SOA maturity influence on digital banking transformation

Alan MEGARGEL
Singapore Management University, ALANMEGARGEL@SMU.EDU.SG

Venky SHANKARARAMAN
Singapore Management University, venks@smu.edu.sg

Terence P. C. FAN
Singapore Management University, terencefan@smu.edu.sg

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RESEARCH ARTICLE

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Alan Megargel[1] · Venky Shankararaman[1] · Terence Fan Ping-Ching[2]

Abstract Digital Banking is an evolution of online banking, where the banks attempt to further enhance customer experience by integrating digital technologies such as mobile technology, social media and analytics. Traditional banks have the highest barriers to entry into the digital banking market due to the presence of legacy core banking systems. These legacy systems while still high performing and reliable, are inflexible to change and are not easily integrated to the modern application systems needed for delivering digital banking services across multiple online banking channels. One solution that is widely adopted in the industry to overcome this obstacle is the implementation of a Service-Oriented Architecture (SOA). In this paper, we investigate the relationship between three factors, namely a bank's technology infrastructure, IT governance processes, SOA maturity, and their impact on time-to-market (T2M) of digital banking products and services. Our research study is achieved through surveys and case study interviews conducted with the chief technologists from eight banks operating in Asia. A key conclusion from our study is that SOA maturity plays a very important role in enhancing a bank's capability towards digital banking transformation. In order to move towards higher levels of SOA maturity, we make three recommendations – establishing an SOA centre of excellence, implementation of a well-architected Enterprise Service Bus (ESB), and adoption of an ESB framework and toolkit.

Keywords: Digital Banking · FinTech · Legacy Systems · Service-Oriented Architecture · SOA · SOA Maturity · SOA Centre of Excellence · IT Governance

1 Introduction

"Digital Banking – a new concept in the area of electronic banking, which aims to enrich standard online and mobile banking services by integrating digital technologies, for example, strategic analytics tools, social media interactions, innovative payment solutions, mobile technology and a focus on user experience." [18]

✉ Alan Megargel:
alanmegargel@smu.edu.sg

✉ Venky Shankararaman:
venky@smu.edu.sg

✉ Terence Fan Ping-Ching:
terencefan@smu.edu.sg

[1] School of Information Systems, Singapore Management University, Singapore
2 Lee Kong Chian School of Business, Singapore Management University, Singapore

There is no standard definition of digital banking, however, the above definition encompasses most of the concepts discussed in the literature. Digital Banking is seen as an evolution from what was previously referred to as e-banking or online banking, with more focus on customer experience.

Digital Banking, which mostly falls within the boundary of retail banking as an industry, is shaped by “five competitive forces” [20] – 1) Customers are becoming increasingly more sophisticated, expecting personalized banking services to be delivered to them at anytime of the day across any channel; 2) Substitutes such as “FinTech” and other IT firms are providing non-bank alternative financial services such as payments, marketplace lending, and crowdfunding; 3) Entrants along with substitutes are more agile than traditional banks, have lower barriers to entry in terms of regulatory controls and legacy infrastructures, and are in fact defining the standards for Digital Banking; 4) Incumbents who are traditional banks are urgently pursuing digital strategies in order to salvage their diminishing market shares, but are severely inhibited due to their existing inflexible monolithic legacy systems; and 5) Suppliers such as technology vendors have relatively limited banking domain knowledge, and their further offerings of ‘commercial-off-the-shelf’ applications will not help traditional banks to unravel their legacy architectures.

Ironically, it is the incumbent traditional banks which have the highest barriers to entry into the digital banking market. Legacy core banking systems, which are inflexible to change, are at the “heart” of the problem, and replacing an existing core banking system on a live bank would be analogous to performing a heart transplant on a runner during a race. Bank management is essentially about managing risk, and the impact of a failed core banking system “transplant” is too high for most of the bank managers to consider it as a viable option. Therefore, core banking system replacements are rare as many banks are still using legacy mainframe technologies built in the 1970s. These legacy systems, while still high-performing and reliable, are inflexible to change and are not easily integrated to the modern application systems needed for delivering digital banking services across multiple online banking channels. The literature reveals universally that the solution for overcoming this obstacle is to implement a Service-Oriented Architecture (SOA) whereby the functionality of underlying legacy systems can be exposed as reusable services which are easily consumed by digital banking channels.

The SOA style of architecture is proven to be more flexible, enabling banks to become more agile, with improved time-to-market delivery of new products and services across multiple channels [25]. There is much written about the benefits of SOA in banking, as well as the lessons learned from failed SOA implementations. Banks that implement SOA well, are in the best position to compete in the digital banking market. However, many banks have either failed to realize the benefits of an SOA, or have not yet invested in it.

In this paper, we define a set of propositions which identify and explain the barriers to entry into digital banking for traditional banks, who are intent on protecting their market share against FinTech substitutes. Through surveys and case study interviews conducted with the chief technologists from various banks, a descriptive analysis of digital banking strategies and implementation challenges is provided, which reveals that SOA maturity has an influence on digital banking transformation. The rest of the paper is organized as follows. In Section 2, we review related literature in digital banking and SOA. In Section 3, we define and explain the three propositions. Section 4 presents the methodology adopted for evaluating the propositions. In Section 5, we present an analysis of the results of the evaluation. Section 6 summarizes the key findings and the implications for senior management. In Section 7, we present the conclusions from our work.

2 Literature review

2.1 Digital banking: response to fintech substitutes

Many traditional banks are urgently pursuing “digital” strategies in order to compete directly with FinTech firms [26]. “Digital Banking” is a buzzword used by many traditional banks in an attempt to position themselves alongside FinTech firms. Anecdotally, some banks have simply renamed their existing “self-service channels architecture” to “digital architecture”. But it’s not that simple. Traditional banks have high barriers to enter into this new digital industry currently led by FinTech firms.

Much is written about digital banking – its evolution, its drivers, trends in the industry, threats from new entrants, and what banks now must do to survive in this digital age. There exists some degree of urgency for banks to accelerate their digitization agendas, driven by a number of factors including: the proliferation of mobile phones, changing consumer habits and preferences towards interacting via digital media, online comparison sites where consumers can share experiences across different banking products and services, demand for 24/7 availability of banking services, and competition from non-bank alternative solutions such as marketplace lending and crowdfunding platforms [6].

A 2015 survey revealed that 72% of bank executives felt their bank only had a fragmented strategy for dealing with digital innovation, and that their legacy infrastructure was the main inhibitor [26]. Legacy monolithic core banking systems are inflexible to change, and are not easily integrated to the modern technology required for digital banking [6]. In order to enable the level of agility required to meet rapidly evolving business requirements, banks will inevitably reach a “point of no return” whereby they will need to break apart their monolithic core banking systems into smaller and more flexible modules [6]. In order to achieve a modular architecture, banks will need to invest in a Service-Oriented Architecture (SOA) which enables the rapid assembly and reuse of “digital assets” [7].

2.2 SOA as an enabler of digital banking

Service-Oriented Architecture (SOA) is clearly an enabler for digital banking. While, in most cases, the SOA literature does not refer directly to digital banking, there is much written on the benefits of SOA as it applies to “e-Banking” or “Online Banking”, which are the precursor terminologies used for digital banking. The benefits of e-Banking include: faster transaction speed as compared to branches, flexibility of banking anytime of the day, better control by customers over their accounts, and lower interest rates as banks pass on cost savings to their customers [2].

An empirical study was conducted on a European Bank with over 1000 branches and over 15,000 employees to determine the impact of SOA on the success of e-Banking, and the results showed a significant positive impact in terms of: a) financial benefits – increased revenues / decreased expense; b) agility to quickly assemble new processes through reuse of existing services; c) improved business-IT alignment; d) improved ROI through service reuse; e) reduced time to market of products and services; f) reduced cost of development through service reuse; g) improved overall reusability of IT assets; h) easier system integration; and i) reduced unscheduled downtime [2].

The business value to be achieved from an SOA investment are – improved business agility and reduced cost as a result of service reuse. However, there are both technical and organizational challenges to overcome [5, 17]. The technical challenges of SOA adoption include: a) the complexity of deciding “the right level of granularity of services”, and b) the complexity of mapping the message level details of legacy systems that are not well-documented [5]. However, once the complexity of service granularity and message mapping are resolved, the overall integration complexity can be reduced through the implementation of an Enterprise Service Bus (ESB) design pattern [5]. Governance is another challenge, as achieving SOA business value requires establishment of clear roles and responsibilities that cut across organization boundaries, compliance to standards, enforcement of policies, and fulfilment of service level agreements [16].

2.3 SOA case studies in banking

Most of the banks are still using legacy systems which are inherently inflexible to change and therefore, with the ability to expose functionality of legacy systems as reusable services, the business case potential for SOA in this industry is generally high [19]. Banks generally do not reveal details of their technology architecture or related internal inefficiencies to the public, therefore the number of case studies in this area is limited, and those that exist are anonymous.

Empirical case studies on two large well-established European Banks referred to anonymously as “Central Europe Bank” and “Northern Europe Bank”, reported significant positive benefits from the SOA adoption in both the case studies [3]. Salient points from the study include: a) services that expose functionality of legacy systems are reusable and also hide the complexity of the underlying system; b) services can efficiently execute composite transactions; c) reusable services “are a source of strategic value”; d) reusable services enable agile development of systems; e) an architecture board decides on the funding of new services; f) policies enforce the reuse of existing services; and g) “SOA invokes an unfamiliar concept that raises barriers to adoption” [3].

Another set of case studies were conducted on the SOA adoption at two large banks in Switzerland, with results indicating that exposing legacy system functionality as reusable services – a) improves business agility and time-to-market; b) reduces cost through service reuse; and c) requires strong architecture governance processes [23]. Similar results were found from studies conducted on a "Large European Bank" and a "Large UK Bank" [8], as well as a "Large Netherlands Bank" [14], and a "Large South East Asia Bank" [27].

2.4 SOA maturity models

SOA implementation in complex organizations such as banks typically span several years [8], and many organizations find it useful to periodically benchmark their SOA maturity in terms of technical implementation, which includes service design, deployment, performance, and reuse; as well as organizational processes which includes architectural decision-making, funding, and benefits realization [9, 12]. There are no pervasive or standard SOA maturity models in the market. However, many of them are founded on and/or extended from the Capability Maturity Model Integration (CMMI) developed by Carnegie Mellon University, which consists of five stages of maturity as follows: 1) "initial" – reusable software components, 2) "managed" – standardization of data and resources, 3) "defined" – support of business processes, 4) "qualitatively managed" – enterprise service architecture, 5) "optimized" – adaptive architecture [9, 10].

There are studies which compare the various SOA maturity models, including: a) Service Integration Maturity Model (SIMM), b) Sonic SOA Maturity Model (SOAMM), c) IT Service Capability Maturity Model, d) Web Services Maturity Model, e) Enterprise SOA Maturity Model, f) IBM Service Integration Maturity Model, g) Combined SOA Maturity Model (CSOAMM), and h) The Open Group Service Integration Maturity Model (OSIMM) [9, 15]. The various SOA maturity models typically layer organizational (non-technical) dimensions such as "benefits & metrics", "methodology" and "governance" across the five CMMI maturity stages [10, 21]. None of the related studies revealed any research instrument such as a survey which can be operationalized.

3 Barriers to entry for digital banks

3.1 Propositions

A theoretical model of digital banking barriers to entry is given in Figure 1 below. Time-to-market (T2M), represented as the dependant variable in the model, is a measure of traditional banks' agility to deliver new innovative digital banking products and services to the market. The barriers to entry, represented as the independent variables in the model, are the inhibitors which are keeping banks from achieving their digital banking time-to-market objectives. The three main inhibitors, which we expect to verify through data collection, are: a) legacy technology infrastructure which is inflexible to change; b) organizational complexity and challenges around technology decision-making; and c) lack of technical knowledge around web services standards and SOA best practices. We propose that banks' assessed level of SOA maturity will have a moderating effect on these inhibitors as predictors of digital banking time-to-market.

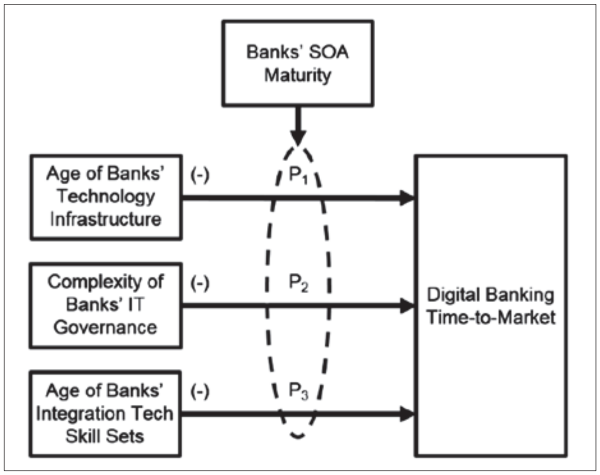

Fig. 1 Theoretical model of digital banking barriers to entry

The following set of propositions are illustrated in the above model as P1-P3.

3.1.1. Proposition 1

P1 – The age of banks' technology infrastructure has a negative influence on bank's time-to-market of digital banking products and services. This causal relationship is reduced as banks' SOA maturity increases.

Rationale – The "age" of technology infrastructure, in this case, is a means to determine the degree to which a technology is considered to be "legacy". An IBM mainframe developed in the 1970s, for example, would be considered as a legacy technology infrastructure when hosting a core banking system in the current era. Legacy core banking systems are monolithic (all-in-one functionality) rather than modular (separate integrated components), and they use outdated and often proprietary (non-standard) integration protocols. Legacy systems are therefore "brittle" (inflexible to change). The literature reveals universally that the solution for overcoming this obstacle is to implement an SOA whereby the functionality of underlying legacy systems can be exposed as reusable services, enabling the agile development of new innovative products and services. We propose that legacy systems are a barrier to entry (inhibitor) for banks' intent on pursuing their digital banking strategies, and the effect of this inhibitor is reduced as the SOA maturity of banks increases. To explore this proposition, a common SOA maturity model will be used to assess each bank in the study.

3.1.2. Proposition 2

P2 – The complexity of banks' IT governance processes has a negative influence on bank's time-to-market of digital banking products and services. This causal relationship is reduced as banks' SOA maturity increases.

Rationale – As a natural consequence of a growing bank, organizations tend to become "siloed", with each business unit having its own dedicated technology and operations functions. The downside effect of this organizational model is that bank-wide technology decision making becomes more complex, and agility suffers in terms of time-to-market of new innovations. As a means to control complexity, banks strive to establish enterprise-wide technology standards and IT architecture standards such as SOA, as well as governance processes to enforce those standards. An effective and mature SOA implementation is one that bridges the gap across organizational silos, aligns to the overall business strategy of the bank, and enables the bank to be agile in terms of time-to-market of new product and service innovations. We propose that complex technology decision-making processes are a barrier to entry (inhibitor) for banks' intent on pursuing their digital banking strategies, and the effect of this inhibitor is reduced as the SOA maturity of banks increases.

3.1.3. Proposition 3

P3 – The age of banks' integration technology skillsets has a negative influence on bank's time-to-market of digital banking products and services. This causal relationship is reduced as banks' SOA maturity increases.

Rationale – The "age" of integration skillsets, in this case, is a means to determine the degree to which technical knowledge about application integration protocols is outdated. File Transfer Protocol (FTP) developed in the 1970s, for example, is used for bulk transfer of data files between applications on a batch processing schedule. Technical knowledge about FTP would be considered as outdated in the context of digital banking whereby application systems are integrated on-demand in real-time using modern web services standards. For banks' technology architects and developers, learning and understanding about how to use modern web services standards, is perceived to be difficult. We propose that the lack of knowledge about modern integration technology is a barrier to entry (inhibitor) for banks' intent on pursuing their digital banking strategies, and the effect of this inhibitor is reduced as the SOA maturity of banks increases.

4 Method

We conducted an "explanatory study" [22, 31] to establish the causal relationship between banks' organizational and technological complexities and banks' time-to-market of digital banking innovations. Following a deductive research approach, a set of propositions were deduced based on the practice-based banking and SOA industry experience of the authors. Therefore, expert opinion ("theory") that the barriers to entry (inhibitors) for digital banking are: legacy technology, complex decision-making processes, and outdated skillsets. Banks tend not to expose (make publically known) their internal inefficiencies due to reputation risk, and the only realistic means to collect data about these inefficiencies is through selected bank's anonymous participation in a multiple case study research project [4, 31]. A mixed methods approach is appropriate for case study based research [28], combining both qualitative and quantitative methods.

The constructs of our propositions, which are highly technical and have bank-wide implications, require us to include the senior-most technology staff as participants in our case study. Typical chief technologist roles which match this requirement are: Chief Technology Officer, Chief Information Officer, Chief Innovation Officer, Chief Architect, Chief Strategist. It was difficult to approach and seek time from these chief technologists. Our realistic aim was to secure participation from three to five banks in Asia. After approaching 12 banks, we were able to secure participation from eight of them.

In order to make the case study participation process more efficient, we included a pre-interview survey to be followed by an interview with the chief technologist (the participant). Our survey questions were grouped into sections to cover the following areas:

- Digital Banking Maturity
- Technology Architecture
- IT Governance
- Core Competencies/Skills
- SOA Maturity

Multiple case studies follow a "replication design", rather than a "sampling design" typically used in surveys [31]. "Literal replication logic" is used in our multiple case study design whereby individual cases are selected which predict similar results [31]. Our multiple cases (banks) are analogous to multiple experiments whereby we expect the findings to be replicated across each experiment. We present 'no-rival theory' of barriers to entry for digital banks, therefore, "theoretical replication logic" which predicts contrasting results is not considered in our multiple case study design [31].

The typical criteria for determining sample size is irrelevant, because sampling logic is not used in multiple case study designs, and hence the judgment for determining the number of cases is discretionary [31]. For a straightforward theory like ours which does not require a high degree of certainty, "two or three literal replications" (cases/banks) would be sufficient [31]. We included eight banks.

Data collected from each case study was written up in individual case reports, one for each bank. Once all individual case studies were complete, a consolidated cross-case report was written. The cross-case consolidated data was then analysed using quantitative and qualitative methods [22, 28], cross-case conclusions were drawn, and arguments were made to declare the propositions as accepted.

All eight banks that participated, labelled as "Bank A" through "Bank H" in the following sections, are operating in Asia, but are not necessarily headquartered in Asia. Headquarters of five out of these eight banks are in Asia-Pacific, two in Europe and one in the US.

5 Results and analysis

The case study data from the eight participating banks is summarized in Table 1 given below. For each variable of our theoretical model illustrated in Figure 1 above, an assessment is given on a Likert Scale. Then to facilitate analysis of the relationships between variables, they are segregated into two groups, for example: Low to High SOA Maturity, and Simple to Complex IT Governance.

Table 1 Summary of case study assessment data

Likert scores for each variable (theme)

Bank	A	B	C	D	E	F	G	H
Time to Market	5.25	4.75	4.50	4.00	4.50	5.25	3.00	4.25
Core Banking System	5.00	2.50	2.00	2.00	4.00	1.50	3.50	2.50
IT Governance	4.00	4.00	3.20	3.80	4.20	3.60	4.80	4.20
Core Compencies	4.75	4.75	4.50	5.00	5.00	5.75	4.75	4.25
SOA Maturity	4.90	3.70	2.90	2.80	3.30	5.10	2.40	2.80

Themes segregated into 2 groups based on clusters of Likert scores

Bank	A	B	C	D	E	F	G	H
Time to Market	Short	Short	Long	Long	Long	Short	Long	Long
Core Banking System	Modern	Legacy	Legacy	Legacy	Modern	Legacy	Modern	Legacy
IT Governance	Complex	Complex	Simple	Simple	Complex	Simple	Complex	Complex
Core Compencies	Weak	Weak	Weak	Strong	Strong	Strong	Weak	Weak
SOA Maturity	High	High	Low	Low	Low	High	Low	Low

5.1 Time-to-market

Time-to-market of digital banking capability, the dependent variable in our theoretical model illustrated in Figure 1, is assessed based on the criteria and rationale provided in Table 2 below. These criteria involve large-scale change scenarios which have implications and dependencies on the overall flexibility of banks' architecture.

Table 2 Time-to-market assessment criteria

Assessment Criteria	Rationale, Implications on Architecture
The length of time taken to introduce (buy or build, and deploy) a full-featured internet banking channel, assuming that funding is not a constraint.	• If an Internet Banking channel exchanges information via on-demand reusable services as opposed to pass-through messages or scheduled batch interfaces, the implementation time will be faster, even in the presence of a legacy core banking system. Pass-through messages and batch interfaces are less likely to be reusable. • The implementation time will improve as the percentage of required services' availability increases. A 100% availability would be the best case, otherwise missing services would need to be developed. • The implementation time will be faster if the internet banking channel conforms to the common requirements of existing services, as opposed to imposing channel specific constraints.
The length of time taken to introduce (buy or build, and deploy) a real-time inbound marketing engine for delivering personalized cross-sell offers targeted to specific customers, assuming funding is not a constraint.	• If the rules that trigger real-time inbound marketing offers are managed centrally by a business rules management system (BRMS) as opposed to hard-coded rules embedded in a channel, and the BRMS exposes those rules as reusable decision services, the implementation time will be faster. • A BRMS-driven marketing engine implies that real-time business events (customer interactions) are captured via a pre-existing enterprise service bus (a collection of reusable services), i.e. an SOA is implemented before a BRMS.
The length of time taken to introduce (buy or build, and deploy) an interactive personal finance robo-advisor, assuming funding is not a constraint.	• If the mathematical rules and algorithms that govern the dialog with customers are managed centrally by an automated advisory

	platform as opposed to hard-coded algorithms embedded in a channel, and the advisory platform exposes its functionality as reusable advisory services, the implementation will be faster. • A centrally managed advisory platform implies that current and historical customer behaviour information is accessible via a pre-existing enterprise service bus (a collection of reusable services), i.e. an SOA is implemented before an advisory platform.

5.2 SOA maturity

The case study survey data reveals that SOA maturity has a positive influence on banks' time-to-market of digital banking capability. Across the eight banks, we looked for cross-case similarities in the grouping of our independent variables as provided in Table 1 above, namely, core banking systems (CBS) which can be legacy or modern, IT governance (simple/complex), and core competencies (weak/strong), where time-to-market capability differs as influenced by SOA maturity. For example, Banks D and F both have legacy core banking systems, simple IT governance, and strong core competencies. What differs is that Bank D with a low SOA maturity has a long time-to-market, and Bank F with a high SOA maturity has a short time-to-market. These cross-case similarities are also present for Banks H and B, as well as Banks G and A, as illustrated in Figure 2 below.

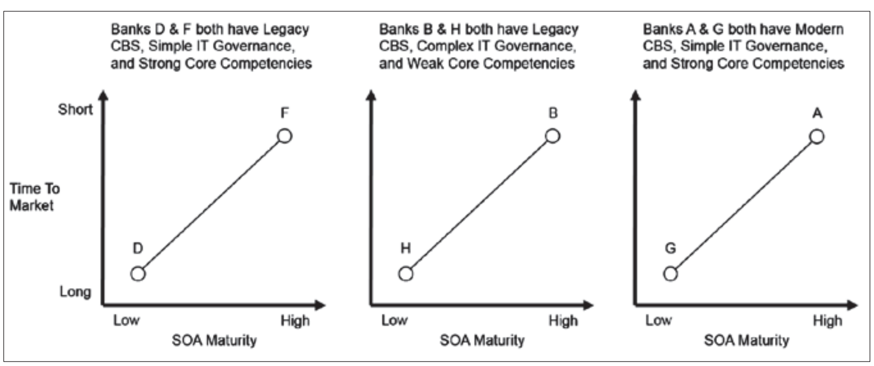

Fig. 2 SOA maturity influence on time-to-market

SOA maturity, the moderating variable in our theoretical model illustrated in Figure 1, is assessed based on the criteria and rationale provided in Table 3 below. These criteria draw from the common findings identified from our literature review in section 2.4: SOA Maturity Models.

Table 3 SOA assessment criteria

Assessment Criteria	**Rationale, Implications on Architecture**
The extent to which reusable services are deployed, for example, “getAccountBalance”, which is developed once and reused by multiple banking applications.	• Reusable services are the building blocks of an SOA which can be quickly assembled and orchestrated to implement complex business logic. • Implementing new business logic using existing services is faster and more cost-effective than developing business logic from scratch for each new set of requirements. • Banks, which embrace service reuse as an architectural principle, are more likely to improve time-to-market of digital banking capability as service reuse rates increase.
The extent to which an Enterprise Service Bus (ESB) is implemented which can be managed centrally as a deployed collection of reusable services.	• An ESB implementation implies that application integration (via services) is managed centrally, rather than distributed across each integration end-point. • The time-to-market and cost benefits of service reuse can be better assured using a central management model of an ESB rather than a distributed model.
The extent to which reusable services provide an intermediate layer of abstraction that essentially decouples the service consumer from the service provider such that the service consumer need not know the data format or transport protocol used by the service provider.	• Services which decouple the service consumer from the service provider via data abstraction are more likely to be reusable, as compared to services which tightly couple application systems via pass-through messages. • A services layer that provides decoupling through abstraction improves architectural flexibility. In that, it is technically possible for a service provider system (such as a core banking system) to be completely replaced (or decomposed into microservices) without requiring any code changes on the service consumer systems.
The extent to which the service schema, the data format exposed to the service	• Data abstraction at the services layer can be better managed (by a

consumers, is aligned to the enterprise data model.	data architect) if it aligns to a common data model, such as an enterprise data model. • Service schemas which are managed and aligned to a common data model, as the basis for data abstraction at the services layer, are more likely to be reusable.
The effectiveness of the SOA Centre of Excellence (or Competency Centre) which enforces bank-wide SOA principles, policies, best practice guidelines, and standards.	• The success of an SOA is better assured with an effective SOA Centre of Excellence (COE), which can be measured in terms of bank-wide service reuse rate and cost avoidance due to service reuse. • Centrally managing/guiding the design of services for optimal reusability, as well as making available and maintaining a bank-wide service catalogue, will better ensure service reuse and thereby improve time-to-market of digital banking capability.
The extent to which bank-wide service reuse rate, and cost avoidance due to service reuse, are published (internally).	• If the cost avoidance of service reuse as a measure of SOA success is published (internally), the bank-wide adoption of SOA will be better assured. • Publishing the success of SOA in financial terms (cost avoidance) will dissuade internal opponents of SOA from bypassing the ESB with point-to-point integration.
The extent to which service reuse cost avoidance figures are included in all project funding proposals which involves application development.	• The financial discipline of including cost avoidance figures (due to service reuse) in all project funding proposals will better ensure bank-wide service reuse. • As project managers get their cost avoidance figures from the SOA COE, use of existing services will be tracked, and new reusable services will be designed as required.
The extent to which both design time and runtime governance tools are implemented, for managing and	• SOA design time governance tools: a) make service design documentation and service contracts available to application

monitoring bank-wide usage of SOA assets.	developers, b) manage service schemas and service templates, and c) manage service lifecycles. • SOA runtime governance tools: a) manage service access/authorization, and b) monitor service usage. • The effective usage of this tools will better assure service reuse, and thereby improve time-to-market capability.
The percentage of core banking functionality, required by channels, which is exposed as reusable services via an ESB.	• As the percentage of required core banking functionality exposed as reusable services increases, architectural flexibility improves, assuming that the services layer provides decoupling through abstraction. Ultimately, a flexible architecture enables the replacement of applications systems with minimal impact.
The degree to which an ESB enables a complete replacement of the core banking system without making any changes to any channel application (e.g. Teller, Internet Banking, etc.).	• This is the "acid test". If a bank is technically able to replace its core banking system (CBS) (at least as a thought experiment) without impacting any of its channels, then it can be said that – a) all of the core banking services are reusable, b) the services layer completely decouples the channels from the CBS through data abstraction, and c) the bank has the option to decompose its core banking functionality into microservices.

5.3 Age of banks' technology infrastructure

As revealed in the literature, legacy core banking systems are inflexible to change and inhibit banks' agility to deliver digital innovation quickly to the market [6, 11, 26]. It is also established that SOA is an enabler which can provide a more flexible and agile architecture, by exposing the underlying functionality of legacy core banking systems as reusable services [1, 2, 17, 30].

Of the eight banks interviewed, five of them (Banks B, C, D, F and H) have IBM mainframe-based (Z/OS, OS/390, AS/400) core banking systems that are on an average greater than 20 years old, two of them (Banks E and G) have more modern client/server-based core banking systems that are between 11 and 20 years old, and one (Bank A) has a new client/server-based core banking system that is less than five years old. None of the eight banks have implemented a modular core banking system implemented as separately deployable microservices, although Bank F is actively working towards that goal.

From the case study survey data, we looked for cross-case similarities in IT governance (simple/complex) and core competencies (weak/strong) in order to isolate the impact of core banking systems on time-to-market, and to see if SOA maturity has any influence on this relationship. Banks A, B, G, and H, all have complex IT governance and weak core competencies. Bank A has a modern core banking system and also has a short time-to-market as expected based on common wisdom. However, a low SOA maturity has a negative influence on time-to-market for Bank G, which also has a modern core banking system, as illustrated in Figure 3 below.

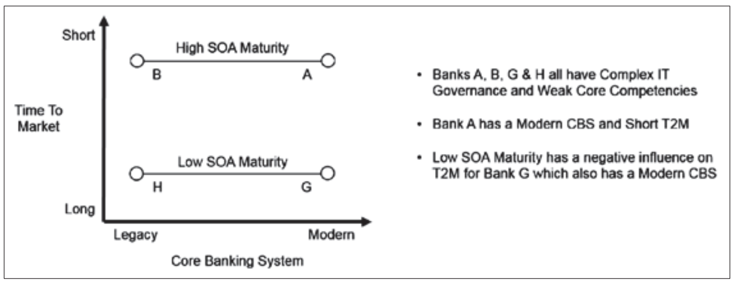

Fig. 3 Core banking systems impact on time-to-market

Table 4 Core banking system assessment criteria

Assessment Criteria	**Rationale, Implications on Architecture**
Core banking system (CBS) architecture classification.	• Legacy mainframe-based systems which use dumb terminals for human interaction and pre-internet era proprietary machine interfaces, are difficult to integrate to and inflexible to change, and therefore, score lower on our Likert scale. • Client/Server-based systems which use network-distributed “intelligent terminals” are more likely to use modern integration standards, and are more modular and flexible to change, and therefore, score higher than legacy systems on our Likert scale. • Modular systems with separately deployed server-side components

	(or microservices) provide the most flexible architecture whereby new banking processes can be quickly assembled using reusable services, and therefore, score the highest on our Likert scale.
Number of years since the initial deployment of the current CBS.	• Systems which were deployed pre-internet era, including mainframes and some client/server-based systems, are more likely to use proprietary machine interfaces which are difficult to integrate and inflexible to change, and less likely to have modernization support from vendors. Therefore, older systems score lower on our Likert scale.

Bank A, having the newest (< 5 years) and the most modern core banking system, had the highest Likert score (5.25) for time-to-market capability as expected, with the added benefit of a new SOA implementation, which if managed well should enable continued high time-to-market capability going forward. They have exposed nearly 100% of their core banking functionality required by their retail banking channels as reusable services.

Banks C, D, and E, understand the benefits of reusable services, but are challenged to expose some of the business logic embedded within their older legacy core banking systems (CBS). As such, some of their digital banking solutions are stand-alone, having implemented separate equivalent business logic external to their CBS. This external stand-alone business logic is less likely to be reusable.

Bank F has the oldest (> 30 years) legacy core banking system. In the absence of an SOA they would likely have the poorest time-to-market capability. However, they also had the highest Likert score (5.10) for SOA maturity. They have overcome the challenges of exposing embedded business logic from their legacy CBS as reusable services, and they have a high degree of service reuse which enables a more flexible architecture and improved business agility to quickly deliver innovative digital solutions to the market. Along with Bank A (having the newest CBS), Bank F also had the highest Likert score (5.25) for time-to-market capability.

A general observation across all of the eight cases is that banks that ranked lower in terms of age/legacy of their CBS and ranked lower in terms of SOA maturity, also ranked lower in terms of time-to-market capability. This shows evidence that legacy systems are indeed an inhibitor for digital banking.

Another observation is that banks with legacy systems tend to rank higher in terms of time-to-market capability if they also ranked higher in terms of SOA maturity. Bank F shows the strongest evidence of this, as they have the oldest legacy CBS, while also having the highest SOA maturity of any of the participants, and this combination puts them on par with Bank A (newest CBS) in terms of time-to-market capability. Therefore, based on our quantitative and qualitative analysis, we have a strong argument in support of proposition P4 – *The age of Banks' technology infrastructure has a negative influence on Bank's time-to-market of digital banking products and services. This causal relationship is reduced as Banks' SOA maturity increases*.

5.4 Complexity of banks' IT governance

IT Governance can be defined as "[s]pecifying the decision rights and accountability framework to encourage desirable behaviour in the use of IT" [29], including managing and monitoring IT investments and benefits. Where "desirable behavior" involves enterprise-wide control of IT investments, it has been found in one study across multiple financial institutes that "IT governance mechanisms conspired to discourage innovation" [29].

Large IT investments proposed by one business unit – even if the intended benefit spans the enterprise – require buy-in from other business units before funding can be approved. The larger the organization is, the more complex these technology decision-making processes become. An effective Enterprise Architecture (EA) practice is one that is able to exert bank-wide influence over architectural direction, and is able to attain buy-in across multiple business units in the support of large IT investments [24].

If we look at large IT investments from a buy vs. build vs. assemble perspective, implementing new solutions using a 'buy (off-the-shelf) or build (from scratch)' approach can be assumed to be more costly than using an assemble (reuse) approach. Assembling new solutions by reusing existing services in a SOA and by leveraging existing enterprise platforms such as Business Process Management (BPM), Business Rules Management System (BRMS) and Enterprise Data Warehousing (EDW) will not only require less capital investment, but will also shift IT governance focus more towards managing and monitoring the benefits of existing IT assets anchored around a SOA. With a mature SOA in place that provides agility and reuse, the impact of complex IT governance processes on the time-to-market of new innovative digital banking solutions should be reduced.

From the case study survey data, we looked for cross-case similarities in core banking systems (legacy/modern) and core competencies (weak/strong) in order to isolate the impact of IT governance on time-to-market, and to see if SOA maturity has any influence on this relationship. Banks C and H both have legacy core banking systems and weak core competencies, as illustrated in Figure 4 below. However, neither bank has a short time-to-market, hence, it is indeterminate if IT governance has any impact, at least based on the case study survey data.

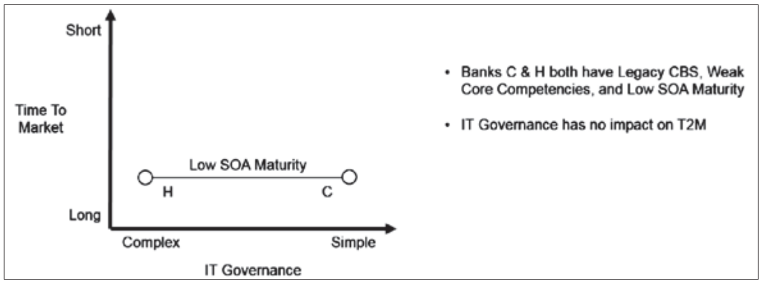

Fig. 4 IT governance impact on time-to-market

Our assessment of bank's IT governance processes takes into consideration – the level of influence enterprise architecture has on technology investments, and the level of financial discipline that is practiced in managing the benefits of technology investments. Our assessment of IT governance complexity in relation to time-to-market capability is based on the criteria and rationale provided in Table 5 below:

Table 5 IT governance assessment criteria

Assessment Criteria	**Rationale, Implications on Architecture**
The effectiveness of the enterprise architecture practice, whereby Enterprise Architects have a bank-wide sphere of influence over their respective architecture domains and are able to set bank-wide architecture direction.	• It is proposed that the time-to-market of digital banking capability is better achieved in the presence of a mature SOA. The benefits of an SOA are more likely to be achieved if there is bank-wide adoption. The bank-wide adoption of SOA is typically inhibited by organizational constraints and lack of senior management buy-in. An effective enterprise architecture practice is one that is able to bridge the gaps between organizational "silos". • If an Enterprise Architect with domain authority over SOA has a bank-wide sphere of influence, and is able to set bank-wide direction, then SOA adoption is better assured, and thereby the time-to-market of digital banking capability is improved.
The extent to which technology standards are enforced bank-wide (as opposed to allowing different technology standards for each business unit).	• The enforcement of technology standards is intended to reduce the Total Cost of Ownership (TCO) of technology assets in the bank, by –

	a) reducing the number of difference vendor licenses; and b) reducing the number of different skillsets required to support the technology. • If the technology enabling digital banking capability, including SOA, is standardized bank-wide, then the financial benefits of digital banking is better assured.
The degree to which technology investments are considered for bank-wide usage, i.e., a multi-purpose technology that can support different business processes, and can be leveraged across different business units.	• Enterprise platforms such as BPM, BRMS, EDW, and SOA (ESB) are intended to support multiple business processes across different business units, e.g.; BPM can be used to manage loan origination and trade settlement business processes. • Enterprise Architects who are able to influence and direct the multipurpose use of these platform technologies, at the point of technology investment (funding) and beyond, are able to better assure bank-wide TCO goals.
The extent to which actual financial benefits (increased revenue or reduced cost) of each technology investment are tracked, and are re-evaluated periodically.	• The business case proposals for funding technology investments include the expected financial benefits, including Return on Investment (ROI). • The financial discipline to track and periodically re-evaluate the actual financial benefit of technology investments will aid in managing technology lifecycles, and thereby better assuring TCO goals.
The extent to which technology investments are customer experience-driven, as a means to gain competitive advantage.	• Digital banking strategies are centred on improving customer experience, to protect or gain market share. • Considering customer experience, leveraging design thinking techniques, before making technology investments, will better assure digital strategy outcomes.

Banks G and H were assessed to have the most rigorous IT governance processes with Likert scores of 4.80 and 4.20 respectively, and were also assessed as having the poorest time-to-market capability with Likert scores of 3.00 and 4.25 respectively. This supports the idea that rigorous IT governance mechanisms can discourage innovation [29]. Bank E was also assessed as having highly rigorous IT governance processes with a Likert score of 4.20, but was ranked higher relative to Bank G and Bank H in terms of time-to-market with a Likert score of 4.50 – the difference being that Bank E was assessed as having a relatively more mature SOA in place. Bank F, being the largest bank in the study, traditionally had highly complex IT governance processes. However, they were also ranked the highest in terms of time-to-market, the difference being that they were assessed as having the highest level of SOA maturity.

Bank G has a highly rigorous IT governance process which is effective in managing and monitoring its IT investments globally, yet, they have not invested in a bank-wide SOA implementation, and therefore, they do not have a flexible architecture which can accelerate time-to-market at lower costs. In contrast, Bank F has recently decentralized its IT governance processes, effectively relaxing its global control of IT investments and have already achieved a high level of SOA maturity which enables a relatively faster time-to-market at a lower cost.

If complex and rigorous IT governance processes inhibit innovation in terms of time-to-market, then we can observe from our study that SOA maturity helps to overcome this barrier. The quantitative analysis of our case study survey data, summarized in Figure 4 above, does not provide empirical evidence, but our cross-case qualitative analysis of the interview comments and observations provides partial support of proposition *P5 – The complexity of Banks' IT governance processes has a negative influence on Bank's time-to-market of digital banking products and services. This causal relationship is reduced as Banks' SOA maturity increases*.

5.5 Age of banks' integration technology skillsets

In order to compete in this digital age, banks must transform themselves to become more like technology firms [13, 26], and move away from the traditional branch-based, account-centric style of banking. Becoming digital has implications on how applications integrate. Traditionally, applications integrate mostly via File Transfer Protocol (FTP) under a scheduled batch process, meaning that transactions are batched up and posted overnight rather than in real-time. Digital banking requires real-time transaction processing, and therefore banks' technology staff need to acquire a new set of core competencies around modern integration standards, technologies, and tools.

From the case study survey data, we looked for cross-case similarities in core banking systems (legacy/modern) and IT governance (simple/complex) in order to isolate the impact of modern integration technology related core competencies/skills on time-to-market capability, and to see if SOA maturity has any influence on this relationship. Both banks C and D have legacy core banking systems and simple IT governance, as illustrated in Figure 5 below. However, neither banks have a short time-to-market, so it is indeterminate whether or not core competencies has any impact, at least based on the case study survey data.

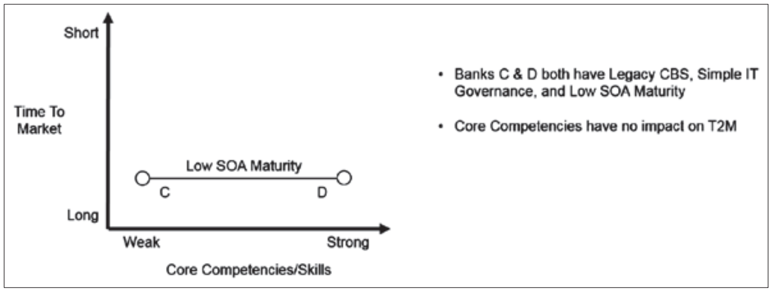

Fig. 5 Core Competencies impact on time-to-market

Software development capability, and integration technology related core competencies/skills, in relation to time-to-market capability are based on the criteria and rationale provided in Table 6 below:

Table 6 Core competencies assessment criteria

Assessment Criteria	**Rationale, Implications on Architecture**
The strength of the bank's software development capability, to support in-house or outsourced application development.	• To compete in this digital age, banks must transform themselves into technology firms. • Increasingly, digital banking capability cannot be provided by COTS systems, rather the capability must be developed within the architectural constraints of each bank, and with agility in order to gain time-to-market advantages.
The degree to which software developers understand XML, XSD, Xpath and other standards, and know how to use model-driven development tools.	• Increasingly, model-driven development tools are used to support the rapid development of software applications, including the complex business logic within BPM executable processes and SOA services. • Modeling tools typically import/export and manipulate data formats that are compliant with industry standards and are supported by multiple technology vendors.
The degree to which software developers understand the current web services industry standards (e.g. SOAP, WSDL) ratified by W3C.	• Model-driven SOA development and testing tools comply with web services industry standards. These GUI-driven tools enable the rapid

	development of complex business logic without writing any code. Service consumer code can be automatically generated by importing the WSDL provided by a SOAP service. • Architectural styles like REST are less likely to be supported by automated code generators, because there are no industry standards for tools vendors to comply with.
The degree to which software developers understand the common enterprise integration patterns, e.g. synchronous request-reply, publish-subscribe, etc.	• SOA services inherently implement the synchronous request-reply message exchange pattern. • Banks which are still implementing an EAI style of integration will typically use asynchronous fire-and-forget or pub-sub messaging patterns. • For a bank to transition to SOA, understanding of both modern standards as well as legacy standards is needed.

Bank H had the lowest Likert score (4.25) for core competencies/skills related to modern integration standards. Even though they were assessed relatively high in terms of IT governance processes (see previous section), the bank still mostly employs a message-oriented EAI style of integration, and have not yet embraced SOA, which is likely contributing to their relatively low time-to-market ranking as compared to other banks. Bank H also typically outsources their application development rather than employing in-house developers.

In contrast, Bank F had the highest Likert score (5.75) for integration technology-related core competencies/skills. They have embraced SOA globally, and do most of their application development in-house. They are very strong in their understanding and implementation of modern integration standards. Despite being ranked relatively low in terms of IT governance processes (see previous section), their high level of SOA maturity likely contributes to their high time-to-market ranking as compared to other banks.

Except for Banks C and H, most of the banks in this study were assessed relatively high in their understanding and adoption of modern integration technology. Other than for the contrast between Banks H and F, there is not a strong indication that integration technology core competencies is a factor in determining time-to-market capability, and it is unclear from the data that SOA maturity has a moderating effect on this causal relationship. The quantitative analysis of our case study survey data, summarized in Figure 5 above, does not provide empirical evidence, but our cross-case qualitative analysis of the interview comments and observations and contrast between Banks H and F, provides partial support of proposition *P6 - The age of Banks' integration technology skillsets has a negative influence on Bank's time-to-market of digital banking products and services. This causal relationship is reduced as Banks' SOA maturity increases.*

6 Discussion

As a result of the individual case study interviews, surveys and analysis of the data collected, we could identify and explain the barriers to entry (inhibitors) for digital banks who are intent on protecting their market share against the FinTech substitutes. Based on the common observations gathered across the individual case studies, we then recommended what actions banks should take in order to overcome these challenges. The barriers to entry are summarized as follows:

Legacy systems – Banks that rank lower in terms of age/legacy of their core banking system (CBS) and rank lower in terms of SOA maturity, also tend to rank lower in terms of time-to-market capability. This shows evidence that legacy systems are indeed an inhibitor for digital banking. Banks which find it difficult to carve out business logic embedded within their CBS also tend to implement pass through messages which expose the underlying CBS interface directly, without any data abstraction, leading to tight coupling between systems and ultimately an inflexible architecture. To work around tight coupling between systems, some banks implement digital banking innovations as stand-alone solutions that bypass the CBS entirely. Banks which suffer from an inflexible architecture due to tight coupling between systems, also tend to implement significant percentages of their application interfaces as batch-mode bulk data transfers rather than on-demand services required by digital banking. Banks with legacy systems tend to rank higher in terms of time-to-market capability if they also rank higher in terms of SOA maturity.

Complex IT governance processes – Banks which have rigorous IT governance processes are effective in managing and monitoring their IT investments globally. However, banks which take a 'buy (off-the-shelf) or build (from scratch)'approach to solution development, even in the presence of a strong enterprise architecture practice, are challenged to attain buy-in across business units for large capital investments, thereby inhibiting time-to-market capability. In contrast, banks which take an "assemble" (reuse) approach to solution development leveraging a bank-wide SOA implementation, even in the absence of an enterprise architecture practice, tend to have accelerated time-to-market capability at lower costs.

Lack of integration technology skillsets – Most of the banks in our study were assessed relatively highly in their understanding of modern integration technology standards. However, not all banks that rank highly in this category had effective SOA implementations. Regardless of any in-house integration technology related skillsets, some banks tend to outsource their application development, including integration components, while other banks tend to develop their applications in-house. The banks which outsource their development also tend to maintain a significant percentage of batch-mode data transfers rather than on-demand services. The banks which were assessed highly for their integration technology skillsets and also develop applications in-house, also rank higher in terms of SOA maturity and time-to-market capability.

6.1 Management implications

SOA centre of excellence – The two highest ranked banks in terms of time-to-market capability both have an effective SOA Centre of Excellence (CoE) which enforces bank-wide SOA principles, policies, best practice guidelines, and standards. The other six banks were assessed as having a poor or non-existent SOA CoE, with the highest Likert item score being "Somewhat Disagree" to the question "Your bank has an effective SOA Centre of Excellence (or Competency Centre) which enforces bank-wide SOA principles, policies, best practice guidelines, and standards. Some of the banks had a SOA CoE in place previously, but then later disbanded this functional group due to various reasons, including: change in management, loss of funding, and lack of senior management support. Without an effective SOA CoE in place, the ongoing success of an SOA implementation is at risk.

SOA framework and governance tools – Referring to the preview of two paragraphs, if the banks with disbanded SOA CoE's had the financial discipline to track and publish (internally) their cost avoidance due to service reuse, then they would likely not have lost senior management support and would not have been disbanded. It all comes down to service reuse rate and cost avoidance due to service reuse as the most important metrics to manage. What some of these banks seem to be lacking is a well-architected ESB (Enterprise Service Bus) framework and runtime governance tools for controlling and monitoring service usage, and design-time governance tools for managing service lifecycles and making reusable services available to application developers.

SOA competencies – From our study, it is clear that an effective SOA implementation seems to be a key factor in overcoming the barriers to entry for digital banking. Using modern integration technology to develop services is easy. To design services for optimal reuse, and to ensure that services are indeed reused, and to ensure that the benefits of service reuse is realized, is difficult. Banks are complex, and to develop SOA competencies entails a long learning curve, several years in many cases. If banks want to compete in this digital age, then they will need a flexible architecture like an SOA which will enable rapid time-to-market capability. Some of the banks in this study could have benefitted early on from a pre-packaged set of banking industry standard services, an ESB framework, a set of runtime and design-time governance tools, and best practice guidelines.

7 Conclusion

In this paper, we evaluated three propositions which identify and explain the barriers to entry for digital banks. The evaluation is achieved through multiple case studies conducted across eight banks operating in Asia, involving an interview and pre-interview survey with the chief technologist at each bank.

The outcome of our propositions is summarized in Table 7 below. Proposition P_1 is supported by the case study survey data and interview comments. Propositions P_2 and P_3 are not supported by the quantitative analysis of case study survey data; however, they are partially supported by the cross-case qualitative analysis of interview comments and observations.

Table 7 Outcome of Propositions (P_1 - P_3)

P_1	The age of banks' technology infrastructure has a negative influence on bank's time-to-market of digital banking products and services. This causal relationship is reduced as banks' SOA maturity increases.	Supported
P_2	The complexity of banks' IT governance processes has a negative influence on bank's time-to-market of digital banking products and services. This causal relationship is reduced as banks' SOA maturity increases.	Partially Supported
P_3	The age of banks' integration technology skillsets has a negative influence on bank's time-to-market of digital banking products and services. This causal relationship is reduced as banks' SOA maturity increases.	Partially Supported

The important observations from our cross-case analysis are: a) SOA maturity is directly related to the time-to-market of digital banking capability; b) a more modern core banking system improves time-to-market capability, however, this can be negated by a lower SOA maturity; and c) as long as SOA maturity is high, improved time-to-market capability can be achieved even in the presence of a legacy core banking system.

A key conclusion from our study is that SOA maturity plays a very important role in enhancing a bank's capability to deliver digital banking transformation. In order to move towards higher levels of SOA maturity, we make three recommendations –

establishment of an SOA centre of excellence, implementation of a well-architected Enterprise Service Bus (ESB), and adoption of an ESB framework and toolkit.

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Glossary

1. **Business Process Management (BPM):** A discipline at the intersection between management and IT, encompassing methods, techniques and tools to represent, model, design, analyse, enact, and control business processes involving humans, organizations, applications, and documents.
2. **Business Rules Management System (BRMS):** Software suite that helps to define, execute and monitor decision logic that is used by other applications.
3. **Enterprise Data Warehousing (EDW):** This includes all the tools and methodologies for developing a unified database that stores the required business information that is accessible by different divisions across the company.
4. **Enterprise Application Integration (EAI):** Deals with technologies and methodologies that enable the integration of applications residing within an enterprise.
5. **Enterprise Service Bus (ESB):** An architecture pattern where reusable business services are exposed using enterprise standard semantics and standard transport protocols.
6. **FinTech:** Firms that are non-bank software technology companies that provide alternative financial services over the internet.
7. **Message-Oriented Middleware (MOM):** A software platform that provides the means to transport messages between business applications using a number of interaction patterns.
8. **Service Oriented Architecture (SOA):** An architectural approach for designing and building applications that tie services together and are defined by industry standard interfaces (e.g. Web Service Description Language).