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# Design and Evaluation of a Technology/ICT Diffusion Method for Banks- Enterprise Architecture Perspective

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**Abstract:** In retail banks, comparing the levels of technological diffusion of "*in between country*" to the "*across country*"" identifies the availability, gaps, and duplicative levels of technologies which are critical for potential investments in the latest competitive technologies. To avoid technology disparities in the diffusion levels, the comparison has to apply rigorous theoretically well founded diffusion models and mathematically proven methods. Aiming at rigorously comparing the diffusion levels, the current study has five objectives (1) Reviewing state-of-the-art of across country of theoretical diffusion models, (2) Reviewing state-of-the-art of across country measuring methods, (3) Reviewing state-of-the-art of across country of diffused technologies and initiatives, (4) Proposing the development of a rigorous *in between country's* Enterprise Architectural (EA) based Measuring Method of Technology Diffusion (EA-MTD) and (5) Evaluating the EA-MTD. The research design of the paper is orchestrated by a 6 phased DSRM which utilizes SLR and CA techniques for Literature reviewing of 71 technology-retail bank articles of 10 across-country for the period of 1999-2024, Multiple Embedded Case Study for the analysis, design, validation, and evaluation (Delphi technique) of 5 retail banks. Reviewing revealed the existence but the weakness of 4 non-rigorous models and/or 22 methods of technology diffusion, 15 initiatives, and 90 cross country diffused technologies, while the EA-MTD demonstrated the existence of 8 commonly delivered BSOs, 11 BUs, 32 BA/Rs, 4 BSs, 4 BFs, and 5 BPs, in addition to 6 AppSOs, 4 AppSs, and 4 AppFs which are derived by 61 AppNs, and 4 AppGs, in addition to the overall levels of the diffusion Groups and the banks scoring of medium levels (66.275%). The findings determined several deficiencies with the existing methods, but the competency of the proposed EA-MTD with 87.14, 83.16, 83.34, 99.06, 87.62, 97.62 of criterions, and an overall acceptance score of 89.660%.

**Keywords:** ICT Diffusion, Technology Measuring Method, Enterprise Architecture, Retail Banks, Multiple Embedded Case Study

## Introduction

Since the emergence of economic industries, the Financial Institutions (FI) specifically the retail banks, have steadily sought to be better than their competitors in the same business domains in between and across country, as the focal point of competition was directed towards the consumers who keep on demanding a higher level of services to get satisfied (Akimova *et al.*, 2018). Similar to the internationally recognized retail banks, the retail banks (Rulebook, 2024; Nicoletti, 2013) provide customers with a broad spectrum of financial services and transactions such as checking, savings, deposits, home and business loans according to Debab & Yateem (2012), for customers to perform multiple transactions including but not limited to Automatic Teller Machine (ATM), Point-Of-Sale (POS) debit, credit, or prepaid cards, debit and credit pre-authorized transfer, home banking via the internet and with an extensively diffused technologies (Rulebook, 2024; Gupta *et al.*, 2008; Nicoletti, 2013).

Scholarly articles such as Pennings & Harianto (1992); Prakash *et al.* (2021); Singhal & Jain (2023) have witnessed how customers have been positively impacted by the rapid investments of technological innovations and increased competition among market participants in between and across countries. In addition, technological diffusion in banks has been found to have direct positive impact on the efficiency of enterprises

which has positively impacted the economic development of these countries Gupta *et al.* (2008) by investing in, providing and acquiring higher technologically diffused service levels to customers in order to gain higher revenues, increased cross-sell ratios and higher customer retention and overall satisfaction (Debab & Yateem, 2012).

To achieve objectives 1,2,3, a comprehensive literature reviewing based on Systematic Literature Review (SLR) and Content Analysis (CA) was carried out to review 71 articles for the period of 1999-2024 over 10 across countries revealed (1) The existence of 4 theoretical models, 22 measuring methods of technological diffusion and 15 functional sets of 90 diffused technologies and 15 technological initiatives and (2) The existence of several relevant deficiencies such as (a) Lacking well-established and mathematically proven theoretical models for the development, validation and evaluation of the method as will be extensively discussed later, (b) Lacking specifically dedicated measuring methods to the banking sector and differs in terms of the dimensions of technology and the level of diffusion measurement Comin & Hobijn (2011), (c) lacking dedication to the retail banks, spanning outdated periods of measurements w.r.t data sets, lacking direct data collection and analysis, (d) lacking of competency TAM's variables and criterions such as easiness, usefulness, decision support, comprehensiveness, timeliness and reuse as suggested by Van Dyk (2014), which enable retail banks to easily identify, learn and implement best fit technologies in order to gain internal, external or generic competitive advantages, (e) showing huge disparities of across-country technological diffusion of banks, which characterize and identify the competitive technological diffusion levels in retail banks and heavy reliance on reliance on untrustworthy public datasets.

This study is aimed to rigorously measure the *in between country* levels of technological diffusion in the retail banking sector in comparison to *across country levels* so to provide recommendations on technological availability, gaps, duplicative levels for potential technology investments. This is derived by addressing 5 research objectives such as (1) Reviewing state-of-the-art of across country of theoretical diffusion models, (2) Reviewing state-of-the-art of across country measuring methods, (3) Reviewing state-of-the-art of across country of diffused technologies and initiatives, (4) Proposing the development of a rigorous *in between country's* Enterprise Architectural (EA) based Measuring Method of Technology Diffusion (EA-MTD) and (5) evaluating the EA-MTD.

To achieve objective 4, we propose the development of EA based Measuring Method of Technology Diffusion (EA-MTD) in the retail banks as insighted by Adwan & Alsaeed (2022); Adwan & Al-Soufi (2022); Hinkelmann *et al.* (2016) and six phased Design Science Research (DSRM) paradigm w.r.t Hevner & Chatterjee (2010); Johannesson & Perjons (2021); Peffers *et al.* (2018) of artifacts development, identification, analysis, validation (i.e. Multiple Embedded Case study approach) suggested by Myers & Avison (2002); Yin (2018); Burger (2006) of the 5 retail banks, at which the primary and secondary data collection were performed based on document analysis via accompanying a developed template of previously set questions, while the evaluation (i.e. two rounded Delphi technique as suggested by Brady (2015); El-Gazzar *et al.* (2016); Keil *et al.* (2013); Strasser (2017)).

Continuing to satisfy objective 4, the EA embraces the philosophy of transitioning retail banks including EA business and tech levels from their baseline/as-is status to their potential/ to-be status according to Adwan & Alsaeed (2022); Adwan & Al-Soufi (2022); Hinkelmann *et al.* (2016) and mathematically measures (measuring method) the diffusion levels of tech applications, systems and tech to the other in between and/or across country competitors, by identifying and analyzing their data (business and diffused tech) of the same business domain (retail banks) as in Adwan & Alsaeed (2022); Adwan & Al-Soufi (2022); Hinkelmann *et al.*, (2016), which would extremely improve the overall sector's tech diffusion competitiveness by providing recommendations on tech availability, gaps, duplicative levels and potential investments.

Continuing the achievement of objectives 1- 5, the DSRM is a problem-solving paradigm which creates innovative artifacts to solve problems and improve the working environment as advocated by Peffers *et al.*, (2018), while the Delphi technique is an IS technique of evaluation for many Information Systems (IS) subjects as described in Hevner & Chatterjee (2010), which aims at obtaining reliable feedback responses of experts as suggested by Johannesson & Perjons (2021) through multiple questionnaires as suggested by Yin (2018) and based on multiple quality criterions (Keil *et al.*, 2013; Myers & Avison, 2002; Burger, 2006).

## *Previous Works*

### *The Financial Institutions and Retail Banks*

To achieve objective 1, the Financial Institutions (FI) are private or public businesses that financially intermediate fund's savers and borrowers together throughout various financial transactions such as investments, loans, deposits and insurance (Pennings & Harianto, 1992). This includes the classification of formats including, deposit-taking institutions (banks, building societies, credit unions, trust& mortgage and credit companies) and is the most popular type, insurance companies and pension funds, or brokers, promoters, underwriters and investment funds. The first

manage deposits and provide credit, while the second provide insurance policies to individuals and companies. The third are individuals or firms that intermediate between investors and securities exchanges. Adwan & Alsaeed (2022) further classify banks according to business activities into retail, commercial and business, investment, private, Islamic, conglomerates, financial services and central.

Adwan & Alsaeed (2022) classify retail banks into retail banks, community banks, community development banks, credit unions, postal saving banks, savings banks, ethical banks, direct or online only banks), have direct connection with individuals and Small and Medium Size Enterprises (SMEs) for current/saving accounts and loans. Retail banking, according to Debab & Yateem (2012) provides broad spectrum of customers with products such as checking, savings, deposits, home and business loans, etc. Elaborated by Nicoletti (2013), in retail banks, customers perform several financial transactions services such as, Automatic Teller Machine (ATM) at which customers withdraw or deposit bank accounts, Point-Of-Sale (POS) debit, credit, or prepaid cards at which customers make card online terminals' purchases and payments via the internet and home banking, debit and credit pre-authorized transfer at which direct deposits, credits of mortgages are issued by third parties, home banking at which online trading is performed via computers, telephones, or mobile devices, payment of bills via telephone allows customers to do direct money transfers to external service providers via the voice commands function, touch tones or human operators, billing by email at which customers pay bills via the internet, debit and credit pre-authorized transfer at which third parties issue direct deposit of salaries and mortgages, payment of bills via telephone external service providers collect payments form customers via the voice commands function, touch tones or human operators and billing by email at which customers pay bills via the internet.

In 2022, the Central Bank of Bahrain (CBB) announced that the number of financial institutions reached 114 of which are 69 wholesale banks and 23 retail banks. According to Rulebook (2024); Nicoletti (2013), retail banks in Bahrain are categorized into conventional/traditional and Islamic banks, 56 of which are conventional in nature while 5 only are locally incorporated capital conventional retail banks (Rulebook, 2024).

### *Theoretical Models of Technological Diffusion*

To achieve objective 1, a comprehensive literature analysis was performed to explain the state-of-the-art of 4 underpinning theoretical models which shape and legitimize the development process of the measuring methods of tech diffusion. Table (1) reveals 4 models such as the epidemic, the probit, the legitimation and competition and the information cascades models.

Explained by Comin & Mestieri (2014); Golichenko (2012), in the Epidemic model, users (adopters) of a new tech share the info to other non-users who adopt the tech and announce its arrival. The first phase of adoption shows low rates of adoption while later phases show higher rates of adoption and tech diffusion. A weakness of this theorem is that the potential users need to be persuaded more than be informed about tech presence. However, Probit model states that each user values the new differently and must be given incentives to adopt faster leading to decrease in cost and consequently, more potential users become actual users. A third type of model puts the emphasis on what happens during legitimation and computation. Legitimation describes the process by which a new tech becomes established until take up rates rise, while computation describes the effect on take up, while info cascades is composed of 3 phases of diffusion such as the initial choice between A and B, the lock-in to A and then the bandwagon induced by imitation, indicating that choices positively impact time path of diffusion.

### *Measuring Methods of Technological Diffusion*

To achieve objective 2, a literature analysis was done to describe the state-of-the-art of 22 measuring methods of Tech diffusion spanning the years of 1999-2024. The methods were based on several theoretical models which differed according to Comin & Mestieri (2014) w.r.t. dimensions of tech and level of diffusion measurement.

The measures at in between country level demonstrate the overall level of tech in a country if there is large cross-country variation in adoption lags but lack the intensity levels demonstration in the country, while measurements of tech diffusion are extended to more disaggregated levels to study the access of producers to a tech when available in a country.

Comin & Mestieri (2014); Golichenko (2012) demonstrated the S-shaped diffusion curves (logistic curve), the tech diffusion which is equal to tech producers divided by potential adopters and the logistic function which is equal to the long-run outcome divided by 1 + e-(constant of integration+ speed of adoption), where the logistic or S-shaped curves measure tech diffusion in many sectors and countries. The methods had certain weaknesses such that traditional measures were not able to measure general patterns. Proposed by Comin *et al.*, (2008); Comin & Hobijn (2004); Zemtsov (2020), the intensive margin of adoption (CHAT country-level dataset) explained ratios for which the tech intensity is divided by population or by GDP. The method was hard to compare across tech because they have different units and disallow measuring the magnitude of the cross-country variation in tech. Comin *et al.*, (2008) proposed the time lag intensity of cross-country differences in adoption method which have years and country across tech and computes time usage lags for per capita GDP. The diffusion curve is related to tech

characteristics across countries, while horizontal and vertical shifts are informative about cross-country differences. But, the model didn't show the income play in tech diffusion. Moreover, the world tech frontier method, proposed by Comin & Mestieri (2014) stated that for each existing tech, a more productive, vintage appears in the world frontier every instant, while the two-step procedure proposed by Comin & Hobijn (2011); Comin & Mestieri (2014) estimated the country-tech specific intercept and plausibility of estimates of adoption lags, however, with the regression method of Comin & Mestieri (2014), homotheticity of tech is a restrictive constraint in reality.

**Table 1:** Chronological list of theoretical models and measurement methods of technological diffusion

| Refs. | Loc | Sector | Model/Method of diffusion | Explanation |
|---|---|---|---|---|
| (Golichenko, '12) | UK | Bank | Epidemic model of info diffusion vs. Probit model | Developed a post S_curve model (epidemic model) and an alternate model (probit model) |
| (Comin & Hobijn, 11) | US | N/I | Historical Cross-Country Technology Adoption (HCCTA) | Developed a model that measured the Technology diffusion of 25 technologies in 23 countries in1788–2001 yrs |
| (Benhabib *et al*., '14) | US | N/I | Confined exponential diffusion based on Nelson-Phelps catch-up model of tech diffusion | Developed a model that integrates between Nelson-Phelps catch-up model of tech diffusion and the logistic model of technology diffusion to generate the total factor productivity level of USA w.r.t 27 countries |
| (Shu & Strsman'05) | US | Bank | Random effect model | Analysed IT productivity of 12 banks for 9 yrs. for analysis (1989-1997) |
| (Zemtsov,'20) | US | N/I | Model of endogenous technology | Developed a tech diffusion model for 19 tec, 21 countries in 1870-1998 based on level of productivity embodied in capital and rate at which the quality embodied in new technology increases |
| (Bloom *et al*., '13) | US | N/I | Non-tournament model of R&D with tech spillovers and strategic interaction | Developed FW showing that tech (R&D) & product market spillovers have testable implications vs. rent spillovers for performance indicators and exploited implications using measures of a firm position by using panel data (1980- 2001) |
| (Comin *et al*., '08) | US | N/I | Model of cross-country historical tech (CHAT) data set | Developed intensive & extensive margins of Tech diffusion curve model of cross-country (CHAT) data set 115 tech in 150 countries for 200 yrs |
| (Achimugu *et al*., '09) | Nig | N/I | Availability of ICT in households indicators | Developed a measure of economic growth in business |
| (Comin & Hobijn, 11) | US | N/I | Adoption patterns | Assembled 3 data sets with country-level measures of tech adoption, in 1000 BC, 0 and 1500 AD, using 12 tech from Atlas of cultural evolution and 24 coded tech |
| (Galang, '14) | US, UK, Fra | N/I | Patterns and intensive margin of adoption by CHAT dataset | Studied approaches of TD & determined diffusion process which are impacted by new tech penetration rates where TD is measured by vertical & horizontal distances of diffusion curves for 25 tech. |
| (Comin& Mestieri,'14) | N/I | N/I | The institution-based strategy theories | Analyzed uneven process of tech diffusion by studying the impact of firm, network, and knowledge characteristics on adoption for Cost reduction |
| (Comin & Mestieri, '18) | US, UK | N/I | The model of adoption and growth | Investigated the lags with which new technologies are adopted across countries and long-run diffusion rates after adoption. The model defines margins of adoption, variation, builds strategy and productivity growth |
| (Comin *et al*., '20) | Sen, Viet | N/I | Firm-level adoption of Tech (FAT) for productivity | Developed measures tech sophistication in businesses to investigate tech adoption patterns across firms, across business, and within fir rms |
| (Kriebel & Debener, '19) | Ger | Bank | IT profitability paradox | Developed two text mining measures: frequency-based assessment of common digitalization keywords in these reports and sentiment of the context |
| (Cirera *et al*., '20) | Sen, Viet | N/I | Firm-level Adoption of Technology (FAT) survey | Developed a model of heterogenious technology adoption (technology curve) with different adoption costs across functions and with non-homothetic production |
| (Del Gaudio *et al*., '21) | EU | Bank | Baseline regression model-based macro industry panel dataset | Developed by collecting dataset of 28 EU countries from indicators of the world bank from 1995 to 2015 on the banking. |
| (Cirera *et al*., '22) | Bang | N/I | Firm-level Adoption of Tech (FAT) survey for sophistication | Developed a technology index to calculate the most advanced technology used by the firm |
| (Rodríguez-Espíndola *et al*., '22) | UK | Manufacturing | Behavioral model | Developed model of institutional theory, resource-based view, and technology acceptance model to develop behavioral model (digital manufacturing technologies)for adoption of BD, AI, CC, and BC for risk mgt in UK |
| (Mamun *et al*., '23) | Bang | Bank | Temporal and cross-sectional graphs (CD)-based growth patterns | Examined the growth pattern of the IT-based banking status for four panels in Bangladesh banks, using cross-section Dependence (CD) tests |
| (Yang & Tajul Masron'23) | China | Bank | The System GMM-two step estimator and data from 118 Chinese banks from 14-21 | Developed a model based on long-tail theory, financial innovation theory, and a two-step GMM model for 118 Chinese commercial banks (2014-2021) to determine how DT affects profitability |

### *Technological Initiatives in Banking*

To achieve objective 3, a comprehensive literature analysis was performed to describe the state-of-the-art of the tech initiatives and diffused tech across-country as shown in Tables (2-3).

**Table 2:** Technology initiatives of retail banks across

| Source # | Loc | Purpose |
|---|---|---|
| Maduku *et al.* (16) | S. Africa | Study factors impacting bank customer attitude of usage of internet and phone banking services in S. Africa |
| Arshad & Ahlan (13) | Tanzania | Investigate the impacts and challenges of ICT adoption in the Tanzanian banks. |
| Blogging on Business (24) | Malaysia | Explore literature on ITO in Malaysia banks to find ITO benefits (economic or business and tech) |
| Wilson (17) | USA | Study the Age analytics as a competing technology in the data driven world in retail banks |
| Gomber *et al.* (18) | USA | Study FinTech to create strategic value |
| Ambalov & Heim (20) | USA | Study emergence of new tech innovations, process disruptions, and services transformation in retail banks |
| Branzoli *et al.* (21) | Kazakhstan | Discuss opportunities for new digital economy (digital tech and multiple ICT related) |
| Branzoli *et al.* (23) | Italy | Measure level of net adoption, AI, CC in banks during Covid in Italy. |
| Shetty & Nekita (23) | India | Study the impact of IT in retail banking to make it strong financial medium for transactions |
| Oladunjoye & Tshidzumba (23) | S. Africa | Study the disruptive technological innovation in 4 S.Africa financial services sectors (retail banks) |
| Bhasin & Gulati (21) | India | Study challenges of Fintech banking sector in India during Covid and top tech trends in Fintech |
| Koneri & Halasagi (21) | India | Study the role and adoption of ICT in banking Sector |
| Kaur & Ali (21) | India | Identify factors influencing bank staff of tech banking to improve adoption of tech banking services |
| Indriasari *et al.* (22) | Indonesia | Review digital bank growth of internet, smartphones, and communication tech during 2015-2022 |
| Carreri *et al.* (23) | Italy | Study the digitalization of work in retail banking industry |

However, it is important to first understand that technology takes several forms of information exchange between two or more computers through any of the several methods of internet-based interconnections and provides fast, relatively cheaper and convenient communication channels (Gupta *et al.*, 2008). Several scholars, including Prakash *et al.*, (2021); Achimugu *et al.* (2009) have witnessed that the banking sector is highly impacted by rapid investments of technological innovations and increased competition among market participants. Advocated by Pennings & Harianto (1992), information technology in banking is comprised of firstly, back-office technology such as computer technology (e.g. installation of on-line terminals, departmental computing, branch system integration and software upgrades) and telecommunication technology (e.g. Satellites and Networks) and secondly, transactional technology includes varieties of ATM based networks, POS systems such as debit card purchasing, home banking services such as bank by phone and corporate electronic banking such as e- cash management and clearing houses.

Tech diffusion in banks has been found to have direct positive impact on the efficiency of enterprises which indirectly positively impacts the economic development of these countries (Gupta *et al.*, 2008). So, to gain unique competitive positions between in between and across countries, retail banks must invest in higher tech based service levels to customers in order to gain higher revenues, increased cross-sell ratios and higher customer retention and overall satisfaction (Debab & Yateem, 2012). The initiatives and the diffused technologies were collected between 1999-2024, reviewed and analyzed from 71 articles across 10 countries from the four continents.

The initiatives and the diffused technologies were collected within the period of 1999-2024, reviewed and analyzed from 71 articles across 10 countries which were distributed among the four continents. The resulting findings according to Table (3) included 90 technologies which have Spanned the internet, Messaging Systems (SMS), Emailing systems, Financial technologies (FinTech), Internet Of Things (IOT), Blockchain Technologies (BCT), Cloud Computing (CC), Information Systems (CRM, CMS, DSS, MIS, Customer management control), ATM, Artificial Intelligence (AI), Payment solutions (Payment TM, Cash Free, E-Wallet), Biometrics, Cryptocurrency, Biometrics, Analytics, Bitcoin technologies, Risk management systems, Robotics, GPS, API, Web and Telebanking/Digital banking. We categorized the 90 technologies into 15 logical functional groupings such as, G1 (Communication and advertisement), G2 ( Financial technologies), G3 (Risk management), G4 (Investment), G5 (Regulatory and compliance), G6 (Payments & clearing technologies), G7 (Communication & Collaboration), G8 (Data management), G9 (Trading & payments), G10 (Financial regulatory), G11 (Management & security), G12 (Automatic telling ), G13 (Financial data sharing &Data Centers), G14 (IT outsourcing) and G15 (Banking Mgt).

**Table 3:** Classification of the diffused technological applications, systems, and technology in across country retail banks

| G_No | G_Function | AppN | Technology | USA | Italy | Kaza | India | Ma | Ind | S. Africa | | Tan |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G1 | Communication and advertisement | App01 | Cell Phone | | | | | X | | X | | |
| | | App02 | Internet | X | X | X | X | X | X | X | X | X | X | X |
| | | App03 | Voice Banking technology | | | | X | | | | | |
| | | App04 | Bulletin board | | | | X | | | | | |
| | | App05 | Smart watch | | | | X | | | | | |
| | | App06 | Voice Mail Service (VMS) | | | | | X | | | | |
| | | App07 | Messaging/SMS apps | X | | | X | | | | | |
| | | App08 | Mobile SMS | | | | | X | | | | |
| | | App09 | Mobile Apps and applications | | | | | X | | | | |
| | | App10 | Account deposits without branches | | X | | | | | | | |
| | | App11 | Mail Alert Service | | | | | X | | | | |
| | | App12 | Email | | | | X | | | | | |
| | | App13 | Development suites & Communication media | | | | | | X | | | |
| G2 | Financial technologies | App14 | Fin Tech Techno (Yap, Recko, AI based, Cashfree, EHF, MoneyTap, Niyo) | X | X | X | | X | X | | | |
| G3 | Risk management | App15 | Human decision-making algorithms | X | | | | | | | | |
| | | App16 | Risk management technology | | X | | | X | | | | |
| | | App17 | Artificial Intelligence | | | | X | | | X | | |
| | | App18 | Learning algorithms | | | X | | | | | | |
| | | App19 | Machine learning algorithms | X | | X | | | | | | |
| | | App20 | Predictive Analytics | X | | | | | | | | |
| G4 | Investment | App21 | Cryptocurrency | | X | | | X | | X | | |
| | | App22 | Bitcoin crypto investment application | | | | | X | X | | | |
| | | App23 | Decentralized finance (DeFi) | | | | | X | | | | |
| | | App24 | Decentralized finance (DeFi) | | | | | | | | | |
| | | App25 | Digital currency | | | | | | | X | | |
| | | App26 | Initial coin offerings (ICOs) | | X | | | | | | | |
| | | App27 | Online-brokerage | | X | | | | | | | |
| | | App28 | Global remittances | | X | | | | | | | |
| | | App29 | FX applications | | X | | | | | | | |
| | | App30 | Crowdfunding | | X | | | | | | | |

## Materials and Methods

Continuing to achieve objectives 1,2 and 3, the Design Science Research Methodology (DSRM) as depicted in . Figure (1) was employed as a research design model to solve certain organizational problems (i.e. measuring technological diffusion in retail banks).

The DSRM is explained by Hevner & Chatterjee (2010); Johannesson & Perjons (2021); Peffers *et al.*, (2018) as a popular information system research for the construction and evaluation of IT artifacts (EA-MTD) and facilities the collaboration of technology, enterprises and individuals, with real-world scenarios (Hevner & Chatterjee, 2010). Thus, due to the combination of qualitative and quantitative nature of at hand research w.r.t the development of the EA-MTD artifact as advocated by Offermann *et al.*(2009); Peffers *et al.* (2018) and blended with enterprises, business processes, technology and individuals, the DSRM can best be embraced as research design. Figure (1) depicts the six phases of the DSRM based on the insights of Hevner & Chatterjee (2010); Peffers *et al.*, (2018), while the following subsections describe the phases. This includes Problem identification and motivation phase, Design and development of a solution phase, Definition of the objectives of a solution phase, Demonstration phase, Evaluation phase and Communication phase.

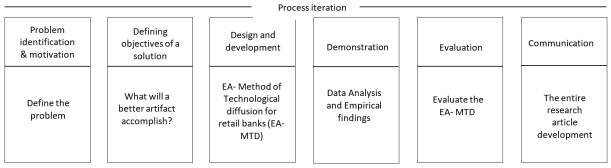


**Fig. 1:** The research design process

### *Problem Identification and Motivation Phase*

To achieve objectives 1,2 and 3, the 1st phase necessitates the identification and conceptualization of the research problem and justification of the value of the solution as a prior step towards the development of the artifact (EA-MTD). Phase 1 is addressed by the limitations of the previous studies in developing technological diffusion measuring initiatives in the financial institutions (retail banks) for current and

potential competitive technological findings to gauge their successes and pinpoint their shortcomings.

The analytical methods of the state-of-the-art of the research study's objectives are performed according to a five phased Systematic Literature Review (SLR) (Levy & J. Ellis, 2006; Okoli & Schabram, 2012) and the Content Analysis (CA) methods (Davies, 2012; Nasir, 2005). The prior helps in generating a comprehensive strategy for article reviewing. Google scholar database was chosen as an off-campus and free search engine to identify English sources, citations, matrices, selection and inclusion of 71 journal articles, conference papers, books and dissertations. The use of Boolean operators of seven thematic keywords during Phase 1-4 revealed an initial list of n = 173 articles, while the selection and reviewing based on relevancy and citation <=1 revealed a final list of n = 71 articles.

The latter is composed of 6 phases to analyze the journal articles' text for valid and quantitative inferences (i.e. Percentages) from the text including selecting sample, determining analysis's unit, specifying scheme, choosing of final categories, performing assessment and analyzing data.

Discussed earlier, the analysis revealed (1) The existence of 15 functional sets of 90 diffused technologies and 15 technological initiatives and (2) The existence of several relevant deficiencies such as (a) Lacking well-established and mathematically proven theoretical models for the development, validation and evaluation of the method as will be extensively discussed later, (b) Lacking specifically dedicated measuring methods to the banking sector and differs in terms of the dimensions of technology and the level of diffusion measurement Comin & Hobijn (2011), (c) lacking dedication to the retail banks, spanning outdated periods of measurements w.r.t data sets, lacking direct data collection and analysis, (d) lacking of competency TAM's variables and criterions such as easiness, usefulness, decision support, comprehensiveness, timeliness and reuse as suggested by Van Dyk (2014), which enable retail banks to easily identify, learn and implement best fit technologies in order to gain internal, external or generic competitive advantages, (e) showing huge disparities of across-country technological diffusion of banks, which characterize and identify the competitive technological diffusion levels in retail banks and greater reliance on reliance on untrustworthy public datasets.

### *Definition of the Objectives of a Solution Phase*

Continuing to achieve objectives 1,2 and 3, in the 2nd phase of DSRM, the qualitative or quantitative objectives of the solution are deduced (Peffers *et al.*, 2018). Recall from section 1 that this research is aimed to rigorously comparing the diffusion levels (i.e. five conventional retail banks (FI-01-FI-05)) to the worldwide (i.e. 10 countries) by the EA-MTD method which addresses 6 criterions including respectively, easiness, usefulness, decision support, comprehensiveness, timeliness and reuse to measure the degree of effortless of the model, enhancement the model provides, decision support, generalizability, cost reduction, time completion and reusability.

### *Design and Development of a Solution Phase*

To achieve objective 4, the 3rd phase of DSRM witnesses the construction of the artifact which could be formed in models, instantiations, methods, structures, or new features of informational, technical, or social resources (Hevner & Chatterjee, 2010). Moreover, knowledge of the required resources and familiarity with theoretical knowledge and benefit from it in solutions is required to construct the artifact Offermann *et al.* (2009); Peffers *et al.* (2018).

The Multiple Embedded Case Study approach was utilized to design and implement the EA-MTD based on five conventional retail banks (FI-01-FI-05) which represent the retail banks. According to Myers & Avison (2002); Yin (2018); Burger (2006), the Embedded Case Study is a methodology of data collection that is comprised of several sub-units of analysis and forms a combination of qualitative (for data collection and analysis) and quantitative methods into one research study. The data collection took several qualitative primary and secondary sources of data.

The primary data collection included structured interview forms (i.e. face-to-face and/or telephone) with close ended questions, as primary source of data, were designed following the insights and guidelines of (Adwan & Alsaeed, 2022; Adwan & Al-Soufi, 2022; Myers & Avison, 2002). Several interview questions concerning the business and technological sides were preplanned and asked to the interviewees as illustrated in Appendix 1. Telephonic qualitative research interviews are believed by Cachia & Millward (2011); Farooq & de Villiers (2017); Synnot *et al.*, (2014) to be much more favorable than other methods due to the methodological validation, saving of time, reducing cost of meeting with larger number of interviewees, not restricting locations. less demanding, greater flexibility, greater anonymity and less intensity and privacy. The key informant interviews were selected based on their perceived ability to provide needed information and with various positions in the five banks (FI-01-FI-05). Interviewees had time frame for answers in English as the official language setup. In addition, participants were cooperatively answering with illustrating examples where possible. At each interview conclusion, the interviewer encouraged open discussion in order to allow the participants to ask and add as many comments as possible they wish to enhance the research according to the suggestions of (Yin, 2018). The interviewees were requested to identify

themselves in terms of job title, educational level and the years of work experience in the respective FIs.

The secondary source of data was collected from the documents provided and websites of the selected FIs at which web content analysis was performed.

The validation of the cases included conducting construct validity, external validity and reliability were conducted according to the insights of (Tsang, 2014). During research design and data collection stages, external validity was satisfied from the fact that this study was drawn from the substantial lack of previous studies, FI-01-FI-05 were selected based on multiple criterions (i.e., conventional retail banks, Bahraini and responsive to interview requests). Moreover, construct validity for data collection and composition stages was claimed by establishing precise operational measures for the study concepts by mapping the data collection questions and measures to the research questions to produces a chain of evidence (Triangulation) at which a draft case study report was regularly reviewed during the composition stage and the end of collection. The development of a repository of business architecture templates guaranteed a concise collection of collection procedures and findings.

The EA-MTD is composed of two architectural subsets including, the Business Architecture (BA), the Information System Architecture (ISA) (Adwan & Alsaeed, 2022; Adwan & Al-Soufi, 2022). The Business Architecture (BA) layer is mapped to the Information System Architecture (ISA) and is composed of several capabilities such as the Business Strategic Objectives (BSO), Business Unit (BU), Business Actors/roles (BA/R), Business Service (BS), Business Function (BF), Business Process (BP). Alternatively, the ISA layer (i.e. the technological applications/systems/technologies) is mapped to the BA components and is composed of the Application Name (AppN), Application Service (AppS), Application Function (AppF), Application Process (AppP). Moreover, the BU holds BA/R, while BS is composed of BP embedded in BF. Alternatively, the AppN delivers an AppS which is composed of AppP embedded in AppF.

The Measurement of the technological diffusion levels (%) is applied for the individual technological applications and systems based on the following Eqs. (1-9) respectively:

Where:

$P$ is the Diffusion

$X$ is the No of rows

$Y$ is the No of columns

$N$ is 0/1

$P_x$ is the Application order in the table

$$P1 = App1,\ P2 = App2,\ P3 = App3,\ ....,\ P61 = App61 \quad (1)$$

The technological diffusion (%) of each App w.r.t. the Application services (AppS) is equal to the ($Sum\ of\ availability\ of$ S $of\ each$ App/$Total\ number\ of$ AppS) 100%, as in Eq. 2:

$$P_{S,x}\% = \frac{\left(\sum_{y=1}^{4} N_{x,y}\right)}{4} \times 100 \quad (2)$$

The technological diffusion (%) of each App w.r.t. the Application functions (AppF) is equal to the ($Sum\ of\ availability\ of\ f\ of\ each$ App/$Total\ no\ of$ App$f$) 100%, as in Eq. 3:

$$P_{F,x}\% = \frac{\left(\sum_{y=1}^{4} N_{x,y}\right)}{4} \times 100 \quad (3)$$

The technological diffusion (%) of each App w.r.t. the Application processes (AppP) is equal to the ($Sum\ of\ availability\ of$ P $of\ each$ App/$Total\ no\ of$ AppP) 100%, as in Eq. 4:

$$P_{P,x}\% = \frac{\left(\sum_{y=1}^{5} N_{x,y}\right)}{5} \times 100 \quad (4)$$

The technological diffusion is measured for 3 formats including, for each application, for each group of applications and for each bank as stated in the following Eqs. 5-9. The technological applications penetration (%) of each App w.r.t. the Application services (AppS), Application functions (AppF) and Application processes (AppP) is equal to the Sum of availability of S, F, & P of each AppTotal no of S, F, & P$x$ 100%, as in Eq. 5:

$$P_x\% = \frac{\left(\sum_{y=1}^{13} N_{x,y}\right)}{13} \times 100 \quad (5)$$

Illustrated in Eq. 6, the technological diffusion (%) of each application is equal to the Sum of availability of Banks Total number of Banks$x$ 100%:

$$P_x\% = \frac{\left(\sum_{y=1}^{5} N_{x,y}\right)}{5} \times 100 \quad (6)$$

However, illustrated in Eq.7, the technological applications diffusion (%) each group of apps is equal to the Sum of availability of apps in each groupTotal number of applications$x$ 100%, as in Eq. 7:

$$G_M\% = \frac{\left[\hat{a}\hat{}\left(\substack{x=61,\ y=10 \\ x=1,\ y=1}\right) N_{x,y}\right]}{61} \times 100 \quad (7)$$

Alternatively, the technological diffusion (%) of all applications in each bank as illustrated in Eq8, is equal to the Sum of percentages of each BankNumber of Apps in each Bank, as in Eq 8:

$$App\% = \frac{\left(\sum_{x=1}^{No.} P_x\right)}{No.} \times 100 \quad (8)$$

Finally, as illustrated in Eq. 9, the technological diffusion (%) of all applications of each bank is equal to the Sum of availability of AppsTotal number of App$x$ 100%, as in Eq. 9:

$$C_y\% = \frac{\left(\sum_{x=1}^{61} N_{x,y}\right)}{61} \times 100 \quad (9)$$

The analysis of data was first triggered by the analysis of the manually collected organizational structures of the FI-01-FI-05 followed by the analysis of interviews and collected documents based on the

protocol templates in Appendix 1 and analyzed thematically following the suggestions of Ritchie *et al.* (2013). Two areas of emphasis were covered in the interview guide. The first was concerned with the business components such as the Business Strategic Objectives (BSO), Business Actors (BA), Business Units (BU), Business Services (BS), Business Functions (BF) and Business Processes (BP), whereas the second area was concerned with the technological components such as the technological applications and systems such as Application Strategic Objectives (AppSO), Application Name (App N), Application Service (AppS), Application Function (AppF) and Application Process (AppP).

Moreover, throughout the document analysis process, general info of each FI was collected such as procedures, policies, organizational structure and documentations of the technological applications, as illustrated in Appendix 1. Furthermore, the collected datasets were manually coded according to a designed matrix of predetermined themes in MS Excel. The data analysis was first triggered by the transcription and analysis of the data collected through the Templates 1-7 of the interview protocol document w.r.t Appendix 1, along with Ambalov & Heim (2020); Branzoli *et al.*, (2023); Blogging on Business (2024); Wilson (2017) and the application of 6 phased Content Analysis (CA) method Davies (2012); Nasir(2005) were performed for analyzing the public and private ministries' portals of Bahrain including selecting sample, determining analysis's unit, specifying scheme, choosing of final categories, performing assessment and analyzing data.

### *Demonstration Phase*

To achieve objective 4, the 4$^{th}$ phase of DSRM is concerned with the explanation of the artifact in several possible forms such as simulation, proof, experiment, case study, or any other activity that the researcher deems appropriate (Peffers *et al.*, 2018). Therefore, the phase represents the analysis of the findings of EA-MTD to eventually answer the aim of the study, as stated by Branzoli *et al.*, (2023). The analysis is summarized as follows but is further explained in Results and Discussion section of the paper.

### *Evaluation Phase*

To achieve objective 5, the 5$^{th}$ phase of DSRM is concerned with comparing the actual results with the goals of the solution from the use of artifact by requesting knowledge of relevant analysis techniques and metrics for evaluation such as logical evidence or appropriate empirical evidence (March & Smith, 1995; Peffers *et al.*, 2018). Evaluation represents the evaluation of the EA-MTD artifact which is verified by applying the Delphi technique to collect expert opinions about the method and the empirical findings in two panel rounds based on several criterions (El-Gazzar *et al.*, 2016; Van Dyk, 2014). Advocated by Keil *et al.* (2013), the Delphi technique is an IS technique of evaluation for many IS subjects which aims at obtaining reliable feedback responses from experts through multiple questionnaires (Brady, 2015) at which a copy of online questionnaires consisting of four parts was designed by Microsoft Forms and the survey links were transmitted to experts along with a cover letter through emails. The first part of the questionnaire explains the EA-MTD and mathematical formulas, while the second part focuses on the demographic profile of the experts and organization. The third part covers the questions based on five point's Likert-type scales (Strongly agree, Agree, Strongly disagree) of six assessment criterions which are composed of three to five measurement items.

The evaluation criterions as suggested by Van Dyk (2014) were based on variables of the TAM model, which have been used in several studies to evaluate IS/IT solutions include easiness, usefulness, decision support, comprehensiveness, timeliness, and reuse. However, the fourth part is based on open-ended questions to express the existing panel experts' views. Easiness criterion measures the degree to which an expert believes that using the model is free of effort, while Usefulness measures the degree to which an expert agrees that using the model enhances the objective. Alternatively, Decision support measures how much the model will provide support for the objective, while Comprehensiveness measures how overarching the model is. In addition, Timeliness measures the cost in terms of time required to complete the model, while Reuse measures how likely the decision-maker will be to use the model.

The panel size of five experts was formed to evaluate the EA-MTD according to the insights of Strasser (2017). Also, since the number of rounds depends on the time and the expected fatigue of experts, two rounds are enough (Brady, 2015). Moreover, for the identification and selection of qualified panel's participants, the study followed the insights of Van Dyk (2014). Moreover, the experts' panel was identified based on three qualifications such as being academically concerned with banking field, having five years or more of experience in IT and/or management and being involved in the processes of technological decision-making. Consequently, seven experts were identified, selected and contacted via email and phone to serve on the panel in the Delphi survey at which the data collection was scheduled for a gap of three weeks for the two rounds together.

### *Communication Phase*

The 6$^{th}$ phase of DSRM is concerned with communicating the importance of the problem and the artifact and the usefulness, effectiveness, and accuracy of the artifact, with as many researchers, practitioners and professionals as possible while conserving confidentiality of the organization (Peffers *et al.*, 2018). Also, it demonstrates the importance and effectiveness to researchers at which the identified problem and the suggested solution are documented as a research publication (Hevner & Chatterjee, 2010; Peffers *et al.*, 2018).

## Results and Discussion

### *The Analytical Findings*

Continuing to satisfy objective 4, the BA analysis of the five retail banks (FI-01- FI-05) revealed, as illustrated in Table (4), the presence of 8 commonly delivered business strategic objectives (BSO01-BSO08), 11 common business units (BU0-BU11), 32 common business actors/roles (BA/R01- BA/R32), 4 common business services (BS01-BS04), 4 common business functions (BF01-BF04) and 5 common business processes (BP01-BP05).

Continuing to satisfy objective 4, the ISA analysis of the five retail banks (FI-01- FI-05) revealed as illustrated in Table (5), the presence of 6 common application strategic objectives (AppSO01- AppSO06), 4 common application services (AppS01-AppS04) and 4 common application functions (AppF01-AppF04) which are derived by 61 dedicated applications and 4 application groups (AppG1- AppG4). The first includes data analysis and integration, IT based innovation, KM provision, premium IT service delivery, business continuity enablement and mitigation of service costs. The second includes the provision of communication services, provision of development services, provision of client services and provision of operational, while the third is derived by 61 dedicated applications (AppN01-AppN61) and 4 application groups (AppG1-AppG4) such as, AppG1 (Audio and Video calls, Auto answer machine and online chat), AppG2 (App and model editing and web design), AppG3 (Customer info record, payment, withdraw, online transaction, deposit and account statement) and AppG4 (Employee performance measurement, leaves, hiring, training, promoting and daily office tasks).

**Table 4:** The BS, BF, BP of the FI-01- FI-05 retail banks

| BA/R id | BA/R Name | BU id | BU Name | BS id | BF id | BF N | BP id | BP N |
|---|---|---|---|---|---|---|---|---|
| A&/R1 | General Manager | BU01 | Management | | | Management | BP01 | Manage banks' risk of financial lending policies and procedures |
| A&/R2 | Head of Legal advisory | BU02 | Legal Advisory Internal audit | BS01 | BF01 | | BP01 | |
| A&/R3 | Legal Advisor | BU02 | Legal Advisory Internal audit | | | | BP01 | |
| A&/R4 | Legal Operator | BU02 | Legal Advisory Internal audit | | | | BP01 | |
| A&/R5 | Risk manager | BU03 | Risk Management | | | | BP01 | |
| A&/R6 | Risk manager | BU03 | Risk Management | | | | BP01 | |
| A&/R7 | Risk manager | BU03 | Risk Management | | | | BP01 | |
| A&/R8 | Manager of info security | BU03 | Risk Management | | | | BP01 | |
| A&/R9 | Manager of Credit | BU03 | Risk Management | | | | BP01 | |
| A&/R10 | Manager of Compliance | BU03 | Risk Management | | | | BP01 | |
| A&/R11 | Head of Audit | BU04 | Internal audit | BS02 | BF02 | Controlling | BP01 | |
| A&/R12 | Manager of int Audit | BU04 | Internal audit | | | | BP01 | |
| A&/R13 | Shariah Compliance | BU04 | Internal audit | | | | BP01 | |
| A&/R14 | Head of Financial control | BU05 | Financial Control | | | | BP02 | Formulate financial reports and planning |
| A&/R15 | Senior of Financial control | BU05 | Financial Control | | | | BP02 | |
| A&/R16 | Head of retail banking | BU06 | Retail Banking | BS03 | BF03 | Customer Affairs | BP03 | Submit customer with services |
| A&/R17 | Manager of Bank branch | BU06 | Retail Banking | | | | BP03 | |
| A&/R18 | Manager of Call Center | BU06 | Retail Banking | | | | BP03 | |
| A&/R19 | Manager of Sales | BU06 | Retail Banking | | | | BP03 | |
| A&/R20 | Head of inv/Gov progs | BU07 | FI & Gov. prog | | | | BP04 | Serve admin and operational functions |
| A&/R21 | Head of HR | BU08 | Human Resources | BS04 | BF04 | Supporting | BP04,05 | |
| A&/R22 | Manager of HR | BU08 | Human Resources | | | | BP05 | Manage and maintain the relation of division |
| A&/R23 | Asst Manager of HR | BU08 | Human Resources | | | | BP05 | |
| A&/R24 | Manager of PR | BU08 | Human Resources | | | | BP05 | |
| A&/R25 | Head of IT | BU09 | Information Technology | | | | BP05 | |
| A&/R26 | Manager of IT | BU09 | Information Technology | | | | BP05 | |
| A&/R27 | Ass Manager of IT | BU09 | Information Technology | | | | BP05 | |
| A&/R28 | Head of Operations | BU10 | Operations | | | | BP05 | |
| A&/R29 | Manager of Operations | BU10 | Operations | | | | BP05 | |
| A&/R30 | Head of facility management | BU11 | Property Facility | | | | BP05 | |
| A&/R31 | Head of projects | BU11 | Property Facility | | | | BP05 | |
| A&/R32 | Manager of properties | BU11 | Property Facility | | | | BP05 | |

Continuing to satisfy objective 4, measuring the diffusion level (%) of individual and group technological applications for FI-01–FI05 resulted in the findings as illustrated previously in Table (6). Respectively, G1 scored medium level of 65.7%, G2 scored medium level of 45.6%, G3 scored medium level of 52.8% and G4 scored high level of 100%.On the other side and respectively, FI-01 scored the highest level of technological/ICT applications penetration of 68.3%, followed by FI-02 and FI-03 concurrently with medium levels of 63.3%, followed by FI-05 with low penetration level of 60% and finally with FI-04 with low level of 55%. The entire retail banking sector has scored a medium level of 66.275% of overall technological/ICT diffusion.

**Table 5:** The technological Apps w.r.t AppS, AppF, BU, BS, BU of the FI-01- FI-05 retail banks

| BS | BU | App id | App-Name | AppS | AppF |
|---|---|---|---|---|---|
| BS01 | BU01 | App01 | VOIP | Provision of Communication services | Audio and Video calls, Auto answer machine, and Online chat |
| | BU02 | App02 | Chatbot | | |
| | BU03 | App03 | Skype for business | | |
| | | App04 | Helpdesk portal | | |
| | | App05 | Cisco Webex Meetings | | |
| | | App06 | X Virtual (VR) | | |
| | | App07 | Zoom | | |
| BS02 | BU04 | App08 | Corporate website | Provision of Development services | Application and model editing, and web design |
| | BU5 | App09 | Sparx system | | |
| | | App10 | NetBeans | | |
| BS03 | BU06 | App11 | Electronic Fund Transfer System (EFTS eDGE) | Provision of clients' services | Customer information record, payment, withdraw, online transaction, deposit, account statement |
| | BU07 | App12 | ATM software | | |
| | | App13 | Customer information file (CIF) | | |
| | | App14 | Customer relationship management (CRM) | | |
| | | App15 | Supply Chain Finance solution | | |
| | | App16 | AI supported Chatbot service via WhatsApp | | |
| | | App17 | Video and WhatsApp Banking | | |
| | | App18 | Account Aggregator | | |
| | | App19 | Open banking API | | |
| | | App20 | Digital banking | | |
| | | App21 | FinTech (BACKBASE) | | |
| | | App22 | Private Banking Solution Banking Solutions | | |
| | | App23 | Sharia compliant financing (Ijara, Murabaha) | | |
| | | App24 | FinTech (BNPL) | | |
| | | App25 | MyB2B | | |
| | | App26 | HelloMoney ATM (POS) | | |
| | | App27 | M-Banking | | |
| | | App28 | Online Fraud detection | | |
| | | App29 | Payment Aggregator | | |
| | | App30 | Data archivist comp | | |
| | | App31 | Mobile Banking App | | |
| | | App32 | Cloud Computing | | |
| | | App33 | X Mobile Banking | | |
| | | App34 | X Online Banking | | |
| | | App35 | Front-end client interface omni-channel portal | | |
| | | App36 | Digital Transaction Banking (DTB) | | |
| | | App37 | Samsung Wallet service | | |
| | | App38 | Contactless payments | | |
| | | App39 | Global Banking Platform (TCS BaNCS) | | |
| | | App40 | APIs and cognitive tools (AI and analytics) | | |
| | | App41 | Cloud Computing | | |
| | | App42 | Open banking | | |
| | | App43 | AWS cloud technologies | | |
| | | App44 | International remittance system (SWIFT) | | |
| | | App45 | Cloud Computing | | |
| | | App46 | Cyber fusion technology | | |
| | | App47 | Threat intelli sharing, incident, security automa (SOAR) | | |
| | | App48 | Temenos retail banking sol and origination on infinity | | |
| | | App49 | Cloud-native solutions | | |
| | | App50 | API | | |
| | | App51 | Open banking | | |
| | | App52 | Global Wallet | | |
| BS04 | BU08 | App53 | EXUS Financial Suite (EFS) | Provision of staff operational services | Employee performance measurement, leaves, hiring, training, promoting, daily office tasks |
| | BU09 | App54 | Microsoft office | | |
| | BU10 | App55 | Microsoft 365 | | |
| | BU11 | App56 | Adobe reader | | |
| | | App57 | Human Resources Management System (HRMS) | | |
| | | App58 | Adobe flash player | | |
| | | App59 | Anti-virus | | |
| | | App60 | Internet banking dashboard | | |
| | | App61 | Firewalls and Intrusion Prevention Systems | | |

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**Table 6:** The Individual and Group technology diffusion percentages and levels

| App-ID | Group category | Description | Retail Banks (FI-01-FI05) | | | | | Ind. Diffusion (%) | Ind. Diffusion level | G. Diffusion (%) | G. Diffusion level |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FI-01 | FI-02 | FI-03 | FI-04 | FI-05 | | | | |
| App01 | G1 | Communication services | 1 | 1 | 1 | 1 | 1 | 100% | H | 65.70% | M |
| App02 | | | 1 | 1 | 0 | 0 | 0 | 40% | M | | |
| App03 | | | 1 | 1 | 1 | 0 | 0 | 60% | M | | |
| App04 | | | 1 | 1 | 0 | 0 | 0 | 40% | M | | |
| App05 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App06 | | | 1 | 1 | 0 | 1 | 1 | 80% | H | | |
| App07 | | | 1 | 0 | 0 | 0 | 1 | 40% | M | | |
| | | | H | H | M | M | M | | | | |
| App08 | G2 | Development services | 1 | 1 | 1 | 1 | 1 | 100% | H | 46.60% | M |
| App09 | | | 1 | 0 | 0 | 0 | 0 | 20% | L | | |
| App10 | | | 1 | 0 | 0 | 0 | 0 | 20% | L | | |
| | | | H | L | L | L | L | | | | |
| App11 | G3 | Clients' services | 1 | 0 | 1 | 1 | 0 | 60% | L | 52.80% | M |
| App12 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App13 | | | 1 | 1 | 0 | 0 | 0 | 40% | L | | |
| App14 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App15 | | | 0 | 0 | 0 | 0 | 1 | 20% | L | | |
| App16 | | | 0 | 0 | 1 | 0 | 0 | 20% | L | | |
| App17 | | | 1 | 0 | 1 | 0 | 0 | 40% | M | | |
| App18 | | | 0 | 0 | 0 | 0 | 1 | 20% | L | | |
| App19 | | | 0 | 0 | 0 | 0 | 1 | 20% | L | | |
| App20 | | | 0 | 1 | 0 | 0 | 1 | 40% | M | | |
| App21 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App22 | | | 0 | 0 | 1 | 0 | 0 | 100% | H | | |
| App23 | | | 1 | 0 | 1 | 0 | 1 | 40% | M | | |
| App24 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App25 | | | 0 | 0 | 1 | 0 | 0 | 20% | L | | |
| App26 | | | 0 | 0 | 1 | 0 | 0 | 20% | L | | |
| App27 | | | 0 | 0 | 1 | 0 | 0 | 20% | L | | |
| App28 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App29 | | | 1 | 0 | 0 | 0 | 0 | 20% | L | | |
| App30 | | | 1 | 0 | 0 | 0 | 0 | 20% | L | | |
| App31 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App32 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App33 | | | 0 | 1 | 0 | 0 | 0 | 20% | L | | |
| App34 | | | 0 | 1 | 0 | 0 | 0 | 20% | L | | |
| App35 | | | 0 | 1 | 0 | 0 | 0 | 20% | L | | |
| App36 | | | 0 | 1 | 0 | 0 | 0 | 20% | L | | |
| App37 | | | 0 | 1 | 0 | 0 | 0 | 20% | L | | |
| App38 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App39 | | | 0 | 0 | 0 | 1 | 0 | 20% | L | | |
| App40 | | | 0 | 0 | 0 | 1 | 0 | 20% | L | | |
| App41 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App42 | | | 0 | 0 | 0 | 1 | 0 | 20% | L | | |
| App43 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App44 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App45 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App46 | | | 0 | 0 | 0 | 0 | 1 | 20% | L | | |
| App47 | | | 0 | 0 | 0 | 0 | 1 | 20% | L | | |
| App48 | | | 0 | 0 | 1 | 0 | 0 | 20% | L | | |
| App49 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App50 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App51 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App52 | | | 0 | 0 | 1 | 0 | 0 | 20% | L | | |
| | | | M | M | M | M | M | | | | |
| App53 | G4 | Operational services | 1 | 0 | 0 | 1 | 0 | 100% | H | 100% | H |
| App54 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App55 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App56 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App57 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App58 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App59 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App60 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| App61 | | | 1 | 1 | 1 | 1 | 1 | 100% | H | | |
| | | | H | H | H | H | H | | | | |
| Total Level (%) | 68% | 63% | 63% | 55% | 60% | 61.90% | 66.28% | M | | | |
| | | | H | M | M | L | L | M | | | |

*The Evaluation Findings*

Continuing to satisfy objectives 1,2,3, apparently, Table (7) demonstrate the descriptive statistics of the evaluation of the EA-MTD revealed overall acceptance score of 89.660% (average Mean = 4.4483) that is, four items were used to measure the easiness criterion at which the descriptive statistics in both rounds show an average Mean of 4.357 and average SD of 0.447, while five items were used to measure the Usefulness at which the descriptive statistics in both rounds show an average of Mean 4.158 and average SD of 0.467. Three items were used to measure the Decision support criterion at which the descriptive statistics in other rounds show an average Mean of 4.167 and average SD of 0.444, while three items were used to measure the Comprehensiveness at which the descriptive statistics in both rounds show an average Mean 4.953 and average SD of 2.500. Also, three items were used to measure the Timeliness criterion at which the descriptive statistics in both rounds show an average of Mean 4.381 and average SD of 0.278, while three items were used to measure the Reuse at which the descriptive statistics in both rounds show an average Mean of 4.881 and average SD of 0.104. The acceptance scores were respectively 87.14, 83.16, 83.34, 99.06, 87.62, 97.62%.

Recall the deficiencies encountered sections 1 and 2, the previous technological diffusion articles lack theoretical, well-established and proven theoretical models for the development, validation and evaluation of the method, while the EA-MTD in this article is based on EA theorem which provides the foundation of measuring (measuring method) of competitive technology diffusion levels to the other in between and/or across country competitors, by identifying and analyzing their data (business and diffused technologies) of the same business domain (i.e. retail banks) by providing recommendations on technological availability, gaps, duplicative levels and potential investments. Moreover, the DSRM was seldomly chosen to design the artifact (i.e. EA-MTD) as previous work demonstrated evaluation utilization of the model development. We, in contrary, employed the Delphi technique for evaluation to provide reliable feedback responses from experts.

W.r.t the technological diffusion initiatives and diffused technologies, there appeared huge disparities of across-country technological diffusion which we believe are attributed to the weakness of several non-dedicated models for technological adoption and diffusion which don't consider the uniqueness of the retail banking and rely on publicly distributed datasets. However, EA-MTD provides an accurate structure w.r.t BA and ISA layers at which the measurement levels can be calculated for the individual and groups of technological apps for the entire banking sector.

**Table 7:** The evaluation findings of the EA-MTD

| Criteria | Items | Round 1 | | Round 2 | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Easiness | It is easy to perform the modules required by the model | 4.429 | 0.619 | 4.714 | 0.238 |
| | It is clear and understandable to interact with a model | 4.000 | 0.333 | 4.286 | 0.238 |
| | It is flexible to interact with the modules of the model | 4.429 | 0.619 | 4.714 | 0.571 |
| | Overall, EA-MTD model is easy to use | 4.143 | 0.476 | 4.143 | 0.476 |
| | Average | 4.250 | 0.512 | 4.464 | 0.381 |
| Usefulness | Using the model saves my time | 4.143 | 0.810 | 4.429 | 0.286 |
| | Using the model improves my performance | 3.714 | 0.571 | 4.000 | 0.333 |
| | Using the model improves my productivity | 4.429 | 0.619 | 4.429 | 0.619 |
| | Using the model enhances my effectiveness | 4.143 | 0.476 | 4.143 | 0.472 |
| | I find EA-MTD useful | 4.000 | 0.333 | 4.143 | 0.143 |
| | Average | 4.086 | 0.562 | 4.229 | 0.371 |
| Decision support | Using the model provides the necessary and sufficient support to the objective | 4.286 | 0.571 | 4.429 | 0.286 |
| | There would be adequate support for the decision to implement the objective | 3.857 | 0.476 | 4.143 | 0.476 |
| | The model is important support to the decision to implement the objective | 3.571 | 0.619 | 4.714 | 0.238 |
| | Average | 3.904 | 0.555 | 4.429 | 0.333 |
| Comprehensiveness | The model is including all the required phases to achieve the objective | 4.857 | 0.143 | 5.000 | 0.000 |
| | The model provides comprehensive phases to guide implementation of objective | 4.857 | 0.143 | 5.000 | 0.000 |
| | Overall, EA-MTD model is comprehensive | 5.000 | 0.000 | 5.000 | 0.000 |
| | Average | 4.905 | 0.095 | 5.000 | 0.000 |
| Timeliness | The model requires time to perform and complete | 4.143 | 0.500 | 4.286 | 0.333 |
| | The model can provide the needed at the required time | 4.000 | 0.333 | 4.857 | 0.167 |
| | The model is efficient w.r.t time required to complete | 4.143 | 0.167 | 4.857 | 0.167 |
| | Average | 4.095 | 0.333 | 4.667 | 0.222 |
| Reuse | I intend to use the model in the future | 5.000 | 0.000 | 5.000 | 0.000 |
| | I am willing to encourage other decision-makers to use the model | 4.714 | 0.238 | 4.857 | 0.143 |
| | I think that I would use the model in the near the future | 4.714 | 0.238 | 5.000 | 0.000 |
| | Average | 4.810 | 0.159 | 4.952 | 0.048 |

To measure the baseline availability, gaps and duplicative levels of technologies as a precursor for potential technological investments, the retail bank sector seeks to embrace a rigorous, theoretically well founded diffusion models and mathematically proven methods. Consequently, a comprehensive literature analysis was performed to review, for the period of 1999-2024, the state-of-the-art of across country of theoretical diffusion models, across country measuring methods and across country of diffused technologies and initiatives. The analysis has revealed the existence of the 4 non-rigorous models and/or 22 methods of technology diffusion, 15 initiatives and 90 cross country diffused technologies. However, analysis demonstrated firstly, the existence of 15 functional sets of 90 diffused technologies and 15 technological initiatives and secondly, the existence of several relevant deficiencies such as (a) Lacking well-established and mathematically proven theoretical models for the development, validation and evaluation of the method as will be extensively discussed later, (b) Lacking specifically dedicated measuring methods to the banking sector and differs in terms of the dimensions of technology and the level of diffusion measurement Comin & Hobijn (2011), (c) lacking dedication to the retail banks, spanning outdated periods of measurements w.r.t data sets, lacking direct data collection and analysis, (d) lacking of competency TAM's variables and criterions such as easiness, usefulness, decision support, comprehensiveness, timeliness and reuse as suggested by Van Dyk (2014), which enable retail banks to easily identify, learn and implement best fit technologies in order to gain internal, external or generic competitive advantages, (e) showing huge disparities of across-country technological diffusion of banks, which characterize and identify the competitive technological diffusion levels in retail banks and greater reliance on reliance on untrustworthy public datasets.

The previously mentioned weaknesses have triggered the proposition of developing and evaluating an EA based Measuring Method of Technology Diffusion (EA-MTD) as suggested by Adwan & Alsaeed (2022); Adwan & Al-Soufi (2022); Hinkelmann *et al.* (2016). The EA-MTD is composed of two architectural subsets including, the Business Architecture (BA), the Information System Architecture (ISA) (Adwan & Alsaeed, 2022; Adwan & Al-Soufi, 2022). In addition, the Measurement of the technological diffusion levels (%) is applied for the individual technological applications is based on 9 formulas. Following the DSRM insights of Hevner & Chatterjee (2010); Johannesson & Perjons (2021); Peffers *et al.* (2018), the generation of EA-MTD was possible throughout development, identification, analysis, validation (i.e. Multiple Embedded Case study approach) as suggested by Myers & Avison (2002); Yin (2018); Burger (2006) of the 5 retail banks in Bahrain, at which the primary and secondary data collection were performed based on document analysis via accompanying a developed template of previously set questions and sub templates as in apprndix-1, while the evaluation utilized two rounded Delphi technique as suggested by Brady (2015); El-Gazzar *et al.* (2016); Keil *et al.* (2013); Strasser (2017)).

The analytical findings of utilizing the EA-MTD demonstrated uniform and extremely expectable and precise results such as the presence of 8 commonly delivered business strategic objectives, 11 business units, 32 common business actors/roles, 4 common business services, 4 common business functions and 5 common business processes. Moreover, the ISA comprised of 6 common application strategic objectives, 4 application services and 4 common application functions which are derived by 61 dedicated applications and 4 application groups. In addition, the diffusion levels of in between country were measured per bank and for the entire retail banking sector. The evaluation findings of the EA-MTD revealed an overall acceptance score of 89.660% based on 6 TAM based criterions; Easiness, Usefulness, Decision support, Comprehensiveness, Timeliness and Reuse.

The EA-MTD was capable to act a rigorous and continuous monitoring tool for the measuring of technology investment requirements of retail banking by overcoming previously deficient methods and providing a real and rigorous features. A future initiative is to design an adaptive repository for recent initiatives and diffused technologies in all retail banks.

The analysis of data was triggered by the analysis of the manually collected organizational structures of the FI-01 – FI-05 followed by the analysis of interviews and collected documents based on the templates in Appendix 1 and were analyzed thematically following the suggestions of Ritchie *et al.* (2013), while for the document analysis, general info of each FIs was collected in datasets and were manually coded in MS Excel. This may be considered biased due to the human involvement. Therefore, a future initiative is decided to enhance the manual procedures by using NVivo qualitative data analysis software and designing an adaptive repository for recent initiatives and diffused technologies in all retail banks.

This study has introduced, developed, implemented and evaluated the EA-MTD. Next steps include to incorporating extra factors that encourage evaluating the technology/ICT in the banking sector based on the fundamental framework of the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

## Conclusion

Aiming to computing rigorous technology diffusion levels in retail banks in comparison to across country levels, this research undergone five objectives including reviewing the state of the art of technological diffusion theories, methods of measurement and diffused technologies and initiatives between the years (1999-

2024), along with proposing the development, validation (construct validity, external validity and reliability) and evaluation of a measurement method (EA-MTD) that is derived from a well-established theory (Enterprise Architecture).

The research design of the paper is orchestrated by a 6 phased DSRM which utilizes SLR and CA techniques for Literature reviewing of over 71 technology-retail bank articles of 10 across-country for the period of 1999-2024, Multiple Embedded Case Study (structured Interviewees and documentation analysis) for the analysis, design, validation and evaluation (two rounded Delphi technique) of 5 retail banks w.r.t easiness, usefulness, decision support, comprehensiveness, timeliness and reuse to enable retail banks to easily identify, learn and implement best fit technologies in order to gain internal, external or generic competitive advantages within and in between country levels.

Analytical findings revealed the existence but deficiency of 4 non-rigorous models and/or 22 methods of technology diffusion, 15 initiatives and 90 cross country diffused technologies, while the EA-MTD demonstrated the existence of 8 commonly delivered BSOs, 11 BUs, 32 BA/Rs, 4 BSs, 4 BFs and 5 BPs, in addition to 6 AppSOs, 4 AppSs and 4 AppFs which are derived by 61 AppNs and 4 AppGs, in addition to the overall diffusion levels of the technology Groups and the retail banks scoring 66.275% and medium levels respectively. Despite the limitation of data collected recency, the findings are found useful in determining the deficiency of the review findings from one side and the adequacy and competency of the EA-MTD from the other side, with 87.14, 83.16, 83.34, 99.06, 87.62, 97.62% of criterions, with total acceptance score of 89.660%.

The EA-MTD was capable to act a rigorous and continuous monitoring tool for the measuring of technology investment requirements of retail banking by overcoming previously deficient methods and providing real and rigorous features. The model and approach used in this study may be applied in other studies, but their results may not correspond to the findings reported in this article. A future initiative is to design an adaptive repository for recent initiatives and diffused technologies in all retail banks.

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## Ethics

The content, data and methodology utilized in this study are all free of ethical issues or conflicts, according to the author. Every piece of data used was gathered morally and with the proper authorization. Additionally, the author attests that no problems are expected when this study is published.

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