Integrating BI Information into ERP Processes
Describing Enablers

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Abstract: Business Intelligence (BI) systems typically report on transactions executed in enterprise information systems such as Enterprise Resource Planning (ERP) systems. Reporting is normally at managerial or executive level, yet substantial benefits can accrue to organizations that successfully integrate BI information back into ERP processing at an operational level. How this integration is enabled is not well understood or researched. In this paper, a multiple case study considering three organizations, factors enabling this integration are described and a process framework is presented indicating the importance of these enablers and the sequence in which these factors need to be considered. New factors not initially considered in the literature emerged such as including big data, using in memory BI and using the same vendor for ERP and BI. However, unless integrating BI into ERP processing is appropriate for an organization, benefits will not necessarily accrue.

1 INTRODUCTION

Enterprise Resource Planning (ERP) systems are enterprise information systems that integrate all facets of business by providing functionality for coordinating and processing planning, manufacturing, sales, accounting, finance and human resources business functions using shared data and information. Business Intelligence (BI) systems can pull data from ERP and other systems, and provide reporting to help users make accurate and timely decisions. Although BI often is reporting on ERP transactional data, BI has been criticized because the level of reporting is mostly at a strategic level as opposed to an operational level, and with a considerable time lag (Bucher et al., 2009). BI methodologies and tools are typically not process-aware (van der Aalst, Zhao, Wang, 2015). Data scientists can now do new and exciting analytics but should not forget that this data needs to improve operational business processes (van der Aalst et al., 2015). Potential solutions to this problem include Real Time Business Intelligence (RTBI) and Business Performance Management (BPM). In RTBI BI reports are generated in near real time, and are used to help an organization carry out operations. BPM is an initiative or framework within business process management (vom Brocke and Rosemann, 2014) under which organizations use IT enabled methodologies to formulate, manage and execute their strategy through Key Performance Indicators (KPIs) (Tank, 2015). In all of these scenarios, ERP systems execute and store transactions, and BI systems report on those executed transactions. Yet there are also potential benefits for the scenario in which BI information is integrated back into ERP processing. However, there are many obstacles to ERP BI integration (Nofal and Yusof, 2013). Hence the main research question posed here is "What factors and conditions enable BI information to integrate and impact on ERP transaction processing?"

This paper addresses this through a short literature review, description of method and findings with discussion.

2 LITERATURE REVIEW

BI integrated with ERP allows organizations to take advantage of ERP data using BI reporting capabilities. Firstly BI developed on the top of ERP has the advantage of simplified data acquisition drawn from a homogenous source (Lupu et al., 2007). Secondly by executing corporate decision making at both management and operations levels back in the ERP system both the BI system and the ERP data are

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better utilized to the benefit of the organization (Chou et al., 2005). While BI provides refined information, BI reports that do not also include context have a diminished impact (Bucher, et al., 2009). Companies that have implemented ERP on a large scale have a majority of process steps managed, planned, and executed in the ERP system. In these cases BI and ERP system integration can be maximized as follows (Bucher, et al., 2009; Chou et al., 2005; Gile, Teubner, Moore and Fossner, 2006):

- Operational processes generate transactional data stored in the ERP system at the operational layer.
- BI sources data from the ERP via extraction, transformation and loading (ETL) processes and presents it in the analytics layer in the DW.
- BI consolidates diverse data into meaningful performance indicators.
- BI performance indicators are used as input to drive operational processes executed in the ERP.

Yet, moving process analysis into an integrated BI environments is still an unanswered research question (Baars et al., 2014). While mining ERP systems to get BI is challenging (Nofal and Yusof, 2013), the feedback loop of BI back into ERP is more so. The feedback loop of using BI to manage operational processes has been termed operational BI (Baars et al., 2014) and is described through several concepts, including RTBI, and BPM frameworks. There is insufficient research on integrating ERP and BI in general (Nofal and Yusof, 2013) and the authors could find limited research that identifies the factors that enable feedback of BI on ERP processing. Hence success factors in the literature for ERP, BI and trends in BI were considered and investigated and are now briefly presented here and summarised in Table 1.

2.1 BI Enablers

BI processes can enable getting the right information in the right quantity, in a timely manner and in a usable format, to impact positively on business operations and tactics (Lupu et al., 2007). Although BI can run on data in any storage, most typically a data warehouse (DW) stores transactional data in the form of structured normalised data or as denormalized or unstructured data optimised for retrieving and presenting information in queries. The DW is populated via ETL, after which the data becomes static. BI then uses this data to create reports and analysis (Tank, 2015). Yet BI implementations can be complex, and projects that deliver the DW

Table 1: BI ERP integration enablers based on the literature.

Category	Enabler	Description	Cite
ERP Installation	ERP support of operations	Operation execution and operational reporting	(Hwang and Grant, 2011)
	Integrated on many levels	Strategic, Systems, Organizational and Technical integration	(Hwang and Grant, 2011)
BI Installation	BI background and uses	Traditional sources, strategic, management reports	(Bucher, et al., 2009; Lupu et al., 2007)
	Different BI Reports	Strategic; Management; Operational	(van der Aalst et al., 2015; Tank, 2015)
	BI Landscape	ERP ETL BI structure and landscape	(Gile et al., 2006; Tank, 2015)
BI Capabilities	Corporate objectives aligned	Drives change and competitive advantage	(Işık, Jones and Sidorova, 2013)
	Data Quality	Consistency, comprehensiveness, timely	(Parikh and Haddad, 2012)
	Integrated on many levels	Data, business process, application, and user integration.	(White, 2005)
	Flexibility	Allows changes in requirements	(Işık et al., 2013)
	Decision tiers	Strategic (data less timely less structured), planning, management, operational (structured timely accurate)	(Işık et al., 2013)
BPM framework	A framework in use	Strategise, plan metrics to achieve goals, monitor against goals, act and adjust	(Tank, 2015)
	KPIs defined and tiered	Strategic, Management, Operational	(Tank, 2015)
	Business context for KPIs	In ERP where operations occur	(Bogdana et al., 2009)
RTBI factors	Different report types	Strategic; management; operational	(Azvine, Cui, Nauck, and Majeed, 2006)
	Organizational readiness	Management; funding; support	(Golfarelli, Rizzi and Cella, 2004)
	Technical readiness	hardware, software, tools	(Golfarelli et al., 2004)

and BI can fail because of the complexity of these processes over the entire organization (Tank, 2015). It has often been shown that the root cause of BI failures is not technology, but organizational, cultural and infrastructural issues (Lupu et al., 2007).

2.2 BI and Business Performance Management Integration

BPM is an initiative where companies align strategic and operational objectives with business activities with the goal of managing performance through informed and better decision making and actions. The BPM core processes are strategize; plan; monitor and analyse; and take corrective action (Tank, 2015). BPM focuses on the entire enterprise and requires access to timely accurate data which provides support for tactical, operational and strategic decision making. KPIs established within the correct business context can allow for real time management and changes (Tank, 2015). A top down enforcing of company strategies via a BPM framework into operational and tactical decisions can be supported using BI (Bogdana, Felicia and Delia, 2009). Although KPIs supported by most BI installations, have high latency and are generated through manual extractions and allocations (Azvine et al., 2006).

2.3 Real Time Business Intelligence

RTBI can be defined as BI that has zero or small latency. RTBI will derive performance measures related to the current situation (as opposed to historical time) in order to drive a decision at that moment. The vision behind RTBI is the seamless transition from data into information into action (Azvine et al., 2006). Classic BI focuses on reporting only, while the vision of RTBI is to provide decision makers at operational levels the information to make changes to processes in real time (Golfarelli et al., 2004). Although data in classic DW and BI solutions is static and may be plagued with data integration issues (Sahay and Ranjan, 2008) these systems are real time capable and form the building blocks of RTBI solutions (Tank, 2015). Thus RTBI can trigger a process, alter the course of a process, or help a human decision be made during a process (Bucher, Gericke and Sigg, 2009) and has been termed real-time process intelligence (RTPI) (Korotina, Müller, Debortoli, 2015). For RTBI to be successfully realised in an organization technical and organizational challenges need to be addressed. Organizational challenges include having top management and organizational support, as well as funding in place (Tank, 2015) and lack of conceptual understanding by business (Korotina et al., 2015). Technical challenges include a lack of standards (Korotina et al., 2015) as well as inadequate hardware, software and tools (Tank, 2015). An assessment of the return on investment of RTPI has been called for (Korotina et al., 2015).

3 METHODOLOGY

This research is qualitative and interpretive using a multiple case study approach (Yin, 2012). Interpretive studies are well established in IS research and include second-order constructs of the researcher's interpretation of interviewees' first-order constructs (Walsham, 2006). The case study approach enables a real-world inquiry of a contemporary phenomenon when the boundaries between phenomenon and context are not clearly evident and is particularly useful for descriptive and explanatory approaches going well beyond exploratory research (Yin, 2012). Generalisations from case studies can include theories (Walsham, 2006). The initial target population for this research was any organization using an ERP system to run a majority of its operational transactions, and a BI system to perform the majority of its business reporting. Three organizations were chosen that had implemented and been operating ERP and BI solutions for several years. The organizations and their main ERP and BI systems are listed in Table 2. The organizations are all large private for profit organizations. Ethics approval from the university was obtained prior to data collection.

Data collection consisted of six interviews and analysis of one document (EP03). The semi-structured questions were framed from the literature and asked about the organisation's BI, ERP, BPM and RTBI usage and capabilities. The respondents are functional experts of BI and ERP use, support and implementation and were interviewed at their work locations during 2015. The respondents and their codes are:

- IT Director or Manager (EP01)
- IT Technology Specialist (EP02)
- IT Director or Manager (OG01)
- IT Technology Specialist (OG02)
- IT Director or Manager (CP01)
- Business Director or Manager (CP02)

Interviews lasted from 30 minutes to one hour and then the recordings were transcribed. Data was analysed using a combination of inductive and deductive thematic analysis (Fereday and Muir-Cochrane, 2008). An initial code book was created

Table 2: Organizations where research was conducted.

Code	Country	Nature of business	ERP and BI systems	ERP users	BI users	Employees	Annual Revenue
OG	South Africa	Downstream, refine, Retail Oil and Gas	SAP	1500	500	4000	R 65 billion
CP	USA	Manufacture, distribution of branded products	SAP COGNOS	1300	390	3100	$1.6 billion
EP	USA	Media production, distribution	SAP + Teradata	3000	1000	8000	$ 12 billion

from the factors identified in the literature and the document and transcribed interviews were analysed for these codes. The phrases or text excerpts were coded and then counted. Then inductive coding was carried out and further factors were identified.

4 DISCUSSION OF FINDINGS

During thematic analysis, each text excerpt alluding to a factor was assessed to be of negative, low, high or critical importance. The importance of the factor was then determined across all data sources and the number of text excerpts counted. The factors and counts are presented in Table 3 with the four new factors not referred to in the literature shown in italic font. Each factor is now discussed.

Table 3: Factors with counts and importance.

Factors	Import -ance	Count (negative, important, critical)
ERP installation success	Critical	19 (1,9,9)
ERP integration success	Low	10 (2,5,3)
BI installation success	High	22 (0,18,4)
BI reporting success	Critical	16 (9,7,7)
BI ETL performance	High	18 (1,15,2)
BI alignment with corporate objectives	Critical	18 (1,8,9)
Quality, timely, comprehensive BI data	High	12 (0,9,3)
BI data integrated with user tiers	High	11 (2,8,1)
BI flexibility	Low	0
BI decision tiers	Low	6 (1,4,1)
BI big data input	High	11 (2,6,3)
BI and ERP from the same vendor	Critical	10 (1,3,6)
BPM top-down framework	Critical	20 (1,10,9)
BPM KPIs defined, tiered and in context	Low	18 (2,9,7)
RTBI report drivers	High	19 (4,8,7)
RTBI organizational support	Critical	22 (5,8,9)
RTBI technical capability	High	14 (3,11,0)
In memory BI	Critical	31 (3,16,12)
RTBI organization appropriateness	Negative	9 (3,5,1)

4.1 ERP Installation Factors

ERP installation factors include ERP installation success and ERP integration success.

The success of the ERP installation includes the purpose and uses of ERP at the organization, the levels of use of the ERP system in terms of delivering operation execution and operational reporting and which processes are implemented. With the integration of all organisational departments, more benefits are gained (Uwizeyemungu and Raymond, 2012). The interviewees considered this factor as critical: *"Supply chain, Procure to pay, build, manufacture, inventory, financial analysis for all of those processes, supply to customer, delivery to customers, for the most part end to end, using ERP solutions"* (CP02).

With an ERP installation integration across dimensions increases company performance and long term success (Hwang and Grant, 2011). However, various levels of integration appear to have occurred in the organizations studied: *"Business process are integrated in SAP in different ways. Different types of customers, one is end to end, others are not"* (OG01). In many cases ERP integration was not achieved: *"the rest of this company does not lend itself to ERP"* (EP01). Therefore this factor was interpreted as not important.

4.2 BI Installation Factors

BI installation factors include BI installation success, BI reporting success and BI ETL performance.

BI installation success addresses the stability and value generated by the BI installation. There were mixed responses to the success of the BI installation. Many indicated success in reporting data from disparate systems: *"The big thing on the DW in our system is all the disparate source systems, we are bringing data together"* (OG02). There were a few critical responses to the ERP connection: *"Yes, your BI and ERP should work"* (CP01). Most reported that BI was stable and running but not perfect. It was therefore interpreted as an important factor.

The BI solution to be successful should address reporting across strategic, management and opera-

tional organizational levels and should consider the content, timing and usefulness of the reports (Gile et al., 2006; Tank, 2015). Respondents referred to BI reporting success repeatedly and mostly identified it as critical. Having BI reporting solutions that address strategic, segment or management and operational reporting solutions was considered important: *"They did all three. I have seen all three with the BI system"* (CP02). *"There are different audiences for different reports"* (EP01).

The ETL into the DW and BI landscape can be complex but a simpler landscape and fewer BI platforms gives a better result, while complex landscapes with several BI instances limit flexibility, add to latencies and don't allow for a holistic solution (Gile et al., 2006). A large ERP simplifies this environment. The homogenous environment and sources of data and extraction processes, integration of objects and technical landscape are all important facets that need to be successfully implemented. The responses show that even with ERP and BI there were still some problems of complexity and latency: *"24 hours on average, overnight reporting lag"* (OG01). *"The system is flooded with lot of background processors when extractors are running and virtually most of the time, due to the resource intensive consumption of the system"* (EP03). ETL performance was therefore considered an important factor.

4.3 BI Capability Factors

Seven BI capability factors include BI alignment with corporate objectives; quality, timely and comprehensive BI date; BI Data Integrated with User Tiers; BI flexibility; BI decision tiers; BI big data input; and BI and ERP from the same vendor.

Alignment of BI solutions to organizational strategic directives is recommended (Işık et al., 2013). The responses showed that corporate direction and BI strategic alignment is overwhelmingly a critical factor: *"Management must put their foot down to ensure that strategy is followed to prevent things getting out of alignment"* (OG02). *"Yes this should be totally a top down approach, where the corporate strategy is driving the BI system"* (EP02).

BI systems with good data lead to satisfied users, and greater organizational success (Parikh and Haddad, 2012). Quality, timely, comprehensive BI data in an organizations was confirmed as important with numerous responses: *"There is a BI hierarchy of needs. You cannot worry about the higher levels until the basic reports at the lower level are correct"* (CP01).

BI involves linking systems, data or functions together, depending on what is appropriate for each organization (White, 2005). How BI is integrated with other systems including ERP and how BI integrates users in the organization through executive, management and operation tiers was commented on by a few respondents and so was classified as important: *"yes, they built specific reports for each of the three levels"* (CP02).

Research emphasises that BI should be flexible and adapable to maximise an organization's success (Işık et al., 2013). There were no responses to the BI flexibility factor so it was seen to not be significant.

BI decision tiers addresses the capability of BI solutions to differentiate the timing of the required information that may be required to make decisions at different levels. Operational decisions require fast structured information, while strategic decisions involve a longer time period, and a wider source of information (Işık et al., 2013). There were few responses for this factor, in only one case was an operational report delivered to a low level supervisor mentioned *"and supervisors were using this report to fix issues real time"* (CG02). This factor was therefore considered not important.

Insights from "big data" can help organizations to improve their customer experience, improve their products, add value and produce a bigger return on investment (van der Aalst et al., 2015). Big data was not initially considered in the literature reviewed but was commented on several times, and was therefore included as an important factor: *"What we don't have is any consumer insights into our data… we would like to know what impacts the weather has on our sales"* (CP01). It was also commented on as required and useful: *"The customer's moods are important"* (OG02). For one of the cases it was seen as not necessary: *"You don't need to have every single store to know how you doing in total, or to know how you doing in specific locations"* (EP01). However, it was not clear that these organization's BI or ERP solutions will ever contain this information: *"social media and emails which will be difficult to store in an operational ERP system"* (OG02).

Having BI and ERP from the same vendor was not in the literature but was added and classified as critical because of responses: *"SAP BW was primarily built to connect to SAP ERP system and for every 50,000 SAP ERP customers there were at least 13,000 SAP BW customers who bought and implemented SAP BW solution"* (EP03). *"Usually it does matter especially with SAP because the BI was built for that ERP system"* (OG02).

4.4 BPM Framework Factors

Two BPM framework factors emerged. Firstly having a BPM framework and secondly having BPM KPIs defined, tiered and in context

The BPM framework is an initiative where companies align strategic and operational objectives with business activities (Tank, 2015). The factor explores what frameworks each organization had in place and how relevant such a framework is. This factor had many comments both important and critical: *"The framework for these KPIs was developed. What the board would say is you need to measure performance. And they sign off on it. Each business unit had their own metrics. The board would then sign off on these measures"* (CP02). BPM KPIs and the tracking of them was commented on as a good tool not specifically to be set up and tracked in ERP or in BI: "The KPIs are strategic, management and operations. You need ways to measure that are not financial. The success should be measured by the appropriate strategy. Not by a tool or any tool" (EP02). This factor has been recorded as critical when a BPM with KPIs is implemented using a top down approach. The fact that the framework was in place was a critical indication of aligned business and executive goals.

BI management systems with KPIs should support strategic, tactical and operational levels (Azvine et al., 2006). However, context with KPIs often implies information from several diverse sources for example the industry KPI is often needed to give a KPI full meaning and to better understand the global competition (Gile et al., 2006). We explored the importance of the types of KPIs that organizations have in place, the nature of those KPIs as well as the levels at which they are tracked. The responses included the types of KPIs that organizations have in place: *"There are 5 strategic objectives, Finance, Business Process, HSEQ* (Health, Safety, Environment, and Quality)*, Other, and Talent Management."* (OG02). KPIs are also tracked outside of formal tools or ERP and BI: *"They put a lot of information into Excel"* (OG02) and *"they are being tracked, but not centralised"* (CP02). The KPIs look back at past performance: *"In the KPIs there are laggards and leaders. These are all laggards, not leaders"* (OG02). KPIs were in place in all the cases and were seen as critical in many cases but were not formalised or built into the ERP or BI systems consistently. This lack of adoption into BI and ERP meant this combination of factors was classified as not important.

4.5 RTBI Factors

Five RTBI factors emerged: RTBI report drivers; RTBI organizational support; RTBI technical capability; in memory BI; and RTBI organizational appropriateness.

Global and market forces could drive RTBI requirements or BPM (Azvine et al., 2006) and a top level strategy in the organization could be driving the push towards a RTBI solution (Golfarelli et al., 2004). There were many responses to the drivers for RTBI: *"It was just the production order and inventory movements. This was something special that they built, so that they could see the performance metrics on a real time basis"* (CP02). This factor was also described as level specific: *"Roadmap says BI is only for info strategic reports… management and strategic will be moved onto more real time"* (OG01). The factor also had negative responses *"Most decisions we make do not require real time decisions"* (EP01). However, the wide variety of responses and the high counts make this factor important overall.

Organizational support indicates organization preparedness for RTBI and support from an executive level for RTBI. For successful RTBI companies require process orientation, technically preparation and management driving the demand (Golfarelli et al., 2004). This includes readiness in terms of management direction, support, and funding. This factor had many critical responses: *"The first thing is to get the conceptualization in place before the tools are in place… they need to ask for it, otherwise you end up with many fast reports that nobody asked for. Executives need to ask for a top down view"* (EP02). However, respondents indicated that their organizations may not be ready yet: *"The problem is I do not know if they know that they have a need for it. It depends on the business unit"* (CP02). *"The strategic people are focusing on operational, because they are still trying to right the ship"* (CP01). The majority of mapped responses make this factor a critical influence.

RTBI technical challenges require the appropriate hardware, software and tools available for the organization (Tank, 2015). The responses around this factor indicated that technology was still challenging: *"We should have around the network planning and transports, but this is still on Excel and after the fact"* (OG02). Technology was not necessarily a constraint: *"This gave potential to tune the existing SAP BW systems integrating SAP ERP"* (EP03). However, this factor also implies that organizations need to have tools and processes in place to

allow RTBI to be implemented: *"We had a very structured approach and they used the consultants to bring in tools, taught us how to use the tools and gave us a structure to work with"* (CG02). With many comments, this factor was coded as important.

In memory BI was not a factor in the literature but was overwhelmingly supported in most cases across all the interviews. Main memory databases or real time databases such as the SAP HANA product are expected to provide high performance and reliability solutions to BI reporting constraints, and are a major phase in business intelligence development (Golfarelli et al., 2004). The factor is an important part of how RTBI can impact operations and reporting, and also in the simplification of the ERP and BI landscape: *"They want to reduce the ETL as much as possible, and pull the ETL into HANA"* (EP02). The inclusion of in memory BI showed a simplified ETL landscape in EG03. It was commented that real time reporting from a RTBI solution is more appropriate for operational and management type reporting, rather than strategic or executive type reporting: *"Roadmap says BI is only for info strategic reports… we can use HANA for line item level reporting on COPA"* (OG01). Therefore the RTBI in memory is a critical factor. The driver for this is to simplify landscapes, improve processing times, and delivery existing reports faster at the management and operational levels in an organization.

Organizational appropriateness was not found specifically in the literature but was added as a factor because of the numerous comments and responses around the suitability of RTBI to a business process or to an organization. This factor is shown to be important in that not every company or department needs to know information in real time: *"the studio CFO does not need know every piece of information in the world to close the books each month"* (EP01). *"If you are in a top down culture organization where your reports are sent out, then maybe RTBI is not such a big deal. The reports can come out once a day or once a week"* (CP01). These responses indicate that the factor is relevant in a negative way because RTBI may not be appropriate.

4.6 Framework of Factors Impacting BI ERP Integration

From a theoretical perspective a process model or theory (Pentland, 1999) showing the significant factors and the sequence of factors is presented in Figure 1. This theory shows the time sequence an organisation needs to follow to integrate BI into ERP processing. Firstly ERP installation and BI installation are required, followed by BI capabilities, BPM framework and then RTBI. In Figure 1, the factors that are seen to be critical are displayed in italic font. The implication is that these should be given a higher priority as they have a greater impact on outcomes. These include ERP installation success, BI reporting success, and BI alignment with corporate objectives. Having ERP and BI from the same vendor is also a critical factor. A top down BPM Framework should also be in place to further push out and drive corporate strategies. When considering RTBI, organizational appropriateness must be addressed through the consideration of the organization and related processes as being appropriate for RTBI. The organizational demand or support for real time reporting and processing should be sought before embarking. In addition, demand for in memory BI processing as a way to simplify RTBI should be considered.

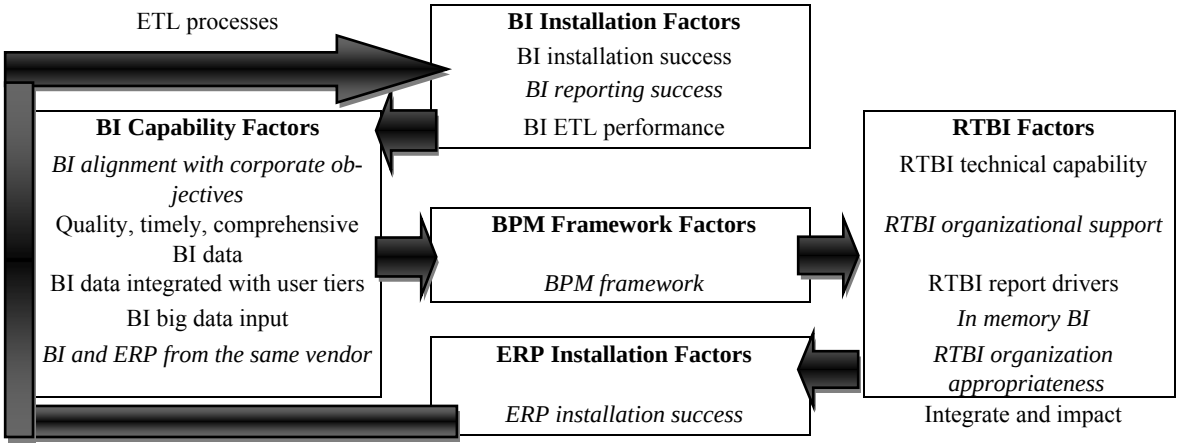

Figure 1: Framework of factors impacting BI ERP integration.

5 CONCLUSIONS

This paper describes factors and conditions enabling BI information to integrate and impact real-time on ERP processing. From a theoretical perspective a process model showing the sequence of factors is presented which includes a successful BI and ERP installation followed by developing relevant BI capabilities and a BPM framework and finally RTBI. Fifteen sub-factors enabling these factors were identified and eight of these were evaluated as critical and hence should be considered and addressed in the organization.

From a practical perspective the factors provided in the framework can assist organizations in better understanding how to get BI and ERP more closely integrated and enable process intelligence to impact real time on ERP processing. A limitation of this research is that only three organisations were found integrating BI into ERP. This is a new area of research that needs more investigation especially the combined impact of unstructured web data and in memory reporting on enterprise information systems and the resultant infrastructure and organizational impacts as well as gaining a deeper understanding of the cost benefit analysis. Design science or action research studies working with practitioners to resolve these challenges is required and as these technologies mature future research could look to validating these factors more broadly.

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