Critical business intelligence practices to create meta-knowledge

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Abstract: In order to successfully implement strategies and respond to business variations in real-time, business intelligence (BI) systems have been deployed by organisations that assist in focused analytical assessments for execution of critical decisions. Although businesses have realised the significance of BI, few studies have explored their analytical decision-enabling capabilities linked to organisational practices. This study investigates the BI practices critical in creating meta-knowledge successfully for strategy-focused analytical decision-making. First, key BI suppliers are interviewed to develop an understanding of their BI capabilities and current deployment practices. Subsequently, two large BI implementation case studies are conducted to examine their practices in data transformation process. Findings reveal that BI practices are highly context-specific in mapping decisions with data assets. Complimentary static and dynamic evaluations provide holistic intelligence in predicting and prescribing a more complete picture of the enterprise. These practices vary across firms in their effectiveness reflecting numerous challenges and improvement opportunities.

Keywords: business strategy; business intelligence; knowledge management; decision support; data transformation.

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1 Introduction

Business intelligence (BI) systems are implemented by organisations to create impromptu data assessment capabilities that enable predictive analytics in varying situations to provide real-time responses (Ongsulee et al., 2018). BI systems support business strategy, and are denoted as 'data-driven DSS' [Power, (2008), p.149; Sirin and Karacan, 2017].

Business processes comprise data storage and data access facilities via knowledge management (KM) systems that transform operational parameters to generate business wide decisions. BI systems enhance decision-making competencies with technology and build skills for data monitoring with analytical tools for improving business performance and reporting (Larson and Chang, 2016). Implications on performance are ongoing and applicable to both "the immediate past and the present simultaneously (i.e., performed and performing)" [Folan et al., (2007), p.605], since re-evaluation of past actions inform on the interpretation of current processes. By developing a culture of knowledge analytics, enterprises create intelligence that feedforwards to better inform the next planning and measurement processes, leading to organisational effectiveness (Richards et al., 2019). BI therefore provides incremental value to organisations as they strive to align performance strategies with their data-to-information-to-knowledge endeavours to reason, predict, comprehend, learn, and establish business decisions (Popovic et al., 2012).

BI systems integrate with organisational knowledge assets, enhancing an organisation's ability to make better-informed decisions, thus improving their risk management and intellectual capabilities (Yiu et al., 2020). This is primarily achieved through the access and retrieval of transactional information captured as enterprise system (ES) data. ESs are highly integrated business process systems deployed by organisations, that are aligned to meet their operational needs and improve information flow (Al-Mashari and Al-Mosheleh, 2015). These systems constitute the knowledge pillars of an organisation's operational structure as they support in the alignment of human, material, information and financial resources with the defined organisational strategy (Asif et al., 2009) to ensure a fit between business process systems and current organisational processes. ESs provide the necessary data support to meet the information needs of an organisation for operational decision making and execution of day-to-day activities.

Knowledge evolves iteratively as firms establish business decisions at strategic and operational levels. Low level discrete data is churned to higher aggregated levels of information, and subsequently by applying experience, judgment, and human intuition to the evolving business flux, knowledge gets built. Multi-level decisions are taken leading to better outcomes and towards consequential decision-making. Organisations utilise pertinent data related to different functions and processes by asking appropriate questions to build information intelligence leading to creation of meta-knowledge (knowledge about pre-selected knowledge) (Evgeniou, 2005; Pitrat, 1996). BI tools support in the extraction and analysis of pertinent data from available data sources (Duan and Xu, 2012; Wang et al., 2018) and in creating more accountability in the strategic and operational decisions that are taken for realising business benefits.

Although significance in use of BI is recognised, few studies have explored their analytical decision enabling capabilities linked to organisational practices (Popovic et al., 2012; Yeoh and Popovic, 2016). Baptista et al. (2010), in their study on IT institutionalisation in firms, revealed that a new technology usually loses management sight after it gets embedded into organisational processes resulting in under-utilised strategic value. Organisations often lack a 'leveraging strategy' and fail to fully utilise available resources by not having an integrated interactive approach supported by knowledge networks and technologies in improving efficiencies and reducing risks in operations (Von Krogh et al., 2001; Del Giudice and Della Peruta Maria, 2016). Consequently, having proper convergence between strategic business information and BI

usage is crucial to corporate growth (Ramakrishnan et al., 2012; Ul Ain et al., 2019). Without this convergence, knowledge creation opportunities are lost, for example, responses to strategic queries posed for achieving business goals may be difficult to comprehend on the basis of the BI practices followed in business firms (Horkoff et al., 2012). Therefore, in the context of information generation capabilities of BI processes, the research question posed is, which are the critical BI practices for successfully creating meta-knowledge to enable strategy-focused decision making?

This study has been undertaken in two stages. First, interviews were conducted with major BI systems suppliers who are experts in the implementation of BI systems to gain insights on the capabilities of these tools and their usability in building meta-knowledge. In the second stage, interviews were conducted with senior executives from two large electronics manufacturing companies. Both these companies had implemented BI tools; therefore, the study examined their practices in the use of BI tools in their data transformation process for achieving their business strategy. This study provides two perspectives, that is perspectives from the BI suppliers and from the BI users on the effectiveness of BI practices for managing business flux and enabling strategy-focussed decision making. Though this research is limited to two case organisations, the study provides a comprehensive view of the BI environment and its potential in assisting managerial decision making.

The study objective has been introduced. The theoretical context with related literature reviews will be explained in Section 2. In Section 3, an evaluation of the BI process within the framework for transformation of data is explained, which methodologically guides execution of this study. The research design and methodology are outlined in Section 4, which provides details in the conduct of the two-stage research. Sections 5 and 6 present the results of the BI supplier interviews and the BI implementation case studies. Section 7 discusses the findings and highlights the critical effectiveness constructs of BI practices in creating meta-knowledge. Section 8 presents the study conclusions and implications. Finally, the limitations and future directions are laid out.

2 Business intelligence

BI environments comprise technologies, architectures, methodologies, and processes which convert data into valuable information to assist in effectively establishing tactical, operational, and strategic decisions (Olszak, 2016; Aruldoss et al., 2014). BI has the application attributes of data marts to collect, analyse, monitor and report a firm's data assets within the different business processes in the value-chain (Arunachalam et al., 2018). BI has become process-centric with embedded capabilities to transform business-related data into analytical information to concurrently link operational processes with analytics (Vuksic et al., 2013). It helps achieve a seamless migration from operational databases to operational actions that deliver business value. BI systems enable data transformation to create useful information and analytical insights that lead into actions, and further assessment of outcomes, which can lead to building up meta-knowledge.

A range of vendors supply BI platforms and tools, from medium-sized specialist companies such as IBM Cognos and SAS Institute to large vendors including Oracle and

SAP. The BI applications have been developed by these vendors using the online analytical processing approach to include functionalities such as writing ad hoc queries, generating end user and enterprise analytic reports, as well as visualisations with dashboard and scorecard functions (Chen et al., 2012) for ongoing operational reporting.

Extant research suggests BI implementation is a complex, resource-intensive and expensive preposition (Yeoh and Popovic, 2016). The technological capabilities developed such as ensuring authorised user access, maintaining data quality, and building abilities for providing predictive, prescriptive and explanatory information in real-time (Isik et al., 2013; Watson et al., 2009). BI success, or positive value achieved from a BI investment, depends upon how well the system is integrated within an organisation. In order to enable staff focus on analysis of information as opposed to its mere generation with improved information quality and standardised processes, application of best practices in the use of a BI architecture is vital to capture relevant data elements (De-Carvalho and Sassi, 2014). The intelligence is based upon organisation-wide effort in making consistent use of these data elements to reach the strategic and operational goals.

Although a plethora of research have been conducted to put forth specific criteria for success of BI (Yeoh and Popovic, 2016) there have been few studies that identify a framework of critical practices holistically. One such three dimensional framework developed by Yeoh and Koronois (2010) comprises the organisational, process-based and technological dimensions. The organisational dimensions include clarity of vision, business case development, and management support. The process aspects stress upon having an approach oriented towards business development, balanced team working, as well as user-focused management of changes. Finally, the technology element encompasses a technical framework that is scalable, flexible and business-oriented along with an emphasis on data integrity. Yeoh and Koronis however note that in absence of clear business strategy, BI implementations seldom provide any significant effect on business. Another study conducted around the same time has emphasised that BI plays a vital role in executing and managing strategies, including sustainability practices (e.g., Petrini and Pozzebon, 2009) which take account of the socio-environmental indicators into organisational strategy.

BI and KM technologies have since evolved in the last decade cascading from a technology-push to a strategy-pull model. Through the use of technology, knowledge could be transferred at the relevant time to the relevant people in the technology-push model, while, the strategy-pull model signifies approaches that use the analytical and creative capability of human beings with data management systems (e.g., ESs) to further build and improve knowledge-intensive business processes (Marjanovic and Freeze, 2011). BI supports such pull-based strategic processes, which can extract relevant data and convert into actionable insights for achieving superior knowledge integration levels. When such data from an organisation's ecosystems is leveraged, its potential value is unlocked turning the data into meaningful insights to drive decision-making (Secundo et al., 2017).

Keyes (2006, p.242) proposes businesses must first develop a model choosing an appropriate organisational scheme (e.g., flow diagrams, hierarchies, matrices, target-setting, benchmarking, or balanced scorecard metrics). They add that the best selection would depend on the abilities of the team in evaluating relationships, costs and benefits, and quantifiable measurements related to the impact from these schemes, which are to be realised. The dependency on enterprise data resources (such as shared data

assets, common business processes, and IT infrastructure) is growing as organisations synergise operations across business units.

For realising organisational collaborative scenarios, ES vendors have created application modules including supply chain management and customer relationship management with KM and BI extensions that can aid in monitoring the overall business health and in strengthening internal capabilities. Interdependencies between business objectives, IT services, and software applications are managed through enterprise alignment (Fonstad and Subramani, 2009; Rahimi et al., 2016). A collaborative network is a necessity in the current business environment and its success depends upon the level of alignment between the different value chain elements (Tafti et al., 2019). As more Internet-enabled collaboration and web information extraction is undertaken with enhanced intelligence capabilities (Srivastava and Cooley, 2003), better competitiveness in organisations can be anticipated (Zhong et al., 2017; Zheng et al., 2012), since internal knowledge is continually incremented. Such blending of technology with collaborative innovation can enable process creativity to drive synergetic operations with better accountability (Esposito De Falco et al., 2017).

3 Strategic enterprise management

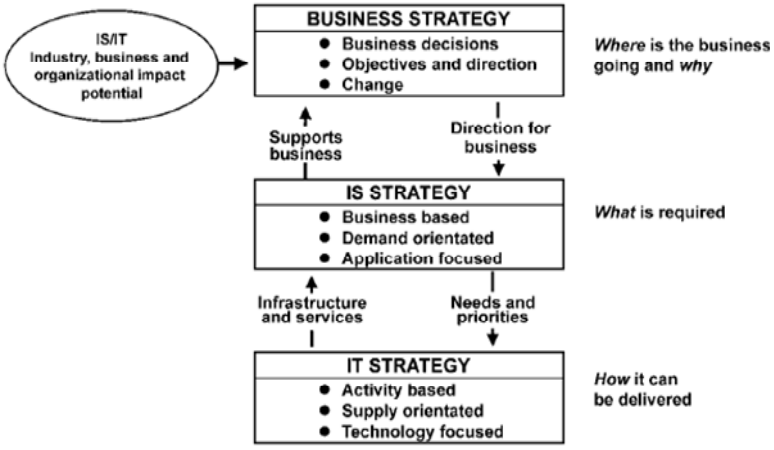
Firms are concentrating on utilising their BI investments at the top-most level in the post-deployment phase (Teittinen et al., 2013). Organisations use BI and the balanced scorecard framework for executing their organisational strategies. The balanced scorecard framework has been leveraged by SAP to create the strategic enterprise management module to fulfil this organisational requirement. Ritchie-Dunham et al. (2000) however view the benefits in operationalising strategy digitally do not guarantee success either by using a balanced scorecard or BI, or in combination, rather would depend on the end users' capabilities. That is, how end users participate in decision making, what questions are asked or what trends are not observed resulting in missed opportunities. For example, focusing only on analysing risks within an organisational scope could limit effectiveness in achieving strategic objectives. "Enterprise risks do not respect the boundaries of the organization" [Oliva, (2016), p.78].

According to Villamarín and Pinzon (2017), strategic decision making in organisations has not achieved success in many BI implementations. In fact, between 70% to 80% of BI projects have failed as per reports because of lack of communication about the information needs (Richards et al., 2014); moreover, these solutions often do not properly present knowledge views to different knowledge agents, such as business users and IT professionals may perceive an evolving situation differently (Del Giudice and Della Peruta Maria, 2016). While choosing an inclusive data gathering approach helps realise BI objectives, an established major cause of its failure is the inadequate tactical association between IT and business strategies. A strategic alignment has a significant impact on manufacturing innovation, organisational capabilities and KM (Akbariyeh and Seddigh, 2017). In addition, a strong relationship between market orientation and innovativeness is evidenced to enhance organisational performance (Acar, 2020) through the process of knowledge acquisition (Ha and Lo, 2018).

A model from Ward and Peppard (2002) (Figure 1) shows an association amid business strategy (comprising strategic goals, decision making, and changes), information

system (IS) strategy (application-driven and business requirement-orientated) and information technology (IT) strategy (technology-driven, activity and supply-orientated). In the model, the downward arrows portray the business roadmap indicating the strategic directions and their reasons, what are the IS strategic requirements and how their delivery is managed through IT strategy. The upward arrows represent the IT services and infrastructure which facilitate IS strategy requirements for realising the overall business strategy.

Figure 1 The association between business strategy and IT strategy



Source: Ward and Peppard (2002, p.41)

The holistic model operationalises use of BI tools by linking specific strategic contexts in building meta-knowledge, instigating analytical thinking, leading to better decision-making. Data is presented via user friendly interfaces, so that knowledge workers can intuitively query the presented information in a logical manner. Using BI tools, the analysis of different datasets in varying contexts help establish interdependencies and links between them. The BI process stipulates how data transformations are used by knowledge workers to support organisational goals realisation while the analytic methods develop meta-knowledge, which is utilised for performance enhancement initiatives. The BI system enables decisions and actions guided by the knowledge-orientated processes utilising primarily the ES data, which are the organisation's knowledge assets. The data analytic process is driven by the organisational strategy. Data analytics can help uncover new relationships to undertake new process initiatives in support of realising business goals. The objectives can be achieved when proper strategic and operational decisions are executed with extraction and analysis of pertinent data through the BI process. However, effectiveness of the knowledge-driven process could be constrained by the lack of ability in using the BI technology to provide accurate information.

This study examines the usage of BI capability and data assets in building meta-knowledge leading to strategy-focused analytical decision-making and its impact on realising organisational benefits. These critical practices in the knowledge-based BI process are evaluated and empirically examined in the transformation phase.

4 Research methodology

In the design of the study, first this research investigates the existing practices of BI deployment with five vendors and consultants who are experts in the field (Microsoft, Oracle, SAP, IDC, and PricewaterhouseCoopers). Data were collected from these firms via interviews with executives who have experience with BI implementation. Their perspectives on capabilities of BI tools and usability to build meta-knowledge provides a distinctive practitioner perspective. In the second phase, an in-depth study of BI implementation in two large cases examines their practices in use of BI tools in their data transformation process for achieving business benefits. Sixteen face-to-face interviews (eight from each firm) of about 45 minutes each were conducted with key BI users. These include operational staff, executives and senior managers of each organisation actively engaged in the use of BI tools as well as information assets to establish decisions.

Based on the snowball sampling approaches (Patton, 2002), the cases were selected using three predetermined criteria for BI implementation cases from the BI suppliers research:

1 both firms should be mature with their BI implementations, so must have at least three years of BI usage

2 to allow common conditions for comparison, the firms must be from a similar class of industry – in this case manufacture and supply of electronic products

3 since manufacturing firms are particularly motivated to adopt a BI and ES due to the nature of the industry (Raymond and Uwizeyemungu, 2007), both firms must be in the manufacturing sector.

In order to establish the study's context, this study uses Ward and Peppard's model from literature. The theoretical framework (Figure 1) provides the basis for *a priori* specification of constructs, comprising the relationships between business, IS and IT strategies. The framework relates to creation of meta-knowledge in alignment to achieving the business strategy by building and utilising context-based information captured through IT tools such as BI. Theoretical propositions have been analysed by comparing the findings from the two cases with existing literature to answer the posed research question.

Questions relating to data transformative BI practices for establishing analytical decisions were asked in the interview. Particularly, attention was given into examining the utilisation of data assets, tools and techniques, and knowledge-based practices in building meta-knowledge leading to strategy-focused decision-making as depicted in the transformation process (Ward and Peppard's model). The condensation method is applied to analyse the empirical data. The data is condensed into pre-defined groupings and categorisation as per the scope of the research questions.

5 Vendor/consultant findings on BI practices

Insights from the BI suppliers convey that as more and more businesses are realising the data analytic and report generation capabilities, the market for these tools too is expanding. However, as per Microsoft, very few implementations have been successful in

the context of extracting core information from huge data warehouses. They stated that while implementations work, there are not enough evidences on its strategic use by organisations for analytical decision making even though the reporting metrics are provided.

Oracle emphasised that BI must not be used as a disparate system in which ad hoc information is put in for analysis, but instead it should tie up with the data warehouse middleware for drilling into the core data. Having the capability of drilling down layer by layer into core data assets for extracting pertinent information to establish decisions is vital for creating intelligence. Oracle further explained what typically happens is that the BI tool is mostly used as a basic reporting instrument without utilising the meta-information (information about pre-selected information) from the storage repository instead of using it as an analytical tool for achieving strategic benefits. It is not fully integrated to get the benefit from the data mining features. This was illustrated with an example of an organisation which "was not looking at the average sales versus air time used by their sales persons on their cell phones, what times of the day are they using, what sort of sales are being achieved, and therefore what is the average revenue per user with such expenses … They are not using the information which is in their system to generate such kind of knowledge."

PricewaterhouseCoopers noted that organisations are able to use the BI system for their benefit in the areas which have a known issue, but they have not been able to measure these accurately or make full use of the statistical tools available.

> "People without BI find it often very hard to see their hit ratios. For example, I know I've done 1,200 quotes and I got to get somebody to work for me half a morning to figure out how many quotes have become orders. If an organization knows there is an issue in some area but does not have all the information, then it focuses attention in order to get the information it is looking for. If it is noticed that the hit ratio in a particular area of the market is a bit low, then the concerning issues can be questioned such as are the distributors not up to mark or whether the price is not competitive enough or is it because of competition. These are some of the areas organizations start to measure if are found not performing as well as expected, with BI."

Technology allows professionals to conduct ongoing evaluations as and when new information becomes available, which then becomes knowledge. So, the benefit to an organisation is by taking in new data, aggregating, and reviewing in the context of their overall business to make incremental decisions on whether the activities they are doing are profitable (or not) for their business. SAP, however noted that firms have been progressively understanding the importance of precise and on-time production of data reports for improving performance, and the maturity in use of BI is gradually growing; but the growth in this regard was slow.

IDC further opined about NZ firms not achieving the desirable levels of maturity in simulating a case scenario or aligning business metrics to performance management processes. They further conveyed that in terms of data governance, secured, flexible and agile data access is now available, so this data currency allows adaptation to business changes. Fast, clean and centralised data sources can restore reliability and trust within users. These services are now available through cloud-based analytic hosting, which assist in data storage, providing analytic and computing power, as well as sourcing of data and processing applications.

Table 1 Important BI tool capabilities for decision support

Element	*BI capabilities*
Customised reports	• Drill-down capability into data layers for analysis with data visualisations (charts, dashboards, trends) with minimal technology burden on user.
	• Assistance to execute user-friendly queries using crosstabs and data-filters to address particular enquiries.
	• Facilitate data analytics (e.g., order-intake analyses or aging analyses to evaluate future forecasts or plan operational capacities) with predictive and prescriptive analytics.
Reduce information overload	• Generate aggregated or distilled information for supporting executives discover data in specific contexts establishing correlations, trends or outliers.
	• Visual presentation of high-quality data mined from heterogeneous environments on a regular basis.
Support management performance evaluation	• Empower executives in creating pertinent data visualisations for knowledge-based decision-making developing transparency in vital data components.
	• Support balanced scorecard usage with integrated data repositories to evaluate performance with aggregated database mining, extending the investigative capacities of managers.
Simulation of business processes and planning of scenarios	• Users can mine transactional data to evaluate variety of simulated results enabled by the dynamic query and report generation functionality.
	• Present multi-views of existing status on organisational initiatives in real-time that can be used for performance enhancement.
	• Different scenarios can be evaluated through application of analytical dispensation with added context, interpretation, and experience.
Add-on features	• Tailored add-on attribute such as more contextual information could be presented through a dashboard for establishing insightful decisions.
	• Allow enterprises to have a reference model that could define a standard for comparing information represented in the form of KPI, scorecard, or business report.
Data governance and cloud connectivity	• Secured data access with agility and flexibility allows adaptation as changes in business are incorporated. Availability of fast, clean and centralised data sources restore reliability and trust.
	• Cloud-based analytics can assist in data storage, analytic and computing power, sourcing data and processing applications.
Collaborative business intelligence	• Current BI tools can achieve better collaboration by easy scheduling, generation and sharing of automated reports. BI alerts can be setup to share publicly or embed in a dashboard for reporting interactively. These functionalities enhance the strategic enterprise management and decision-making processes in businesses.

Furthermore, current BI tools can achieve better collaboration by easier scheduling, generation and sharing of automated reports. BI alerts can be setup to share publicly or embed in a dashboard for reporting interactively. These functionalities enhance the strategic enterprise management and decision-making processes to achieve business goals.

For managing business strategies, the process of extracting data through BI and using in balanced scorecards was referred to as the most common technique by the BI vendors. The participants showed concern in the use of balanced scorecards and its effectiveness since this required applying a high degree of strategic thought process. One BI supplier stated when organisations usually refer a scorecard, they 'just mean KPI reporting'. In order to evaluate various available opportunities for future planning, BI tools support in providing 'what if' analyses in examining the differing possible scenarios. With the ability to identify the opportunities for success and their correlated drivers, businesses create novel performance management methods for realising strategies. To assess a firm's status or any specific business information, online dynamic queries can be executed in a user-friendly manner integrating ES data with BI tools to deliver customised reports. For example, the SAP informant explained that in order to track the current material available for a specific part in stock and in pipeline, companies review inventory status such as stock in transit, in the warehouse and in work-in-progress (WIP) by running online dynamic queries through BI. Therefore, BI systems improve productivity and overall business processes at the organisational level, assisting managers in building a complete picture using consolidated information according to their absorptive and rational intellectual capability. Some vital BI tool capabilities in enabling organisation-wide information distribution for decision support as explained by the vendors and consultants are summarised in Table 1.

6 Findings from case studies on BI practices

The study in the second phase comprised conduct of semi-structured interviews in two large electronics-manufacturing firms BVN and CVN (pseudonyms) who had implemented a BI system, to explore their use of BI for analysis, making decisions and creating knowledge. Brief descriptions of the two cases are shown in Table 2.

Table 2 Case study comparative descriptions

	BVN	*CVN*
Setup	1966	1988
Product manufactured	Electronic telecommunication chipsets	Electronic devices for fleet-tracking, car-navigation, and marine-application
Employee numbers	760	780
BI/ES	BI (SAP)/ES (mySAP)	BI (Cognos)/ES (SyteLine)
ES modules	Manufacturing, finance, and HR	Manufacturing, finance, and field service

6.1 BVN findings

BVN have deployed SAP BW (business data-warehouse) solution to incorporate their high-volume, real-time processing needs. The BW environment was recommended by their IT specialists to help accurate forecasting of their sales information. It was vital for the BVN team to have clarity on project plans, their scope, budgets and timelines, and manage performance through metrics.

Managers could mine the data from their BW and align specific operational strategies with evaluation methods based on metrics using scorecards for optimal responses. The IT project manager stated that for generating reports, their BW data was not directly transferrable into the BI tool. Based on the knowledge creation requirements, the relevant information was built up manipulating the SAP data output via structured query language (SQL) statements.

The IS manager clarified that by using the SQL query process, precise business information based on the operational needs could be generated. Visualisation through graphs and data summaries with pivot tables could be produced. These reports could be further manipulated by transferring the information into more flexible applications such as Microsoft Excel, which is more user-friendly in comparison to SAP's proprietary ABAP reports. The BVN IT team conveyed that the way SAP BI was designed, the transactional data could not be transferred directly into the BI solution when it was implemented. The IS manager clarified, "with this the BI tool would get swamped with data." He explained that for the purpose of reporting data summaries were built through transfer of transactional data into the BI tool by running specific data summarising tools. Using SQL database, a summary of the transactional data could be cubed, which could crunch the numbers on the relevant fields, and diced and sliced for reporting. The business managers at BVN instead of using the BI tools themselves via the in-built functionality were dependent on their organisational IT experts for transforming data and generating information. The IT experts focused on the maintenance of high-quality cubes of data transferred through BI to create customised reports based on user needs. However, the IS manager stated in case of a requirement for viewing from which customer order or job order the data was pulled out was not feasible, since the summarised information was used without drilling down functionality. He further conveyed that their current version of SAP BI had this issue, but their organisation was considering upgrading to business objects, which included the drill-down capabilities, then they would have the capability of handling transactional data. It would be helpful for building knowledge instead of only relying on an ABAP report. The manager concluded that timely upgrade of appropriate technologies was vital for the company. The operations manager noted that retaining information from their legacy systems (mySAP BI) while upgrading new tools such as business objects helped in managing performance reviews.

Recently, BVN has designed new scorecards for performance management, which the management team controls and monitors with an ongoing evaluation process. Once the objectives are defined with target benchmarks approved by management, the key performance indicator metrics are extracted from ESs and monitored against goals. However, BVN's BI tool deployment is not mature enough to allow comprehensive performance evaluations. BVN managers clarified one of their main objectives as being able to analyse data through dynamic online queries using BI with drill-down into data layers. They noted analytical support through features such as SQL queries, filters, crosstabs, and other report features, which help them in discovering data in specific contexts, establishing correlations, making trends or identifying any outliers. Additionally, the BVN management highlighted the importance in use of both – static analysis through BI reports and dynamic analysis via BI ad hoc queries – for predictive and prescriptive decision-making. The operational managers at BVN intensely

collaborate with their IT experts for maximising their BI use. Training and skills development in use of BI is proactively pursued.

6.2 CVN findings

Cognos Impromptu BI system has been deployed by CVN as an add-on to their ES – SyteLine. The IT manager at CVN clarified that the BI tool has usefulness for managers who may require an ad hoc report due to issues faced by them. He explained that the BI tool could generate ad hoc reports without the need of a user going to an IT specialist requesting a differently laid out report since some specific information required is not available. Furthermore, he stated, "BI assists in getting the needed information through the system efficiently and quickly." Users can efficiently develop an understanding of the operational status accurately when they are equipped to extract data easily. Moreover, this ease in data access adds to timeliness and also individual's accountability in making decisions in this era of business turbulence.

In the opinion of operations manager, though the necessary data could be accessed via the BI tool, people were dependent on the few BI license users, which would always be an issue because those users continually seemed occupied. Being able to pull out a customised report from IT specialists involved big delays which were based on the person requesting for it. The manager stressed that having one individual or team of BI people who knew the BI architecture and data mining structure could assist in building customised reports for every user. Further, the report could be formatted to bring into Excel. The users could then themselves manipulate the data and information. "It would be ideal to provide the collaborative BI tool licenses and training to users themselves, to enable them create and share information efficiently."

The IT manager however explained that the user is insulated from the complexities of the data warehouse through the BI tool, to allow focus of user in data analysis for driving the business. The manager further clarified that the BI tool performance could be improved through creating summaries, information sorting, and applying crosstabs and filters. Both, predictive and prescriptive information could be queried through the SQL-based tool with extraction of drilled-down data viewed via output reports in real-time. The report and query performance could further be enhanced as users learnt through experience. Simulations from different strategic 'what if' scenarios lead to more informed decision-making to achieve goals. A business information view is presented controlling access of data through deployment of appropriate technology, its configuration with user permissions set. The definition of data quality and security requirements are established through the in-built BI functionality.

The operations manager, while appreciating the functions of existing BI tools, suggested that the BI processes should include more data visualisation capabilities built into the system. According to the manager, although the system has the ability to transfer high quality data from different warehouses for visual presentation and analytical decision-making, the process is superior with use of dynamic analysis through BI instead of standalone reports. He stated, "knowledge is created as more and more information is accessed and individuals are inclined towards viewing it in different ways since they are gaining some insights from it." He further stated that all the users would like to see the BI information differently. There could not be a possibility of having adequate standard reports in the system that please all users. Therefore, when users have the ability to

extract data themselves, they would like to dice and slice the data, and look at the information the way they want to.

7 Discussion

Different BI suppliers and case organisation respondents have explained the various critical BI practices to successfully build knowledge by converting enterprise wide data for strategy-focused analytical decision-making. Findings from this study highlight the capability of BI tools in integrating organisational data and helping users to create meta-knowledge. When business analytics is applied by organisations to identify bottlenecks, simulate scenarios, measure performance and monitor progress using BI technologies, information is transformed into knowledge, and subsequently with interpretation, context, and experience evolves into meta-knowledge. Such data-driven processes help managements understand differences within unpredictable circumstances, logically strategise allocation of resources, and execute quick actions. The usefulness of BI tools in mapping context-specific decision-making and valuable data is highlighted in this study. Interactive operational dashboards and actionable data visualisations have come to the fore, overriding the earlier common use of spreadsheets. With improved data quality, secure and clean data are now used with simplistic and dominant presentations.

The BI tool is often used to report localised data views of operational processes within a specific functional context, which could be consequential within the wider framework for achieving strategic directives. Such localised view of trivial reporting data at operational level has been reported by Jung et al. (2015, p.192) as being 'critical', reflecting the "assigned work at their own level while contributing toward overall operational performance measurements for the enterprise." However, these are often used as static tangible standalone measurements for predictive and prescriptive analytics. To fully exploit the intelligence from these reports, further dynamic analysis is needed. Practices considered critical for leveraging BI to transform data into meta-knowledge and share organisational information for producing benefits are summarised. Table 3 provides an analytical case comparison highlighting the critical effectiveness constructs and the current practices of the BI process.

The findings align with the emphasis of a clear business-driven strategy by Yeoh and Popovic (2016) for BI impact and their organisational, process and technology related factors. The data analytic process begins with the setting of business objectives that align with the organisational targets and strategies. These goals lead the organisation towards new projects and actions by implementing process changes and driving new initiatives as represented by the hierarchy in a volcanic activity format shown in Figure 2. The BI system is utilised as a KM enabler to guide actions in these projects. It manages the knowledge-based processes such as digital dashboards, KPIs, and scorecards assisting the analysis of extracted data. Company managements review metrics captured by these reporting methods assessing outcomes with their reasons. This leads to the development of meta-knowledge to establish strategic decisions depicted by business insights eruption in Figure 2. The use of data from the data warehouse, which are the main knowledge assets, is at the core of this process depicted as the magma chamber. These data analytic methods create knowledge used in different process improvement programs and projects

for realising the organisation's strategic objectives and targets depicted as the outflowing benefits in Figure 2.

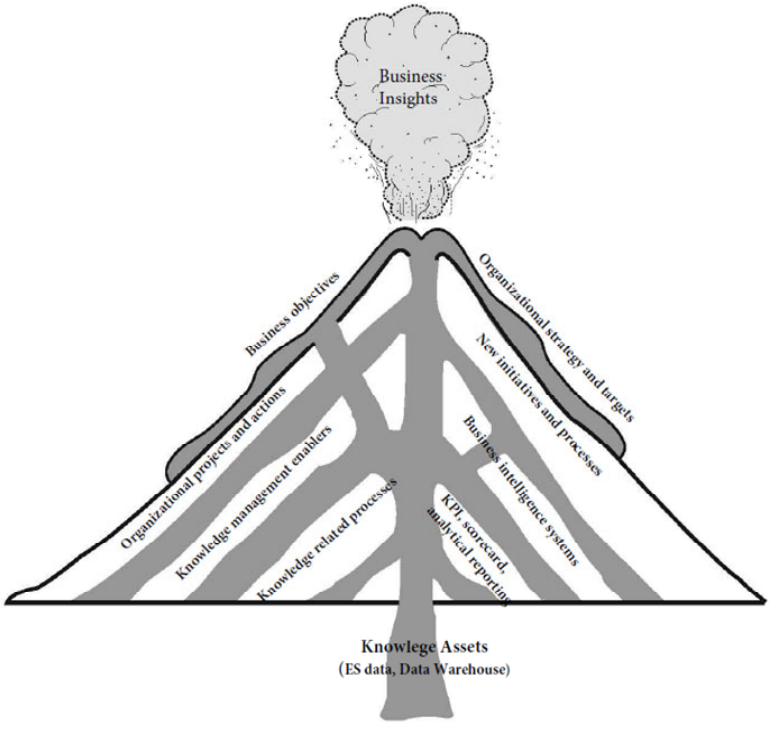
To be able to extract the underlying data successfully, findings from this study stress upon the tying up of BI tools with the data warehouse. This will allow drilling through the data tables to extract core information by users instead of using the BI system with selected data transferred into the tool or data configured into catalogues as found in the BVN case. The business managers at BVN were governed by the IT experts for generating information due to lack of drill-down utilities, which eventually reduced the impact of their BI tool.

Table 3 BI practices considered critical for creating meta-knowledge

BVN	*CVN*	*BVN and CVN*	*BI practices context*
Assessment of scope, budget and KPIs of new initiatives/projects through metrics using scorecards	Establishment of clear goals by the executive team through dashboards/trend lines with data visualisations	Aligning operational strategy with IT and business strategy	Alignment to business strategy
Clarity on project plans, deadlines, and performance management	Benchmarking project plans and outcomes with baseline for measuring results	Simulations through different strategic scenarios to achieve goals	
While upgrading new BI tools such as business objects, retain the legacy system knowledgebase, e.g., mySAP BI	Demonstration of empowerment to support efficient decisions by managers	Creating a digital environment in use of a BI and developing a culture in use of data for knowledgeable decision making	Organisational change management
BI users collaborating with IT experts for maximising BI usage	Dedicated administrator and local support in use of collaborative BI tools	Impart usability support and training to BI users and develop BI skills of administrators	Training and IT support
Data analytic extensions comprise reporting tools, crosstabs, filters, and SQL-based queries to discover data in specific contexts with correlations, trends or outliers	Data governance with ability to transfer high quality, secured and trust-worthy data from different warehouses for analytics	Analyse metrics by drilling through data layers using online dynamic query tools for monitoring performance	Data governance and management process
IT experts maintain cubes of high-quality data transferred through BI	Data quality and security definitions are embedded into the in-built BI process	Establish use of static, dynamic, predictive and prescriptive analytics	
Timely upgrade of appropriate technologies. Use of add-ons based on requirements	Configuring and utilising relevant and updated technologies	Accessing the central data repository that integrates information sources and different data warehouses	Technology management

The lack of data migration across platforms is therefore one concern, which could lead to under-utilisation of its capability. This aspect also matches with Baptista et al.'s (2010) research that revealed that company managers lose the strategic value of IT over time due to under-exploitation leading to loss in sharing vital information, thus increasing business risks. This underutilisation of information has been explained by Del Giudice and Della Peruta Maria (2016, p.485) as "a failure or shortage of knowledge sharing" resulting in inappropriate actions. The holistic organisational processes landscape can be affected due to the overlooking of IT infrastructure, which comprises monitoring of business activities and enterprise-wide information sharing.

Figure 2 A model for transforming data through the BI process



Note: Volcanic structure adapted from Pearson Education (2010).

Impromptu intelligence generation by users themselves through the BI process can create a more accurate picture opposed to data extraction from IT experts via ad hoc reports which usually can only provide a partial view of the context.

Findings have revealed that although businesses setup performance metrics with BI and have established active commitment of users and management, these firms have not been able to maximise utilisation of their BI tools to fully exploit the core data. From the findings, commonly faced issues for use of BI tools include:

1 its use as a data analytic system for achieving strategies since its typical use is in reporting KPIs by metric measurement

2 its usability limited to few select staff instead of every BI user for establishing decisions

3 drilling down through data layers for extracting information instead of using data supplied into BI tool for analysis

4 responsibility of the IT team for data integration from disparate sources instead of business managers

5 poor data quality maintenance discipline by the organisation.

These findings are consistent with Isik et al. (2013, p.13) who have highlighted that for BI success, its integration to other systems, direct user access, and technical competences including maintenance of data quality are critically essential though, the "decision environment does influence the relationship between BI success and capabilities." However, managements do realise that despite the risk and significance of facing various resource management difficulties, utilising BI competences effectively can achieve deeper insight to manage the dynamic and volatile business environment.

8 Conclusions and implications

Findings have revealed that maturity in using BI has substantial influence on organisational practices, with variations in perceived effectiveness and in their use. This suggests that whilst there is a universally applied core BI process in industry, many BI practices are highly context specific. There has been a significant rise in the overall use of BI with its increased data analytic and business reporting capability; however, some strategy analyses developments have also been achieved using independent databases applications. Static analysis is complimentary to dynamic analysis and is linked to strategic implications for predicting and prescribing a more holistic picture of the enterprise. The managerial capability in realising organisational goals depends on use of both static and dynamic analyses in the BI process including the use of visual analysis process tools by leveraging existing infrastructure. A BI assessment plan permits alignment of the enterprise goals with process metrics to implement a business strategy contingent on investigating opportunities and risks. This allows firms to improve functional effectiveness, increase organisational efficiency, and realise future-based strategies. Furthermore, BI practices enable value chain alliances such as vendors, customers, distributors, and subsidiaries to share and evaluate valuable information including pending orders, sales volumes, and inventory status, which assist in aligning demand with planned supply.

This study has identified the critical practices in the BI process for building meta-knowledge and highlighted organisational strategies that positively impact operational effectiveness and corporate success. These practices assist in successful deployment of the BI process for strategically monitoring and measuring the underlying issues. BI tools can enhance the reporting formats of analytical measurable aspects required for meeting business goals through visuals (tabular data, graphical models) or by providing summarised reports. However, the study found BI practices to vary across firms in their effectiveness and usage, reflecting numerous technology challenges and lost opportunities. Knowledge assets must be engrained within BI processes to create meta-knowledge for enhancing analytical competences and decision-making. Across the

experts and firms examined, seven specific practices that influence BI effectiveness resulting from superior knowledge creation are:

1 Alignment of BI processes towards achieving goals and strategies with data discovery and visualisations.

2 Organisational change management towards creating an environment for use of BI empowering managers for proactive decision-making.

3 Training of staff and IT support in use of BI.

4 Data governance and management strategies to access high quality, secured and trust-worthy data for static and dynamic analytics, as well as predictive and prescriptive analytics.

5 Timely upgrade of technologies including use of add-ons based on requirements, their integration and configuration.

6 Cloud connectivity assistance in data storage, analytic and computing power along with data sourcing and processing applications.

7 Collaborative BI tools can achieve better scheduling, generation and sharing of automated reports.

These functionalities enhance the strategic management and decision-making processes in businesses by building up of BI practices.

Tangible measurements from operational processes have been analysed for interdependencies to specific contexts enabling data transformation with creation of knowledge first, leading to meta-knowledge. The findings of this study inform both business and researcher community on the practices that influence BI effectiveness to enhance knowledge-creating capabilities. The critical BI practices have been captured, both, from the perspective of BI suppliers and the BI users for managing strategy-focussed decision making, which is a unique contribution of this paper. The proposed model (in Figure 2) has contributed to an improved theoretical understanding of how knowledge-based enablers inform the data transforming process to create meta-knowledge with use of BI.

9 Limitations and future research directions

Though this research is limited to two case organisations, the study provides a comprehensive view of the BI environment and its potential in assisting managerial decision making. However, this research is limited to two manufacturing firms in the electronics business sector. Future research could replicate this study across different business sectors and compare usage patterns in BI practices in these sectors. A comparison with the findings reported here would further help in elucidating the critical BI practices to create meta-knowledge for strategic decisions across industry.

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