constraints that influence whether technology use can translate into welfare or performance gains (Adams & Jumpah, 2021; Tambo & Wünscher, 2017). In practice, upstream actors' readiness to engage with new technologies, including enabling beliefs and perceived barriers, becomes a critical precondition for any intervention that depends on sustained digital participation.

This is where readiness constructs are analytically useful. While technology acceptance models (TAM) and related adoption frameworks have been widely applied across organizations and MSME contexts (e.g., Purnamasari et al., 2020; Siregar et al., 2017; Taherdoost, 2018; Arifin et al., 2016), they are often deployed around a specific system or use-case. By contrast, the Technology Readiness Index (TRI) conceptualizes a more general predisposition to embrace new technologies, capturing both drivers and inhibitors that can shape how individuals approach unfamiliar digital tools (Parasuraman, 2000). This readiness perspective aligns with diffusion thinking, which argues that adoption patterns depend not only on the innovation itself, but also on how potential adopters perceive and engage with it over time (Rogers, 2003).

Recent empirical work has demonstrated the practicality of TRI in varied Indonesian settings and technology domains, ranging from public service and education systems to sectoral applications in agriculture and financial services. These studies suggest that readiness measurement can reveal actionable segments and barrier profiles relevant for intervention design (e.g., Fitriani et al., 2022; Kuswanto & Panggabean, 2025). However, TRI studies have largely been conducted in services, education, MSMEs, or general sectoral settings, leaving limited evidence on upstream actors in export-linked botanical value chains, particularly in

peripheral regency-level contexts where infrastructural and trust-related constraints can shape digital participation. A TRI-based assessment in this context is therefore valuable as a baseline for designing inclusive digital supply-chain initiatives that are feasible for upstream participation, rather than relying on one-size-fits-all assumptions about technology uptake.

Accordingly, this study addresses a specific knowledge gap by examining technology readiness among upstream actors in an export-linked botanical value chain in a regency-level setting in West Kalimantan, Indonesia. The research problem is the uncertainty of whether upstream digitalization can be initiated effectively when perceived benefits and openness to technology coexist with strong perceived discomfort and insecurity. The objective of this study is to profile TRI drivers (optimism and innovativeness) and TRI inhibitors (discomfort and insecurity) to provide a readiness baseline for intervention design. The novelty of this study lies in extending TRI evidence into an upstream, export-linked value-chain context in a peripheral region, where readiness is likely to reflect a value–risk tension rather than uniformly positive or negative perceptions. The theoretical contribution is strengthening empirical understanding of how TRI drivers and inhibitors coexist in upstream value-chain settings beyond commonly studied service or MSME contexts. The practical contribution is offering a baseline readiness profile to guide staged and trust-sensitive digitalization strategies, including low-friction entry tools, clear data-governance, and gradual progression toward more structured digital supply-chain practices.

METHOD

An exploratory, cross-sectional survey design was employed to assess individual technology readiness among upstream actors in an export-linked botanical value chain in a regency-level setting in West Kalimantan Province, Indonesia. To protect commodity and participant confidentiality, the focal product was anonymized as an endemic botanical leaf commodity and the study location was reported at the regency level. Accordingly, the empirical evidence reflects this regency-level upstream context and should not be interpreted as representing all areas of West Kalimantan.

Respondents were recruited using purposive sampling to capture key upstream roles in the local chain, including smallholder producers and local intermediaries involved in first-mile aggregation and trading. Inclusion criteria were active involvement in upstream activities in the study area and willingness to participate. A total of 60 completed questionnaires were retained as valid responses for analysis. The sample size was determined pragmatically based on the limited number of active upstream actors in the regency-level setting and the exploratory objective of establishing a baseline readiness profile. The 60 valid responses were considered sufficient to cover key upstream roles and to support descriptive reporting and internal-consistency checks at the dimension level. No claims of province-wide representativeness or causal inference were intended.

Technology readiness was measured using the Technology Readiness Index (TRI) adapted from Parasuraman (2000). TRI comprises four dimensions: optimism and innovativeness (drivers), and discomfort and insecurity (inhibitors). Content validity was supported primarily by adopting an established TRI instrument and preserving the original construct definitions, while item wording was translated into Indonesian and context-adjusted to improve comprehension in an upstream commodity setting without changing construct meaning. Prior to the main survey, a brief field pretest (clarity check) was conducted with approximately 12 upstream individuals during enumerator preparation to confirm item comprehension and wording suitability. Feedback from this pretest was used to refine phrasing and reduce ambiguity. No statistical validity testing was conducted at the pretest stage; the pretest was intended to support face validity and comprehension only. All items were rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

The final retained items were four items for optimism (TR1–TR4), four items for innovativeness (TR5–TR8), three items for discomfort (TR10–TR12), and four items for insecurity (TR13–TR16). One discomfort item (TR9) was excluded due to inconsistent item behavior within its dimension and improved internal consistency after removal. Inhibitor dimensions (discomfort and insecurity) were coded and reported in the barrier direction, where higher values indicate stronger perceived discomfort and insecurity.

Data analysis focused on descriptive and exploratory procedures. Respondent characteristics and TRI scores were summarized at the item and dimension levels using descriptive statistics. Internal consistency was evaluated at the dimension level using Cronbach's alpha, and item diagnostics were used to support the treatment of TR9. Given the exploratory purpose and modest sample size, the analysis emphasized pattern identification rather than confirmatory construct validation, structural modeling, or causal claims. In addition, brief informal follow-up conversations were conducted with several respondents to clarify item interpretation and contextualize the survey patterns. These conversations were not audio-recorded, were not systematically sampled, and were documented only as brief field notes. Therefore, they were not treated as qualitative data and were not analyzed thematically; their role was limited to contextual clarification (Creswell & Plano Clark, 2017). For the exploratory comparison between smallholder producers and local intermediaries, the Mann–Whitney U test was used to assess whether the observed role-based differences in TRI dimension scores were statistically meaningful. This non-parametric test was selected because the TRI scores were derived from Likert-type items, the group sizes were modest, and the analysis was intended as a simple exploratory comparison rather than a confirmatory test of group differences. Respondents outside the two main upstream roles were excluded from this role-based comparison.

RESULTS AND DISCUSSION

Results

A total of 60 upstream actors participated in the survey. Overall, the sample was predominantly male and concentrated in working-age groups. Most respondents reported secondary-level education and were primarily engaged as local intermediaries and smallholder producers, with the remainder consisting of other upstream-related roles. Involvement in the value chain was generally established, with most respondents reporting at least one year of experience. Detailed respondent characteristics are presented in Table 1.

Table 1. Respondent Characteristics (n=60)

Characteristic	Category	n
Gender	Male	37
	Female	23
Age	< 25	11
	26 – 35	20
	36 – 45	17
	>45	12
	Primary school	10
Education	Junior high	15
	Senior high	33
	Bachelor	2
Upstream Role	Smallholder Producer	25
	Local intermediary	23
	Other upstream related roles	12

Characteristic	Category	n
Length of Involvement	< 1 year	9
	1–3 years	31
	> 3 years	20

Technology readiness was assessed using the Technology Readiness Index (TRI), comprising four dimensions: optimism and innovativeness (drivers), and discomfort and insecurity (inhibitors) (Parasuraman, 2000). Internal consistency was examined at the dimension level. Cronbach's alpha values for optimism ($\alpha = 0.615$) and innovativeness ($\alpha = 0.678$) were marginal, but considered usable for this exploratory assessment given the modest sample size, context-adjusted wording, and objective of establishing a preliminary readiness profile rather than conducting confirmatory scale validation. Accordingly, findings related to these two dimensions should be interpreted with caution. Insecurity showed slightly higher internal consistency ($\alpha = 0.696$), while the refined discomfort scale demonstrated stronger internal consistency ($\alpha = 0.762$) after excluding TR9. Corrected item–total correlations were also inspected to assess item coherence within each dimension. The observed ranges were 0.098–0.596 for optimism, 0.193–0.608 for innovativeness, 0.142–0.692 for insecurity, and 0.448–0.718 for the refined discomfort scale. TR9 showed a negative item–total correlation (–0.063) and was therefore excluded from the discomfort composite. Reliability results are summarized in Table 2.

Table 2. Internal Consistency of TRI Dimensions (Cronbach's Alpha)

TRI dimension	Items	Cronbach's Alpha
Optimism (driver)	TR1–TR4	0.615
Innovativeness (driver)	TR5–TR8	0.678
Discomfort (refined; TR9 excluded) (inhibitor)	TR10–TR12	0.762
Insecurity (inhibitor)	TR13–TR16	0.696

Descriptive statistics indicate a clear tension between perceived benefits and perceived risks (Table 3). Optimism ($M = 4.51$, $SD = 0.686$) and innovativeness ($M = 4.55$, $SD = 0.548$) were high, indicating strong perceived usefulness of technology and openness to trying new tools. At the same time, the inhibitor dimensions were also high, with discomfort ($M = 4.60$, $SD = 0.697$) and insecurity ($M = 4.74$, $SD = 0.528$), indicating substantial perceived difficulty/unease and perceived risk or distrust related to technology. To provide more detail for this exploratory assessment, item-level descriptive statistics are reported in Table 4.

Table 3. Descriptive Statistics of TRI Dimensions (Likert 1–5)

Statistic	Optimism (driver)	Innovativeness (driver)	Discomfort (inhibitor)	Insecurity (inhibitor)
N	60	60	60	60
Mean	4.51	4.55	4.60	4.74
Median	4.75	4.75	4.67	5.00
Std. Deviation	0.686	0.548	0.697	0.528
Minimum	2.00	2.00	1.00	2.50
Maximum	5.00	5.00	5.00	5.00

Note: Discomfort and Insecurity are reported in the barrier direction (higher scores indicate stronger perceived discomfort/insecurity). TR9 was excluded; Discomfort was computed using TR10–TR12.

To provide greater detail beyond dimension-level summaries, Table 4 reports item-level descriptive statistics for the retained TRI items. This allows the contribution of individual questionnaire items to each TRI dimension to be observed directly.

Table 4. TRI Item-Level Descriptive Statistics (Likert 1–5)

Dimension	Item	Mean	SD	Alpha if Item Dropped
Optimism	<i>Driver – TRI 1</i>	4.45	1.048	0.490
	<i>Driver – TRI 2</i>	4.05	1.431	0.487
	<i>Driver – TRI 3</i>	4.80	0.443	0.685
	<i>Driver – TRI 4</i>	4.73	0.841	0.422
Innovativeness	<i>Driver – TRI 5</i>	4.48	0.770	0.510
	<i>Driver – TRI 6</i>	4.77	0.427	0.736
	<i>Driver – TRI 7</i>	4.52	0.873	0.509
	<i>Driver – TRI 8</i>	4.43	0.909	0.609
Discomfort	<i>Inhibitor – TRI 10</i>	4.53	0.812	0.626
	<i>Inhibitor – TRI 11</i>	4.67	0.795	0.547
	<i>Inhibitor – TRI 12</i>	4.60	0.924	0.858
Insecurity	<i>Inhibitor – TRI 13</i>	4.80	0.403	0.773
	<i>Inhibitor – TRI 14</i>	4.65	0.917	0.468
	<i>Inhibitor – TRI 15</i>	4.77	0.767	0.619
	<i>Inhibitor – TRI 16</i>	4.73	0.733	0.536

Note: Discomfort and Insecurity items are reported in the barrier direction (higher scores indicate stronger perceived discomfort/insecurity). TR9 was excluded; Discomfort was computed using TR10–TR12.

Item-level results (Table 4) are interpreted by separating TRI into **drivers** (optimism and innovativeness) and **inhibitors** (discomfort and insecurity). On the **driver side**, within optimism, TR3 had the highest mean ($M = 4.80$) while TR2 had the lowest ($M = 4.05$); within innovativeness, TR6 was the highest ($M = 4.77$) and TR8 the lowest ($M = 4.43$). On the **inhibitor side** (reported in the barrier direction), within discomfort (refined), TR11 had the highest mean ($M = 4.67$) while TR10 had the lowest ($M = 4.53$); within insecurity, TR13 had the highest mean ($M = 4.80$) while TR14 had the lowest ($M = 4.65$). Although item means are generally high, standard deviations indicate non-trivial dispersion in responses across several items (e.g., TR2 SD = 1.431; TR12 SD = 0.924, compared with lower dispersion on TR6 SD = 0.427 and TR13 SD = 0.403), suggesting that agreement was not uniform among respondents. This pattern may indicate that perceived benefits and openness toward technology coexist with strong perceived barriers in the same population. In an upstream, export-linked value chain context, such a profile could be consistent with respondents recognizing practical value while simultaneously expressing concerns related to trust, information exposure, and perceived risk.

An exploratory role-based comparison was conducted between smallholder producers (Petani) and local intermediaries (Pengepul), as these two groups represent the two main upstream roles involved in first-mile production, aggregation, and information exchange in the local chain. This comparison included group descriptives and a Mann–Whitney U test to assess whether the observed differences in TRI dimension scores were statistically meaningful. Respondents in other upstream-related roles were excluded from this comparison. Group sample sizes, means, medians, standard deviations, and Mann–Whitney U test results are presented in Table 5.

Table 5. Group Descriptives and Mann–Whitney U Test of TRI Dimensions by Upstream Role (Farmer vs Intermediaries)

Dimension	Group	N	Mean	Median	SD	Mann-Whitney U	P-Value
TRI Optimism	Intermediaries	25	4.51	4.75	0.635	279	0.855
	Farmer	23	4.42	4.50	0.844		
TRI Innovativeness	Intermediaries	25	4.43	4.75	0.766	261	0.580
	Farmer	23	4.66	4.75	0.334		
TRI Discomfort	Intermediaries	25	4.73	4.67	0.272	281	0.886
	Farmer	23	4.43	4.67	1.022		
TRI Insecurity	Intermediaries	25	4.69	5.00	0.651	269	0.673
	Farmer	23	4.76	5.00	0.341		

Note: The comparison is descriptive and exploratory and is not used for causal inference; Inhibitors (Discomfort, Insecurity) are reported in the barrier direction (higher scores indicate stronger perceived discomfort/insecurity). Mann–Whitney U tests are two-tailed. The U and p-values refer to the comparison between Petani and Pengepul for each TRI dimension. Respondents in other upstream-related roles were excluded from this role-based comparison. Inhibitors (Discomfort, Insecurity) are reported in the barrier direction, where higher scores indicate stronger perceived discomfort/insecurity.

Table 5 suggests broadly similar TRI profiles between Petani and Pengepul. On the driver side, optimism was comparable across roles, while innovativeness was descriptively higher among Petani than Pengepul. On the inhibitor side, discomfort was descriptively higher among Pengepul, while insecurity remained high in both groups. However, the Mann–Whitney U tests did not indicate statistically significant role-based differences for optimism ($U = 279$, $p = 0.855$), innovativeness ($U = 261$, $p = 0.580$), discomfort ($U = 281$, $p = 0.886$), or insecurity ($U = 269$, $p = 0.673$). Therefore, the observed mean differences should be interpreted as descriptive patterns rather than statistically meaningful differences between roles. The most visible descriptive contrast is in discomfort variability, which was higher among Petani than Pengepul, suggesting that perceived difficulty or unease with technology may be more heterogeneous among producers.

Discussion

This study provides an exploratory profile of technology readiness among upstream actors in an export-linked, smallholder-based botanical value chain in a regency-level setting in West Kalimantan, using the Technology Readiness Index (TRI) as the analytical lens (Parasuraman, 2000). The central empirical pattern is an ambivalent readiness configuration: both driver dimensions (optimism and innovativeness) and inhibitor dimensions (discomfort and insecurity, reported in the barrier direction) are high at the dimension level (Table 3), and this pattern is reinforced at the item level (Table 4). What is genuinely distinctive in this context is not simply that readiness is “high” or “low,” but that perceived benefits and openness to technology coexist with similarly high perceived barriers within the same upstream setting, which provides a more realistic baseline for designing feasible digitalization pathways.

First, in TRI terms, high optimism and innovativeness indicate that technology is broadly perceived as useful and worth trying, while simultaneously high discomfort and insecurity indicate that engagement is constrained by perceived difficulty, unease, and trust-related concerns (Parasuraman, 2000). This combined profile suggests that upstream digitalization is unlikely to be driven by perceived usefulness alone. In diffusion terms, adoption decisions are shaped not only by perceived advantages but also by perceived risk, uncertainty, and trust boundaries, which can slow or fragment uptake even when attitudes toward benefits are positive

(Rogers, 2003). In an upstream, export-linked value chain, these inhibitors can be particularly consequential because many digital tools increase visibility of transactions, records, and coordination, which may be perceived as both enabling and exposing.

Second, the item-level patterns help clarify what “high drivers and high inhibitors” mean in practice. On the driver side, optimism and innovativeness items are consistently high, with optimism ranging from TR2 (lowest mean) to TR3 (highest mean), and innovativeness ranging from TR8 (lowest) to TR6 (highest) (Table 4). On the inhibitor side, discomfort and insecurity items are also high in the barrier direction, with discomfort (refined) spanning TR10 to TR11 and insecurity spanning TR14 to TR13 (Table 4). At the same time, dispersion is non-trivial on selected items (e.g., higher SD on TR2 and TR12 relative to TR6 and TR13), indicating that agreement is not uniform. This heterogeneity implies that a single, uniform readiness profile does not fully describe the upstream segment, even when central tendencies appear consistently high.

Third, role-based descriptives further suggest where heterogeneity may matter operationally. The comparison between smallholder producers (Petani) and local intermediaries (Pengepul) shows modest mean differences on drivers and inhibitors (Table 5), but more visible differences in dispersion for certain dimensions. In particular, discomfort shows substantially higher variability among producers than intermediaries, suggesting that perceived difficulty or unease with technology is not evenly shared among producers. This aligns with the practical reality that upstream roles can differ in workflow exposure to record-keeping demands, coordination intensity, and perceived consequences of information visibility. Therefore, the same digitalization initiative may be experienced very differently across upstream roles even when average scores appear similar.

Fourth, these findings carry clear implications for upstream value-chain digitalization strategies. Where drivers and inhibitors are simultaneously high, feasibility is likely to depend on staged implementation that reduces perceived burden while building trust. Low-friction entry tools that fit existing routines can be prioritized first, followed by incremental steps toward more structured practices as perceived value becomes tangible and trust is established. In export-linked chains, governance design becomes central because concerns about information exposure, misuse, or competitive risk can directly amplify inhibitor perceptions. As a result, adoption pathways may benefit from explicit data-governance rules (what is recorded, who can access it, and for what purpose), simple training that targets the most variable barrier points, and role-sensitive support that does not assume homogeneous capabilities or concerns.

Fifth, the study contributes to TRI literature by extending readiness evidence into an upstream, export-linked value-chain setting that differs from the service, education, and general MSME contexts more commonly examined in prior TRI applications. The findings show that TRI drivers and inhibitors can coexist strongly within the same upstream population, indicating that readiness should not be interpreted only as enthusiasm or resistance toward technology. Instead, in first-mile value-chain settings, technology readiness may reflect a simultaneous recognition of digital value and concern over difficulty, risk, trust, and information visibility. This supports a more context-sensitive interpretation of TRI when applied to peripheral, smallholder-based, and export-linked commodity chains.

However, the findings should be interpreted cautiously because the study is exploratory, context-specific, based on purposive sampling, and relies on self-reported perceptions. In addition, the marginal reliability of the optimism and innovativeness dimensions suggests that future studies should further validate the TRI instrument in comparable upstream settings with larger samples and stronger measurement checks.

CONCLUSION

This study assessed technology readiness among upstream actors in an export-linked, smallholder-based botanical value chain in a regency-level setting in West Kalimantan, Indonesia, using the Technology Readiness Index (TRI) as the analytical lens. The findings indicate an ambivalent readiness configuration in which perceived benefits and openness toward technology coexist with strong perceived barriers related to difficulty, risk, and trust. Theoretically, this study extends TRI literature by showing that readiness drivers and inhibitors are not necessarily opposite conditions in upstream value-chain settings. Instead, they may coexist strongly within the same population, especially where digitalization involves first-mile coordination, information visibility, traceability expectations, and trust-sensitive exchange. This suggests that TRI can be used not only to measure general technology readiness, but also to reveal value–risk tensions that shape digitalization feasibility in peripheral, smallholder-based, and export-linked commodity chains.

Practically, the study contributes a baseline readiness profile that can inform feasible and inclusive digitalization strategies. The findings suggest that upstream digitalization should begin with low-friction tools aligned with existing routines, introduce clear data-governance and trust protections, and scale gradually toward more structured digital supply-chain practices as perceived value and control are established. The role-based comparison did not reveal statistically significant differences between Petani and Pengepul, but it indicated descriptive heterogeneity in barrier-related perceptions, particularly discomfort variability. This supports the need for staged and role-sensitive implementation without overgeneralizing differences between upstream roles. This study is limited by its exploratory and context-specific design, purposive sampling, marginal reliability in two TRI dimensions, and reliance on self-reported perceptions rather than observed technology use. Future research should validate the TRI profile in comparable upstream settings with larger samples, stronger measurement checks, and links between readiness patterns, actual technology-use behavior, and operational outcomes.

Author Contribution

Single author: Conceptualization, research design, instrument development, data collection, data analysis, interpretation of results, manuscript drafting, and final revision.

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Conflicts of Interest

The author declares that there is no conflict of interest related to this study.

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