Trust in information security technology: an intellectual property analysis

Appendix A

Defining and Linking Metrics for Patent Analysis

Metrics play a critical role in assessing and monitoring patents analysis, guiding decision-making, and driving continuous analysis of intellectual property [1]. Effective metrics definition and linkage ensure alignment with objectives, clarity in measurement criteria, in accountability, and in findings for a decision making in results clarity. In this vein, this appendix explained the rational of choosing the variables analyzed in this study.

The metrics linked to both dependent and independent variables in our study are supported by national (commercial) indexes, which are interconnected with federal enterprise governance in several ways:

Firstly, operational efficiency of federal enterprises rely on efficient and modernized systems. National software spending enables governments to acquire and implement software solutions that streamline processes, automate tasks, and improve overall operational efficiency [2]. This efficiency can lead to cost savings, better resource allocation, and more responsive public services. Second, federal enterprises service delivery is often measured by its ability to deliver services to citizens in a timely and satisfactory manner [3]. Commercial software can enhance service delivery by providing tools for managing public programs, handling citizen inquiries, processing transactions, and delivering information and services through digital channels [4]. Effective software solutions enable governments to better meet the needs and expectations of citizens, improving overall satisfaction with government services. Third, modern federal enterprises are increasingly reliant on data for decision-making and policy formulation [5]. Commercial software spending allows governments to invest faster in data management and analysis tools that enable them to collect, store, analyze, and visualize data more effectively. By leveraging data-driven insights, governments can make informed decisions, identify areas for improvement, and monitor the impact of policies and programs on citizens and communities. Fourth, as federal enterprises digitize more of their operations and services, cybersecurity becomes increasingly important for ensuring the integrity, confidentiality, and availability of government systems and data [6]. National software spending can support investments in cybersecurity solutions and risk management practices to protect government assets and mitigate cyber threats. A secure and resilient IT infrastructure is essential for maintaining public trust and confidence in government institutions [7].

Additionally, national R&D activities also intersect with federal enterprise governance in several ways: First, commercial R&D investments contribute to innovation and technological advancement, which are essential for betterment of society [8]. By funding R&D initiatives, governments can stimulate innovative ecosystems, foster the development of cutting-edge technologies, and drive economic growth. Effective governance frameworks enable federal enterprises to leverage commercial R&D outputs and integrate innovative solutions into their operations [9]. Second, national R&D efforts often lead to the development of new products, services, and technologies that have implications for public policy and regulation [10,11]. Effective federal enterprise governance involves establishing regulatory frameworks that encourage innovation while ensuring consumer safety, environmental sustainability, and compliance with ethical standards. By monitoring and regulating commercial R&D activities, governments can promote responsible innovation and protect public interests. Third, federal enterprises often collaborate with commercial entities, academic institutions, and research

organizations to advance R&D objectives and address complex societal challenges [12]. National R&D initiatives facilitate collaboration and partnerships across sectors, enabling federal enterprises to access external expertise, resources, and infrastructure. Effective governance structures facilitate the formation of strategic partnerships, manage collaboration risks, and ensure alignment with organizational goals and priorities. Forth, commercial R&D activities also generate valuable knowledge, intellectual property, and technological innovations that can be transferred to federal enterprises through licensing agreements, technology transfer programs, and strategic partnerships [13,14]. Effective governance mechanisms facilitate the acquisition, adoption, and integration of innovative technologies and best practices into federal enterprise operations, enabling them to remain agile, responsive, and adaptable in dynamic environments. Fifth, national R&D investments require rigorous performance monitoring and evaluation to assess the impact, effectiveness, and return on investment of R&D programs and initiatives [15]. Effective governance frameworks incorporate mechanisms for monitoring R&D outcomes, tracking key performance indicators, and evaluating the contribution of R&D investments to federal enterprise goals and objectives. By systematically evaluating R&D performance, governments can allocate resources more effectively, identify areas for improvement, and optimize R&D strategies to maximize societal benefits and economic value [16] .

National software spending plays a critical role in enhancing federal enterprises by improving operational efficiency, enhancing service delivery, enabling data-driven decision-making, and strengthening cybersecurity and risk management practices. Effective use of commercial software can help governments achieve their objectives more efficiently and deliver better outcomes for citizens and communities. Additionally, national (commercial) R&D activities play a pivotal role in shaping the landscape of federal enterprise governance by driving innovation, informing policy development, fostering collaboration, facilitating knowledge transfer, and enhancing performance monitoring and evaluation processes. Effective governance structures enable federal enterprises to leverage the benefits of commercial R&D investments and navigate the complexities of the innovation ecosystem to achieve their mission and objectives effectively.

Building upon theses perspectives, our analysis is grounded that national software spending and R&D in ZT can support federal enterprises in enhancing security and compliance. National software spending can support the acquisition of advanced security software and tools to protect sensitive data and critical infrastructure within federal enterprises. Additionally, R&D in ZT can lead to the development of innovative security solutions that address emerging threats and vulnerabilities, ensuring compliance with regulatory requirements and safeguarding against cyberattacks [17,18].

Innovativeness and adaptability is also benefited by R&D in ZT encourages innovation and the exploration of new technologies in the market that can help federal enterprises adapt to changing environments and stay ahead of the curve. Investing in cutting-edge software solutions and ZT R&D allows federal enterprises to remain competitive, drive digital transformation initiatives, and capitalize on emerging opportunities in the technology landscape [19].

Other perspective is about cost savings and resource optimization. By investing in efficient software solutions and leveraging ZT innovations from the market, federal enterprises can achieve cost savings and optimize specialized resource utilization to the core of government businesses [20]. ZT patents offer federal enterprises opportunities to enhance efficiency, improve service delivery, strengthen security and compliance measures, foster innovation, and adaptation, facilitate data-driven decision-making, and achieve cost savings and resource optimization. By leveraging advanced software

solutions and embracing ZT innovations, federal enterprises can drive meaningful impact, deliver value to stakeholders, and achieve their mission and objectives effectively.

References Appendix A

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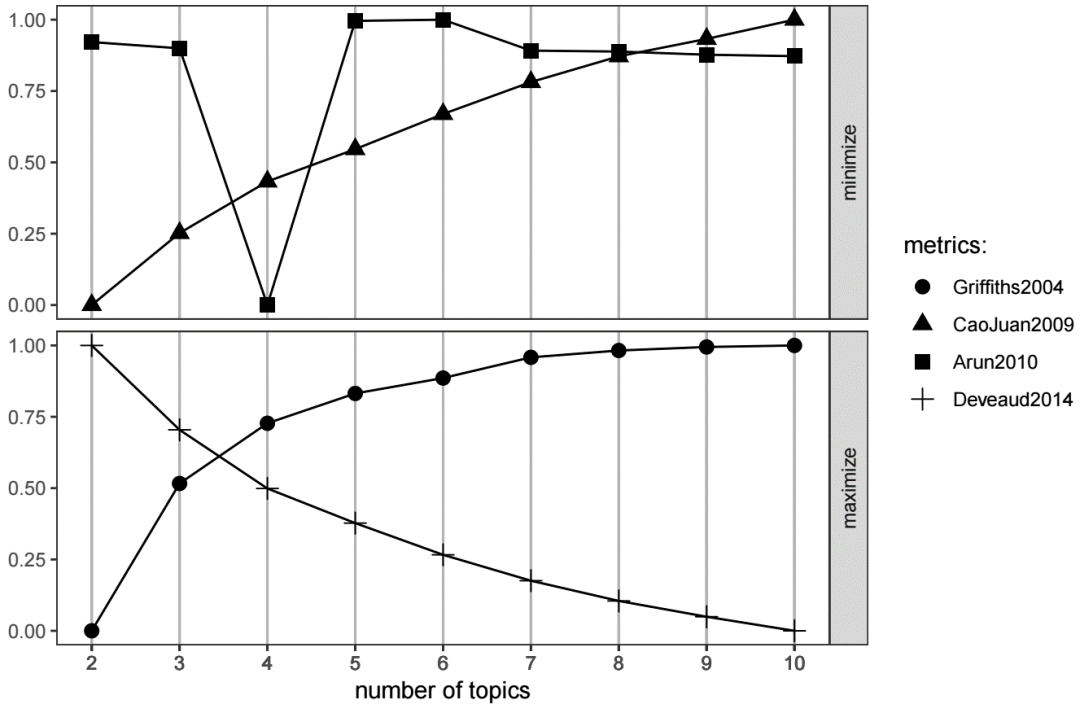
Appendix B

Table B1. Topic Modeling (LDA) Results

Topic	Topic Label	Keywords	Patents Total
1	Cloud Security	system, service, cloud, platform, trusted, based, security, computing, environment, management, configured, computer	131
2	TinIS Method	trust, safety, method, time, field, model, claims, evaluation, invention, dynamic, main, obtaining	202
3	Access Control	access, user, control, module, security, policy, resource, system, information, authority, management, agent	136
4	Network Security	network, node, security, communication, chain, based, virtual, block, connected, machine, unit, function	139
5	Device Security	device, key, plurality, includes, secure, file, encrypted, generating, devices, interface, methods, public	202
6	Data Processing Flow	data, based, processing, flow, controller, domain, storage, sdp, encryption, source, operation, algorithm	130
7	Identity Authentication	authentication, terminal, information, identity, method, verification, packet, invention, comprises, end, system, authorization	149
8	Security Structure	request, device, application, service, server, client, target, gateway, method, information, access, message	208
Total			**1297**

Figure B1. Topic Modeling (LDA) Graph Results



Appendix C

Table C1. ZT intellectual Property Application

Application Office	Abbreviation	INPADOCs
Canada	CA	3
China	CN	784
Germany	DE	3
European Patent Office (EPO)	EP	16
United Kingdom	GB	1
Hong Kong	HK	2
India	IN	2
Japan	JP	4
Republic of Korea	KR	23
Russian Federation	RU	2
Taiwan	TW	6
United States	US	388
World IP Organization (WIPO)	WO	68

Note. N = 1,297

Table C2. Descriptive Statistics

Variables	Mean	Std.Dev.	Minimum	Maximum
e-participation	1.997	0.014	1.858	2.008
Regulatory Quality	1.735	0.099	1.462	1.937
Government effectiveness	1.851	0.044	1.719	1.978
ZT strategic patent	0.587	0.154	0.301	1.582
ZT technological portfolio	1.362	0.252	0.752	2.709
Gross expenditure on R&D	1.715	0.096	0.142	1.956
Software Spending	1.670	0.245	1.250	2.008
Cooperation Dummy	0.346	0.077	0.301	0.477

Table C3. Correlation Matrix

Variables	epart	regq	govef	strategic	ztport	gross	softs	cdum
e-participation (epart)	1							
Regulatory Quality (regq)	0.441	1						
Government effectiveness (govef)	0.402	0.983	1					
ZT strategic patent (strategic)	0.361	0.566	0.544	1				
ZT technological portfolio (ztport)	0.320	0.362	0.339	0.401	1			
Gross expenditure on R&D (gross)	0.612	0.833	0.802	0.461	0.348	1		
Software Spending (softs)	0.513	0.857	0.832	0.619	0.480	0.703	1	
Cooperation Dummy (cdum)	0.144	0.103	0.091	0.147	0.125	0.121	0.161	1

Note. N=1297; $p < 0.001$ for all coefficients (2-tailed)

Table C4. Variance Inflation Factor Results

Variables	VIF
ZT strategic patent	1.726
ZT technological portfolio	1.374
Gross expenditure on R&D	1.991
Software Spending	2.822
Cooperation Dummy	1.048

Appendix D

Four regression models for Government effectiveness and Regulatory Quality (Table B1 and B2) use panel OLS to consider the heterogeneity of unobservable effects attributed to assignees and time effects. Models (B1), (B3) and (B5) are fixed effects models that only include control variables. Models (B2), (B4) and (B6) are the full models for fixed effects that include all control and independent variables for *Government effectiveness, Regulatory Quality, and e-participation*, respectively.

Table D1. Fixed Effects Analysis on Government effectiveness

	Model (B1)		**Model (B2)**	
Variables	Coefficient	t-value	Coefficient	t-value
ZT strategic patent			0.007*	2.538
ZT technological portfolio			-0.007***	-4.798
Cooperation Dummy	-0.013**	-2.633	-0.012*	-2.485
Software Spending	0.057***	28.217	0.058***	24.687
Gross expenditure on R&D	0.090***	17.832	0.090***	17.990
Constant	0.367***	53.075	0.372***	53.948
Observations	1,297		1,297	
Assignee	602		602	
Adjusted R-squared	0.801***		0.806***	

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

Table D2. Fixed Effects Analysis on Regulatory Quality

	Model (B3)		**Model (B4)**	
Variables	Coefficient	t-value	Coefficient	t-value
ZT strategic patent			0.022***	3.787
ZT technological portfolio			-0.014***	-4.515
Cooperation Dummy	-0.025*	-2.489	-0.024*	-2.392
Software Spending	0.131***	31.377	0.130***	26.774
Gross expenditure on R&D	0.241***	23.094	0.240***	23.317
Constant	-0.075***	-5.327	-0.065***	-4.596
Observations	1,297		1,297	
Assignee	602		602	
Adjusted R-squared	0.849***		0.853***	

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

Table D3. Fixed Effects Analysis on e-participation

	Model (B5)		**Model (B6)**	
Variables	Coefficient	t-value	Coefficient	t-value
ZT strategic patent			0.001	0.631
ZT technological portfolio			0.001*	1.998
Cooperation Dummy	0.005**	1.937	0.004	1.818
Software Spending	0.005***	4.759	0.003**	3.073
Gross expenditure on R&D	0.035***	13.564	0.035***	13.543
Constant	0.620***	174.482	0,620***	172.906
Observations	1,297		1,297	
Assignee	602		602	
Adjusted R-squared	0.405***		0.407***	

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

Appendix E

A system of generalized method of moments (GMM) is used to produce consistent estimators of coefficients by conducting differences of equation and then applying t-1 lagged dependent variables as instrument variables to control the endogeneity. Two-step GMM estimation is performed through Arellano–Bond/Blundell-Bond tests for autocorrelation. These tests were performed in Stata software examining the differences between L(1) and L(2). Specifically, an L(1) autoregressive process is one in which the current value is based on the immediately preceding value, while an L(2) process is one in which the current value is based on the previous two values. The results were consistently similar when we dropped and added the lags of the instrument variables. Four models for the Government effectiveness and Regulatory Quality GMM test are presented in Tables C1 and C2. Model (C1) is a system GMM model that includes only the effects of the control variables on Government effectiveness. Model (C2) is the full system GMM model that includes all effects of the control and independent variables on Government effectiveness. Model (C3) is a system GMM model that includes only the effects of the control variables on the Regulatory Quality. Model (C4) is the full system GMM model that includes all effects of the control and independent variables on the Regulatory Quality. Model (C5) is a system GMM model that includes only the effects of the control variables on e-participation. Model (C6) is the full system GMM model that includes all effects of the control and independent variables on e-participation. The results of the Arellano–Bond/Blundell-Bond tests for zero correlation in the first-differenced errors in models in Tables C1, C2 and C3 reject the null hypothesis and cannot reject the hypothesis at the second order. The results show that the instrument variables are valid.

Table E1. GMM results on Government effectiveness

Variables	Model (C1)		Model (C2)	
	Coefficient	*z*-value	Coefficient	*z*-value
ZT strategic patent			0.212***	4.34
ZT technological portfolio			-0.099***	-3.46
Cooperation Dummy	-0.052	-0.86	-0.065	-1.30
Software Spending	0.268	0.69	-0.012	-0.04
Gross expenditure on R&D	0.277***	5.61	0.263***	6.12
Constant	1.175***	3.36	1.523***	5.01
Arellano–Bond test for L(1)	0.220**	1.94	0.118	1.22
Arellano–Bond test for L(2)	-0.125	-1.09	-0.168*	-1.62
Model fit	Wald $x^2(5) = 50.32$ Prob > $x^2 = 0.000$		Wald $x^2(7) = 95.05$ Prob > $x^2 = 0.000$	
Number of Instruments	37		37	

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

Table E2. GMM results on Regulatory Quality

Variables	Model (C3)		Model (C4)	
	Coefficient	*z*-value	Coefficient	*z*-value
ZT strategic patent			0.412***	4.27
ZT technological portfolio			-0.200***	-3.59
Cooperation Dummy	-0.123	-1.02	-0.149	-1.53
Software Spending	0.149**	1.94	0.093	1.48
Gross expenditure on R&D	0.427***	4.34	0.401***	4.80
Constant	0.517	1.43	0.961**	3.10
Arellano–Bond test for L(1)	0.261**	2.26	0.158*	1.64
Arellano–Bond test for L(2)	-0.962	-0.85	-0.155	-1.50
Model fit	Wald $x^2(5) = 43.68$ Prob > $x^2 = 0.000$		Wald $x^2(7) = 88.65$ Prob > $x^2 = 0.000$	
Number of Instruments	37		37	

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

Table E3. GMM results on e-participation

Variables	Model (C5)		Model (C6)	
	Coefficient	z-value	Coefficient	z-value
ZT strategic patent			0.007	0.17
ZT technological portfolio			0.541**	2.27
Cooperation Dummy	0.571	1.13	0.510	1.12
Software Spending	-0.031	-0.87	-0.010	-0.030
Gross expenditure on R&D	0.093**	2.36	0.062*	1.67
Constant	2.751***	4.66	2.379***	4.32
Arellano–Bond test for L(1)	0.688***	4.11	0.685***	4.55
Arellano–Bond test for L(2)	-1.132***	-4.27	-0.969***	-3.93
Model fit	Wald $x^2(5) = 34.98$ Prob > $x^2 = 0.000$		Wald $x^2(7) = 50.74$ Prob > $x^2 = 0.000$	
Number of Instruments	37		37	

Note. *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

The results of the Arellano–Bond test for zero correlation in the first-differenced errors in models (C1) and (C3) also reject the hypothesis of first order (L1) and cannot reject the hypothesis at the second order (L2). Models (C2) and (C4) cannot reject the hypothesis of first order (L1) or second order (L2). These results show that the instrument variables are valid. From the results, we find consistent effects of the independent variables on Government effectiveness and Regulatory Quality. We find that ZT technological portfolio is significantly and negatively associated with Government effectiveness and Regulatory Quality in the same way as the Heckman model, which shows significant and negative associations. Cooperation variables are also negatively and not significantly associated with government effectiveness and regulatory quality in the same way as in the Heckman model except for Government effectiveness. These results indicate that the heterogeneity of cooperation across the samples can be significantly controlled by using the endogeneity control method based on GMM. Software spending is not significant and is negatively associated with Government effectiveness, in contrast to the Heckman model. This may be because radical increases in software spending in broad-based momentums can be rare as governments expand their digital services size by their needs and public policies impacted by political influences, public opinion, or budget capacity to buy them.

Models (C5) and (C6) reject the first-order (L1) and second-order (L2) hypotheses, showing that the instrument variables are not valid for *e-participation*. From the results, we find consistent effects of the independent variables only on *government effectiveness and regulatory quality*.