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Understanding the benefits of ontology use for Australian industry: A conceptual study

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Abstract

In IT, rather than philosophy, an ontology makes explicit the meanings of terms used in domains, or concerning a specific reality, so that people and machines can precisely discuss the meaning of data. Specifically, ontology makes data sharing and analysis easier by making the meaning of data, and of the reality to which the database refers, explicit. Ontology has significant uptake in biomedicine but not yet in industry despite much technical development and reporting of specific successes. This research seeks to determine how and why organisations gain benefits from using ontology leading to a rigorously tested model of how business gains benefit from ontology use. This research in progress paper develops a model explaining the benefit of ontology use to firms and outlines our plans to test the model empirically. The outcome is significant for Australian industry because it will guide the efforts of organisations to use ontology effectively.

Keywords

Ontology, business process value of IT, business operating model.

INTRODUCTION

Information and communication technology infrastructure is evolving into collections of loosely coupled systems, provided from both within organisations and via the Internet. Semantic interoperability of processes and greater integration of information sources are key requirements for these systems to function effectively (Orbst, 2003). In order to achieve semantic interoperability is the need to use ontologies as the basis for both human and machine-interpretable semantics.

Ontology is the study of existence and the nature of reality (Honderich, 1995). Ontology is used in ICT because many systems have representations of parts of reality at their core (databases) (Milton, 2007). Ontology is used in ICT in two ways. Firstly, ontology is used to analyse the semantics of modelling tools used in analysing and designing systems (Wand and Weber, 1993 & 2002; Milton and Kazmierczak, 2004). Secondly, ontologies are used to specify the terms, the meaning of terms (semantics) and the relationships with other terms for a specific slice of reality (e.g., order-entry sales business process) or domain (e.g., Accounting) (Guarino, 1998, Smith, 2004). It is the second use that applies in this study. This builds on the first and allows the interoperability of processes by using the meaning of an item in the ontology to interpret and map data and to meaningfully interpret messages (Liu et al., 2008, Höfferer, 2007, Brockmans et al., 2006). This use allows for automated reasoning about the reality represented as facts in databases because the ontology contains the semantics of the relevant parts of reality.

Ontology has been particularly successful in biomedical applications evidenced by the growing acceptance of the Gene Ontology and by the existence of an Open Biomedical Ontology Foundry that is supported by researchers in several disciplines (Smith et al., 2007). Ontology is used in biomedicine to mark up databases of observations so that the sharing of data sets, of both results and methods used, is possible (Smith et al., 2007). Ontology is also used to relate terms used in one discipline to a different discipline (eg. clinicians, public health researchers, and geneticists) and to relevant scientific literature.

Despite growing success in medicine (Bodenreider and Stevens, 2006) and increasing use, there has not been *widespread* adoption of ontology despite perceived need, for example, in the Australian building industry (Aranda-Mena and Wakefield, 2006) and the Australian food industry (Wilkins, 2005), and a growing list of successes evidenced by at least one series of workshops showcasing success of ontology in business called Formal Ontology Meets Industry (see e.g., *Formal Ontology Meets Industry 2009*: <http://www.loa-cnr.it/fomi2009>). We believe this lack of widespread adoption is due to a lack of systematic and rigorous analysis of rich case studies into how businesses use ontology leading to a model for repeating this success. Without this analysis companies will be reluctant to invest in ontologies.

Thus this research aims to understand the benefits of ontology to business processes by systematically studying the use of ontology by Australian companies. The research question for this study is: How does ontology use lead

to business process value in Australian companies? As an initial step to address this question, in this paper, we develop a conceptual model based on the Business Process Value Framework of Mooney et al. (1995) and the Organization's Operating Model of Ross et al. (2006). This model shows that ontology use will lead to value (benefits) for businesses at the business process level. Further, we expect the benefits derived to vary according to the operating model underpinning the business. Specifically, we propose four propositions regarding the levels of benefits expected from the use of ontology when different levels of standardisation and integration of business processes are found. This model will later guide our empirical study involving a multiple case study to rigorously analyse how and why organizations use ontologies and their impact on business processes and at the same time to validate the conceptual model.

The full research study, beyond this model building stage, shows promise to both theory and practice. In terms of theory we expect to contribute a rigorously tested model of how businesses benefit from using ontology. The model is also based on existing information systems theory about business process architecture and about the value of IT for business processes. For practice we will ultimately contribute guidance for managers seeking to use ontology that is based on evidence, and to clearly describe the value of using ontology.

The paper is structured as follows. We begin by considering generally the use of ontology in businesses, particularly in processes. Following this we present the operating model that explains that the use of IT generally is to support business processes in ways that relate to a firm's business architecture. We then describe specific measures of value extracted by using IT at the level of business process. Finally, we describe the model in detail before briefly outlining the empirical stage of the research that will follow and then conclude.

ONTOLOGY USE

Ontology is used to describe the semantics of some specific slice of reality (e.g., my order entry sales business process). This includes naming specific parts of reality and describing how the parts of reality relate. For example, things of interest to the firm, such as customers or suppliers, could be represented in this way. However, business processes themselves could also be described in an ontology. Importantly, an ontology also codifies the relations between portions of reality to allow reasoning. An ontology thus provides a formal (codified) standardised nomenclature and semantics of the slice of reality. This codification is both machine and human readable and allows for matching of data to parts of reality, for integration of data and for reasoning about data. Data could be from existing data sources (e.g., databases), or could relate to participants in a business process (e.g., customer, supplier), or could be measurements of a business process (e.g., time to handle, failure rates). Further, a standardised nomenclature allows for standardisation of all aspects of processes.

There is recognition that ontologies have a role in business processes for integration: "Ontologies allow the integration of the online process knowledge used by eBusiness organizations when they are shared between software agents to allow systems to use a common vocabulary and standard interpretation of the meaning of problem-domain constructs" (Singh and Salam, 2006). The sharing can also be with human actors. This integration may not only be within the organization but also between organizations. Nevertheless, the vision of semantic eBusiness such as this is "an approach to managing knowledge for the coordination of e-business processes through the systematic application of Semantic Web technologies" (Singh et al., 2005).

Business process monitoring and quality assurance more generally also benefits from ontologies (Thomas et al., 2005) with specific uses cited in the literature: e.g., in medical manufacturing (Little, et al., 2008) ontologies are used to analyze problems with the process and seek systemic improvement by analyzing the relationship between outcomes and the materials, personnel, and machinery used in the process. Further, semantic analysis can also benefit business intelligence.

Despite these and many other applications of ontology in business, the systematic study of how firms use ontology for business benefit has yet to be undertaken. This systematic study is needed because achieving specific uses and benefits does not provide the guidance for organizations investing in such an expensive technology. This conceptual study lays the ground-work to rigorously study and understand exactly how organizations are using ontology. We do this by relating ontology use to important theory about how a firm's business processes relate to their overall operating model. This is important because in order for firms to use costly and complex technology such as ontology, we need to understand how the use of the technology relates to overall business and IT strategy. Further, in order to extract full use of ontology we need to explain and understand how ontology use relates to measures of value of IT for business processes. Consequently, the next two sections explain two key bodies of theory for the problem: (1) the operating model of firms (Ross et al., 2006), and (2) how to measure value at the business process level.

OPERATING MODEL

As part of their enterprise architecture, Ross & Weill (2006) have proposed classification of business units according to an operating model. An operating model encapsulates the complexity of cross-organizational analysis and communication. Two dimensions are used to classify the operating model (Ross, et al. 2006) of firms, (1) the level of standardisation of key business processes and (2) the level of integration of key business processes. These two dimensions then produce four categories of operating models: coordinated, diverse, unified and replicated.

Standardisation of key business processes: Companies with a high level of standardisation tend to have similar key business processes across all business units, regardless of who executes the process. The benefits of a high level of integration are efficiency and predictability across the organization. The costs are less chance of local innovation and the cost of adopting a standardised approach. Companies with a low level of standardisation have very few identical key processes and local innovation is encouraged and frequently observed.

Integration of key business processes: The level of integration of key business processes is evidenced by the degree of sharing data across and between key business processes and between all business units. A high level of integration is indicated by a high degree of such sharing. A high level of data integration also requires standardisation on the meaning of the shared data, so that integration is practical and seamless. A organization where key data elements are not standardised, such as customer identification number, typifies a low level of integration, and typically has problems combining data about suppliers and customers. Companies may seek to share data between different business processes (end-to-end) across all business units or across the same business process and business units. Often this is done to develop a single face to customers or suppliers. For example, an organization may share data about a customer's order from the show-room through to the manufacturer and component suppliers.

The operating model of an organization can be determined by combining its perceived levels of standardisation and integration. The resulting classes of operating model are diversification, replication, coordination and unification. *Diversification* has low levels of integration and standardisation, and so business units are allowed to develop without standardised processes or sharing of data between or within processes. *Replication* has low levels of integration but high levels of standardisation, and applies to companies that depend on tightly controlled and replicated processes, but with no need to integrate data between or within processes outside the different parts of the organization. *Coordination* has high levels of integration but low levels of standardisation, where sharing data between and within processes is critical but local diversity in process design is encouraged. *Unification* has high levels of both integration and standardisation.

Ross et al., (2006) provides a methodology for classifying business units according to this operating model, based on their degrees of data standardisation and integration. The degree of integration is observed by examining the extent to which completion of one business unit's transactions depend on data from another business unit being available, accurate, and arriving at a required time. The degree of standardisation is observed by examining how similar business processes are in different locations and the degree to which differences or diversity are encouraged. Ross et al., (2006) go further and suggest that firms move through stages of maturity leading ultimately to a level where modularity allows for a degree of agility than less mature firms achieve.

VALUE OF IT FOR BUSINESS PROCESSES

Business benefit from IT is measured through appropriate value metrics. Most research into the value of IT uses the organization as the unit of analysis and measure benefits at that level (profit, productivity, sales). However, there is growing evidence that the benefits and value of technology are based at the process level (Mooney et al, 1995, Tallon, 2007, Melville, et al., 2004, Keen and Thamworrarong, 2006, Rahim and Kurnia 2006; Melville, et al., 2004; Kurnia and Swatman 1997) and that measurement of benefit is most meaningful at the process unit of analysis through value metrics and enabling mechanisms. This research adopts a process-oriented framework for measuring the value of IT, based on the work of Mooney et al., (1995) and uses this as the basis for the measurement of value in the model developed in the research.

Process-based value is classified into three dimensions based on the effect that IT has on processes, namely automational, informational, and transformational (Mooney et al, 1995). Each class of effects include possible mechanisms and indicative metrics. However, both the mechanisms and metrics "should be chosen by the individual firm in accordance with the specific objectives for which the technology is deployed." (Mooney et al., 1995) Similarly these effects ground our research but do not prescribe it. We expect to be able to generalize based on seeing patterns between the different ways that firms gain benefit from ontology. We discuss each of these in the following paragraphs.

Automational effects are those effects that come from "IT as a capital asset being substituted for labor" (Mooney et al., 1995). The gains include "productivity improvements, labor savings, and cost reductions". Indicative

metrics include Labor costs, Reliability, Throughput, Inventory costs, Efficiency, Administrative expense, Control, Reporting, and Routinization.

We expect that the benefits of ontology to accrue based on labour saving by automating data matching between business units for process integration.

Informational effects are those effects that “emerge primarily from IT’s capacity to collect, store, process, and disseminate information.” Benefit is likely to accrue through “improved decision quality, employee empowerment, decreased use of resources, enhanced organizational effectiveness and better [process] quality.” (Mooney et al., 1995). Indicative metrics include Utilization, Wastage, Operational flexibility, Responsiveness, Operational process quality, Effectiveness, Decision quality, Resource usage, Empowerment, Creativity.

We expect that the benefits of ontology to processes will accrue based on corporate data and information about processes being more easily pooled from across the firm and that this is likely to apply in all quadrants of the operating model. Because of standardisation of nomenclature we expect that data quality will improve. We also expect that ontology, when used to help analyze differences in process quality and performance (eg. Little et al., 2008) will lead to better use of resources and process quality. We also expect that ontology will aid data integration by providing consistently high quality data available about entities engaging in business processes regardless of the source system. We also expect that advanced business intelligence applications would be categorised as informational benefits of ontology use.

Transformational effects are those effects that “support process innovation and transformation” (Mooney et al., 1995). Indicative metrics include Product and service innovation, Cycle times, Customer relationships, Competitive flexibility and capability, Organizational form.

These effects are much more difficult to analyse. Mooney et al., (1995) suggest that these effects emerge after the more fundamental automational and informational effects have been seen and are thus of a higher order. For example, operational processes once automated will lead to second order informational benefits that in turn leads to analysis that transforms the process. We expect that in some cases the analytical power of ontology by being able to reason about process performance in this way will enable such transformations (e.g., Little et al., 2008). We also expect that some applications of business intelligence unlocked by ontology will enable transformations of processes or conceptions of new processes. Further, ability to modularise processes is enhanced by describing it using ontology. This in turn may enable some business modularity discussed as the most mature stage of businesses in Ross et al., (2006). Explaining how such transformations are enabled using ontology will be an exciting outcome of the research.

THE DEVELOPMENT OF A CONCEPTUAL MODEL

There are two major uses of ontology in the context of business processes. Firstly, ontology provides a means for the integration of different information sources (e.g., different databases referring to customer or supplier) required for a business process. Secondly, ontology provides a way for terminology and semantics standardisation by providing a vehicle for an agreed set of terms and semantics. This agreement may be within a company (e.g., the ANZ bank) or it could be across an industry (e.g., the finance industry). Standardisation can regularise the terms used for data needed by a business process (i.e., to help integration), but it may also involve regularising the business process itself (i.e., to help with process quality).

The central role for ontology is in helping integration in organisations. Ontology helps integration by matching terms from different information sources that refer to the same part of reality. Integration like this can help business processes that span different parts of an organisation. Ontology integrates data from many sources (Fensel, 2004) by matching the semantics of the data (Bergamaschi et al., 1999; Noy, 2004). This is particularly useful where data resides in silos or in different IT systems. Further, literature (Fonseca et al., 2002) suggests that ontologies would be useful as an integrating technology between existing legacy systems. Information management trade literature also suggests that data about business processes in organizations could be integrated using ontology (Linthicum, 2004). Ross Weill et al., (2006) have also found that matching data between the silos of legacy and other systems is an important part of IT architectures because “integration links the efforts of organizational units through shared data” (Ross et al., 2006). Shared data are about customers, products, and suppliers. In these cases “integration requires companies to develop standard definitions and formats for data that will be shared across business units or functions” and that getting these “can be difficult, time-consuming decisions.” We expect then, that organizations requiring data integration for processes spanning the organization will use ontology in that role.

Standardisation goes beyond that demanded by integration (above) and includes standardisation of business processes. Process standardisation is becoming increasingly important for some organizations (Davenport, 2005) and is a necessary precondition to the outsourcing of processes (Wüllenweber, 2008). “Standardization of business processes and related systems means defining exactly how a process will be executed regardless of who

is performing the process or where it is completed” (Ross et al., 2006). Where standardisation of business processes is found one expects to see a need to analyse and improve the quality of business processes across the company. Ontology has been used in process analysis (e.g., in medical manufacturing, see Little and Bisantz, 2008 and in the petrochemical industry, see Little et al., 2008) where differences in process quality are traced back to variations in materials, operators, or machinery in processing / manufacture. In such research, accurately describing the process through ontology and tracing data about process performance back to specific participants in the process led to more accurate analysis of failings in the process. Ontology helped in this because it gave a rationale for grouping data with the relevant part or participant in the process prior to data analysis. We expect then, that high standardisation of business processes would require in part a standardised nomenclature of information required for the operation of, and generated by, the standardised processes.

Ross et al., (2006) have found that it is use of a technology in supporting an organization’s operating model that moderates the benefits of using it. Further, the pivotal dimensions that determine the operating model are the degree of standardisation and the degree of integration of its business processes across and between business units resulting in four operating models: Unification, Coordination, Replication, and Diversification. Thus, we expect that an organisation may use ontology for either standardisation alone (Replication) or integration (Coordination) alone and therefore achieve a medium value from ontology (for standardisation or integration). An organisation using ontology for both integration and standardisation (Unification) will achieve a high value from ontology. Organisations in the diversification quadrant will extract a low value from ontology using ontology only for firm level reporting probably around the only standardised processes where external auditing requires compliance (e.g., occupational health and safety, or financial reporting). Summarising, the value is ‘high’ if ontology is used in both process integration, and process standardisation it is ‘medium’ if it is used in either integration or standardisation; it is ‘low’ if it is not used for either. For these uses (i.e., for integration and/or standardisation) we will also see expressions of specific value realised by case study firms in the three categories in Mooney et al., (1995) vis: automational, informational, and transformational.

This leads to four propositions around the research question:

Proposition 1: That ontology use leads to high value (i.e., for integration and standardisation) for business processes in companies with a unification operating model.

Proposition 2: That ontology use leads to medium value (i.e., for integration only) for business processes in companies with a coordination operating model.

Proposition 3: That ontology use leads to medium value (i.e., for standardisation only) for business processes in companies with a replication operating model.

Proposition 4: That ontology use leads to low value for business processes in companies with a diversification operating model.

The propositions encapsulate the ‘big picture’ explanation of how ontology leads to value for firms using ontology. However, the details of the mechanisms by which this is achieved are critical to a deep and generalisable understanding of how business extract value from ontology use including the mechanisms by which ontology use leads to value for business processes. The mechanisms by which the value is realised relate to those outlined in the previous section: automational, informational and transformational value of ontology use.

Beyond this broad measure, the value that ontology provides will be realised via the Mooney et al., (1995) metrics outlined in the previous section. Specifically, ontology will deliver automational, informational, and transformational value in both the integration and standardisation applications and are described in the previous section. The ways in which this is achieved is largely part of the reason for this study. Indeed the mechanisms by which organisations achieve value will lead to much more targeted and reproducible use in organisations generally.

Based on the above discussion, we argue that the Ontology Use will lead to a net benefit or Value for Business Processes (Mooney et al., 1995) in companies, moderated by an organization’s Operating Model (Ross et al., 2006). This is conceptualized in Figure 1.

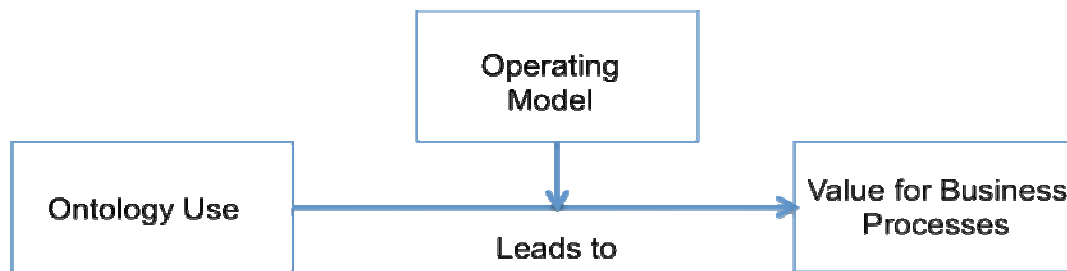


Figure 1: The theory about value of ontology in business processes

Ontology is used to integrate data from disparate sources by providing a means of matching terms and to standardise terminology including semantics. Mooney et al., (1995) have suggested that process-oriented studies of organisations offer the best opportunity to gain meaningful measures of the value of IT for business. The value of IT for business processes can be measured and mechanisms can be described (Mooney et al., 1995).

The next section describes how the empirical stage will support the testing of the model, and the articulation of the details of the model.

NEXT STAGE IN RESEARCH

For the next stage of the study, we will validate the proposed model and explain how Australian companies are realising the value in their business processes. For this purpose, rigorous multiple case studies will be conducted to understand the benefits of ontology use for companies in each of the four quadrants of the operating model proposed by Ross et al., (2006), and how the net benefits are realised (including costs involved). Specifically, eight (8) case studies will be gathered from organizations in the finance industry, two (2) in each quadrant of the operating model and are selected enabling theoretical replication (Yin, 1994). Each case study will examine four business processes that use ontology.

Qualitative data analysis is the most appropriate approach to the collection of this case study data to rigorously test the model by testing the propositions posited earlier. Within-case and between-case analysis is expected to yield further depth into how and why ontologies are used by organizations to benefit business processes by uncovering reasons beyond those postulated. We will use recognised guidelines (Yin, 1994; Lee, 1991) to ensure rigour in the testing of our propositions using case studies. Rigour is embodied in four key criteria: internal validity, construct validity, reliability, and external validity. In the following discussion, techniques from Sarker and Lee (2003) are used to shape the design of this study along these four key criteria.

We will collect and analyse data from each case study site for four (4) business processes (at each case study site) that use ontology (the input variable). Four business processes are for literal replication of the effects on business processes at each site and will enable us to reach saturation (Yin, 1994). The four business processes are embedded cases and are used to help ensure the external validity of each case study (Sarker and Lee, 2003) by increasing the number of processes observed. Construct validity is enhanced at each site by gathering data from many observations of the four focal processes and from a diversity of actors in each process (Sarker and Lee, 2003). We use replication logic in this study (not sampling logic) in that we are testing different instances of the same propositions at each case study site and in each of the four processes at each case study site.

Thus for each process studied we will observe and gather data from the participants in, and managers of, those business processes, (to see how ontology is used in each process and thereby the value of it). We will also examine the documentation about the procedures used to implement those business processes, and the data resources that are part of those business processes (to see how the process integrates with others through data, and the ways in which data are generated and used in each process – including data about the performance of the process itself). In addition, relevant documents including policies and procedural guidelines will be sought, where they are available and have implications for the selection, adoption and use of ontology, and on the standardisation of processes across the organization.

The mechanisms and details of the model will be articulated using the techniques from Miles and Huberman (1994). Specifically, these techniques will be used to analyse the data with the specific outcome of detailing the mechanisms by which value is extracted from using ontology in the processes. The first part of the data analysis using within-case study analysis techniques of tabular dimensionalisation of the data, and graphical derivation of causal relationships in the data. These approaches are particularly useful in uncovering issues and relationships in the data, in finding patterns in gathered data, and in the derivation of interpretations and viable explanations. This stage will also involve identifying ways to use ontology, and the coding of the gathered data in tables structured

around of these uses. These tables include Change Matrix, Effects Matrix: Direct, Meta, and Side Effects and Explanatory Effects Matrix structures, derived from Miles & Huberman (1994). This form of data coding and analysis is well suited to deconstructing and gaining insight into the structure of complex data, largely in the form of natural language. The data will be analysed through the construction of causal diagrams that qualitatively derive the ways to use ontology (ontology use), casual relationships between identified uses, and their relationships to the response (the value.) Graphical visualization and interpretation of tables and directed graphs are considered important components of this research methodology, to allow interpretation of the data that is grounded in the transcripts and documentation that has been gathered in this stage. The outcome of this will be a series of case-based mechanisms detail how value is derived from ontologies for the processes within each of the selected case studies.

The final analysis will involve the construction of cross-case tables, based on the key themes that emerged from the cause and effect tables. Visualisation and interpretation is an important part of this. Qualitative Comparative Analysis techniques (Ragin, 1992) will be applied to the data from multiple cases to analyse commonality in the casual models across the eight cases. Using similar analysis techniques to those in the within-case stage, cross-case analysis will be conducted across all of the gathered cases. This analysis may uncover reasons for gaining benefit to business processes of using ontology beyond those predicted and is therefore important. It also allows us to more deeply investigate the role of the moderator.

CONCLUSIONS AND FUTURE WORK

This research in progress paper introduces a testable model that explains how firms extract value of using ontology in business processes. The model is based on theory that describes the role that IT plays in business architecture, and theory that explains how IT contributes to value for business processes. These theories together with literature describing ontology use contribute to a testable model explaining how and why firms benefit from ontology use. The model allows for a systematic and rigorous test of the value to firms of ontology use that will be tested in the next empirical phase.

The model states that ontology use in business processes will lead to value in assisting integration and standardisation. The use will extend beyond automational and informational use and lead to transformational use (e.g., advanced quality assurance and process improvement). The model also suggests that it depends on how a firm is designed as to whether the firm uses ontology for either or both of (1) integration of processes across business units and (2) standardisation of processes across the firm. The model will be tested in the next (empirical) stage.

The empirical stage of the research proposes to test the model predicting the use of ontology in industry by undertaking rigorous case studies. The outcome will be detailed mechanisms and essential conditions by which benefits are derived from using ontology with business processes. Further, this research will clearly articulate a role for ontology in a company's IT strategy and technical architecture. This will mean that organizations will target the investment in ontologies wisely. This is possible because this research is linked to the Ross et al. (2006) research into enterprise architectures and IT strategy. The model, described in this research in progress paper, is an essential first step in the larger program.

Apart from the specific outcome of the research we expect also to be able to relate ontology use and the maturity of an organisation's use of IT. Specifically, Ross et al., (2006) suggest that once an organisation reaches a degree of modularity in its business processes then hitherto unreachable levels of agility in business processes is enabled. It is likely that use of semantic interoperability, and standardisation of process through ontology (including nomenclature and semantics) will enable quicker re-assembly of process fragments. We may find evidence to support this also.

We expect to make significant contributions to both theory and practice. Both articulate to the different audiences how a maturing technology benefits firms at the process level.

To theory, we expect to contribute because:

- (1) despite the fact that many ontologies have been built, and a growing list of businesses using ontology, and the use of ontology in biomedicine specifically is increasing, the uptake by organizations generally remains low due to unclear and generalised benefits that may be obtained. This research is significant in that it systematically studies how ontology benefits business processes in Australian companies;
- (2) development of a rigorous model of benefits that is dimensionalised according to an established operational framework (Ross et al., 2006) means that findings will be readily integrated into the enterprise architecture strategic planning, maturity model and governance strategy already established by Ross, Weill & Richardson (2006).

In terms of practice the research will contribute by

- (1) providing evidence-based guidance to organizations regarding investment in ontological technology and to ensure that benefits can be obtained, and
- (2) giving clarity in how and why ontology contributes to using information for process improvement.

We also expect to find in the case studies, some evidence of transformational use of ontology for companies that are at the highest level of maturity according Ross et al., (2006). This will particularly be significant for explaining how web technologies can benefit mature firms by allowing them to fully exploit business modularity through technology supporting segments of processes.

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