TRANSFORMING STRATEGY - ANALYTICAL INFORMATION SYSTEMS AND THE RESOLUTION OF STRATEGIC BUSINESS ISSUES – A CASE STUDY

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ABSTRACT

Building on arguments by Nolan (2012) and Ward (2012) about the need for impact studies of strategic information systems and a better understanding of the transformative effects of information systems on strategy, this paper focuses on providing a method to transform strategy in businesses using information systems as the base. This paper demonstrates the impact and value of using an information system to assist a manufacturing company address identified strategic issues of improving the speed of product development and, through getting new products to market more efficiently, improving the company's competitive position in the marketplace. The paper shows the transformative strategic value of applying heuristics to business processes captured in information systems in a manufacturing company. The manufacturing company was losing market share through not being able to get its new products to market quickly enough. As a result, the company was not reaching its intended business targets. The researchers collected the specific business process information and knowledge in the company and developed an information and knowledge management system. A heuristic was then applied to the manufacturing process to determine better models of product development and manufacturing that would enable faster to market product development and thus enable better strategic alignment between company expectations and realisation of market share, transforming the business strategy of the company. The paper demonstrates the value and impact of strategic use of information systems as a means of directly solving business problems through information analysis.

1 Introduction

Ward (2012) argued for impact studies in strategic information systems embedded in practice that also contribute to theory. Following Wilkes (1991), Cavaye and Cragg (1993) and Gable (2010), Buhl et al. (2012) also argue for more boundary spanning in strategic information systems research. Gable (2010) argued that much of strategic information systems is under-researched including the value of Information Systems (IS) in strategy and its impact and the role of IT in product technology, what Nolan (2012) calls product-driven transformation. Wagner et al. (2014) show that alignment affects organizational performance, and drives alignment and ultimately IT business value. Following a call from Peppard et al. (2014) that much of the IS research has failed to report on the real work of IS strategy by examining actual process at a detailed and micro level, this paper focuses on the strategic role that the analytical evaluation of the relationships between repeated and deterministic processes in business can play in both transforming and resolving business problems through the use of information systems in a manufacturing case study context. The paper demonstrates the impact information systems can have in a manufacturing context and highlights an exemplar of product-driven technology transformation using an information system.

Porter (1991, 1993) argues that the fundamental purposes of strategy are to maintain competitiveness through cost efficiencies and to maintain position in the market (Porter 1991, 1993). Product development and transformation are means of gaining business advantage. Customisation in product development is used to differentiate core products to suit different requirements. This can help business gain competitive advantage in the market (Bartlett & Ghoshal 2013; Nicholls & Eady 2008). For an organization to perform well in the product development process, it requires particular expertise from specific groups of people inside and outside the organization, with particular expertise often involving tacit knowledge. Effective manufacturing of customised products has been shown to be not simply a knowledge problem but rather is one of more effective knowledge management (Nicholls & Cargill 2006; Schilke 2014), and of appropriate and targeted analysis of knowledge in systems through the extraction of relevant data that clearly shows processes and points of inefficiency in those processes (Kanjanabootra et al. 2012, 2013)

Traditional strategy theory focuses essentially on transaction cost analysis (Liebeskind 1996; Porter 1991). The underpinning principle here is that investment in innovation creates new knowledge and the risk associated with it is reflected in the return on that investment. However, such theory offers no understanding of what particular strategies are needed to be put in place to assure this return. The knowledge-based theory of the firm was an attempt to do this. This theory builds on the Resource-Based Theory of the Firm (Conner & Prahalad 1996; Wernerfelt 1984), which argued that the basis for competitive advantage results from the extent and application of the resources available to the firm. Connor and Prahald (1996) extended that argument to include knowledge as a key organizational resource. Fundamentally, strategically addressing cost issues can lead to significant benefits for manufacturing product development processes.

Grant (1996) in his development of the specific Knowledge-Based Theory of the Firm, viewed organizations as environments where knowledge from individuals have been integrated through employee's interaction in the organization. In the knowledge-based theory of the firm the organization is not just about reference to knowledge application, but rather also relates to knowledge creation. Grant has reviewed factors such as organizational existence, coordination, structure and boundary, and has analysed how these factors affect competitive advantage and sustainability of the organization. Grant argued that organizations have to utilise the individual knowledge of their employees, not just use what they have but also they have to create an organizational environment where individual knowledge can be integrated and create new knowledge. The goal was to utilize individual's knowledge by improving knowledge sharing and creation within these factors to maintain or increase organizational competitive advantage (Grant 1996). In this study the capture of knowledge, shared or otherwise, was seen as essential by the company executives, to address the business problems identified. The knowledge-based theory of the firm (Grant 1996; Grant & Baden-Fuller 2004; Nickerson & Zenger 2004) argues that having useable knowledge in an organization is the basis for sustainable competitive advantage. Our paper reports a case study that demonstrates that this useable knowledge can be identified through measurement and analysis, particular when it is based on the consistent application of algorithms to organisational knowledge located within the organisation's business information systems.

2 The Case Study Company

The Company involved in this research was a customizing refrigerated display cabinet manufacturer. The company manufactured customized refrigerators in various forms such as food product display units for supermarkets, wine cellars, fresh produce displays, dairy cabinets etc. These customized refrigerators differ between units as each customer has particular requirements. For example one section of any supermarket has to store dairy products which requires one temperature set at a certain point while in another section of the same supermarket there is a need to store meat or frozen seafood products which require another temperature set point. This is an important issue, as some of the products require an accurate temperature set point because the products may lose their quality if the temperature set point cannot be maintained.

Furthermore, their clients' (which are mainly the big supermarket operators in Australia) requirements are very specific. For instance, some supermarket locations have greater numbers of consumers than other locations, therefore, the turnaround rate of their commodities in display cabinets are also high. This means new products at ambient temperature or products just arrived from a delivery have to be added to the cabinet more frequently. Such differences in the company's products then have a direct effect of the needs for different cabinets' cooling capacities. In addition, supermarkets know that customer behaviour is constantly changing and their demand for products to be sold in different ways is increasing. This is a key factor in the deployment of refrigerators as most of the products in supermarkets can be, and often are, displayed in open cabinets. This is necessary because products now must have a good appearance to the customer without visual obstruction and which make it easy for customers to choose products.

The company also has to meet the national standard for refrigerated display cabinets AS 1731: Australian Standard. These standards are changing frequently and in the past two years are being modified again to meet new carbon emission requirements. Therefore the company has to bring these needs and changes into the design and development of new refrigeration products by using their expertise in engineering knowledge to design and manufacture refrigerated display cabinets that meet the needs of supermarket clients, their customers and both new and old manufacturing and environmental standards.

The company indicated that it needed assistance in developing better and more effective processes for product improvement, and that it wanted to improve the time it takes from concept to manufacture to meet the changing demands and individual requirements of their clients. The design of refrigeration systems is not deterministic; it can at best be 'simulated' using gas diffusion and cooling space simulation modelling approaches. The engineers at the company already have access to simulation programs (CFD Software) but in their opinion there are too many assumptions associated with the input parameters and as a consequence, the output results are not sufficiently accurate for their purpose. Observations by the researcher of the engineers' production planning meetings shows that resolving problems is done by trial and error using tacit knowledge and expert knowledge in discussions. Currently the make-span of a new product at the company can be as long as one year. It is critical strategically for this make-span to be reduced to survive in the marketplace. The company needed their strategy transformed. The researchers decided to first build, then mine and analytically use an information system using heuristics to create the transformation needed.

3 Research Methodology

The research reported in this paper involved the iterative design and building of a knowledge specific Information System for the explicit intent of enabling the company involved to address its strategic business problems. The system development framework was created by application of a Design Science research paradigm (Gill & Hevner 2013; Gregor & Hevner 2013; Markus et al. 2002; McKay et al. 2010; Venable et al. 2010). 'The fundamental principle of Design Science research is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact' (Hevner & Chatterjee 2010, p. 5). March and Smith (1995) have suggested that there are two activities in Design Science research: build and evaluate. The research methodology was built on the Design Science principles suggested by Hevner et al. (2004), Vaishnavi et al. (2008) and Arnott and Pervan (2010): a viable artefact had to be developed; the problem had to be relevant; the design had to be evaluated for utility, quality and efficacy; the research had to make a significant contribution and be rigorous, based on an iterative research process, to enable the artefact to be readily understood and able to be used by both technicians and management. This research adopted the Design Science guidelines of Hevner et al. (2004) as the framework for the research process.

The case study Company involved had two identified issues they believed needed to be addressed: improving product development time spans and reducing costs, and improving their relative competitive advantage and position in the marketplace. This study developed initially from uncovering company and engineering perspectives on requirements for the system, operationally and strategically. An IS developer then undertook an iterative process of development through building and evaluation. At stages through this process the engineers and the researchers together built and modified a systems architecture based on a shared understanding of the domain knowledge of refrigeration engineering. Three versions of a Knowledge Management System (KMS) were built using iterative testing, evaluating and then applying outcomes through 6 applications of action research cycles. Each cycle followed the process described by Baskerville and Wood-Harper

(1996). Collecting the data was a research process using that data first to enable system development, secondly through action research, evaluating the models and then using research algorithms to mine the knowledge and information in the system to resolve the business problem identified in the company. The outcome was the provision of research-based systems and research driven set of solutions.

Data was collected using multiple techniques including structured, and sometimes serendipitous interviews, shadowing, observation of meetings, observation of laboratory testing and as well as the embedding of an IS developer into the work of the engineers over a 5 month period (Authors 2013). Data in various forms, from production plans, laboratory testing data, drawings, standards documents and interview transcripts were classified, cross-referenced and stored in the KMS. The engineers involved were integral to the design and development process used in building, changing, adopting, using and re-changing the KMS. In this study, the researchers and the host-organization were working together intentionally to solve particular problems (Hart & Bond 1995). In the evaluation of the knowledge system the six cycles of action research and evaluation were interlinked until the problem was solved.

The iterative process of the research, grounded in Design Science method, is illustrated in Figure 1 below. Design Science requires the production of artefacts. In this case two artefacts were created, the information system and the algorithm for analysis of data in that information system. Design Science also requires an iterative process of interaction between the stakeholders involved and an iterative process of evaluation. Details about that part of the research process are in Authors (2013). This paper focuses on the development and use of the second artefact as a means to enable transformative strategy.

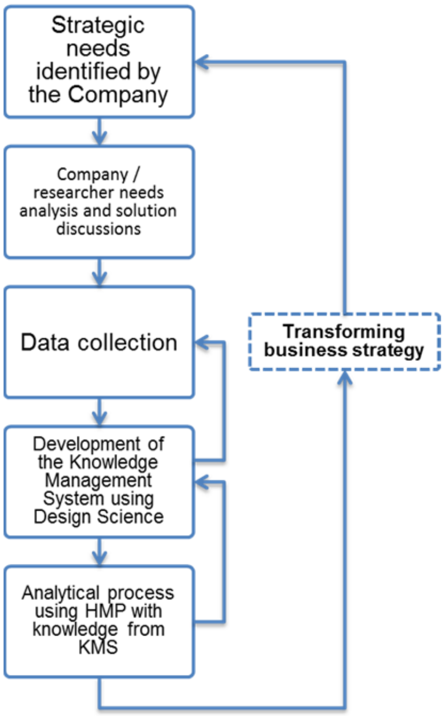

Figure 1 Research process

In this study the initial product was a KMS built on an ontology derived from the expert knowledge of one of the researchers, a mechanical engineer, and a team of engineer end users. Ontologies are rarely, if ever, created or used in business to classify and store created tacit knowledge, and have seldom played that important role (Boh 2007; Milton et al. 2010). Ontology offers a means to classify that interaction and collaboration with the elements of both tacit and explicit knowledge in a codified format. The IS developer used multiple versions of both the ontology and the developing KMS through feedback between the engineers and the IS developer to gain as complete as possible an understanding of the effectiveness of the KMS applied in the engineering workplace. However, such systems alone don't solve strategic issues. The information/knowledge embedded in information or knowledge systems has to be evaluated systematically to modify, change, and measure impacts through analysis. In this study the application of heuristics to the stored knowledge located in the information system, provided the transformative process analysis for the business solution the company needed.

4 Applying Heuristics - Enabling And Transforming Strategy

The idea for the application of heuristic process mining (HPM) in this research was developed from van der Aalst et al. (2003). This algorithm has been used in process mining in various applications (Weijters & Van der Aalst 2003). The intention was to gain understanding of the event in a process perspective which can help the researcher answer the 'How?' question about the process. The algorithm in this research ascertained the causality of sequences and extent of the ordering of tasks in the process. It has been shown that the α-algorithm can reveal what is hidden in workflows and is extensively validated as tool in manufacturing and work process design (van der Aalst & Ton & et al. 2004; Weijters et al. 2003). This research examined the heuristic order of tasks in the workflow nets derived and mapped from the product testing processes used in the Company, stored in the information system developed by the researchers. This was than built on using captured company information stored in various formats and knowledge derived from company employees, plans, documents and business plans (Authors, 2013).

There were assumptions that had to be made about the process in its application in this study. These assumptions were that only complete workflow logs and noise free workflow logs are useable. Complete in this sense means the actual tasks in the log records have been executed and have been recorded correctly without any omissions. Noise free logs were process logs where everything has been registered correctly and contain sufficient information (van der Aalst & Ton & et al. 2004). This approach then examined the heuristic order of tasks in workflow nets. Workflow net is a subset of Petri Net (Pnina et al. 2008; Weijters et al. 2003). The workflow net structure is simpler and requires a smaller set of construction. However, the expressiveness is high and can precisely represent the workflow (van der Aalst & Ton & et al. 2004).

In workflow nets, if task A happens then task B always happens immediately; this is likely to mean that task A has a dependency relationship with task B (Weijters et al. 2003). The α-algorithm focuses on the four kinds of ordering relationships between task A and task B in a workflow log. These relationships can be seen in the workflow log (Weijters et al. 2003). The relationships between tasks in workflow are one or other among these four types:

- $A > B$ If and only if there is a trace line in W (workflow) in which event A and directly followed by event B.
- $A \rightarrow B$ If and only if $A > B$ and not $B > A$ and this relationship is the so-called *dependency relationship* (*B* depends (directly) on *A*).
- $A \# B$ If and only if not $A > B$ and not $B > A$ this relationship is the so-called *non-parallel* relation.
- $A \| B$ If and only if both $A > B$ and $B > A$ is the so-called *parallel relation* (it indicates potential parallelism).

However, noise free and complete logs are difficult to find in reality. Sometimes system operators miss recording one or more steps during the process or mistakenly record some steps more than they actually occurred. Noise and incompleteness in the log can affect the validity of an α-algorithm result. As a result heuristic mining techniques have been developed to be less sensitive to noise and incompleteness (Weijters et al. 2003). However, complete and noise-free workflow is the ideal.

This research adopted the heuristic mining technique from van der Aalst et al. (2004). There are three steps in the heuristic process mining. Firstly, dependency and frequency table construction is undertaken. Secondly, reduction of dependency and frequency graphs occurs and lastly workflow net from D/F graph is generated. This process was applied to the problem of reducing the make-span in the Company product development process.

First step: Generally workflow logs contain information about the process (Schimm 2004). The information mentioned is a set of events (Aubrey 2006; Kwanghoon 2009; van der Aalst & Weijters 2004; Weijters et al. 2003) which occur at the beginning of the process followed by subsequent events and it keeps continuing until the process is finished (van der Aalst et al. 2007; Weijters et al. 2003). The notations in developing the dependency and frequency process are:

i. $\# A$ is the overall frequency of task A

ii. $\# B < A$ is frequency of task A directly preceded by another task B

iii. $\# A > B$ is relationship of task A directly followed by another task B

iv. $\$ A \rightarrow^{L} B$ is a heuristic rule that use to construct local metric that identify the strength of the dependency relation between task A and another task B. Local metric IV can be defined as

$$\$ A \rightarrow^{L} B = \frac{(\# A > B - \# B > A)}{(\# A > B + \# B > A + 1)}$$

The frequency of the order of task A and tasks B has to be counted and recorded, than the algorithm is used to calculate D/F values. This results in a dependency metric between task A and task B. The value of dependency and frequency value (D/F) is between -1 to 1. A value approaching 1 means the relationship between two tasks is very strong and it is plausible that task A is the cause of task B. Frequencies of pairs of tasks have to be identified because the heuristic approach can show how certain the relation is between tasks A and task B (Weijters et al. 2003). The frequency of an occurrence of events can be used as a factor to identify the certainness of phenomena. One example from our case study is shown in Figure 2. Each T value is a specific task defined from the 41 tasks collected and then classified by the researchers from analysis of documents and observation of actual work in the company.

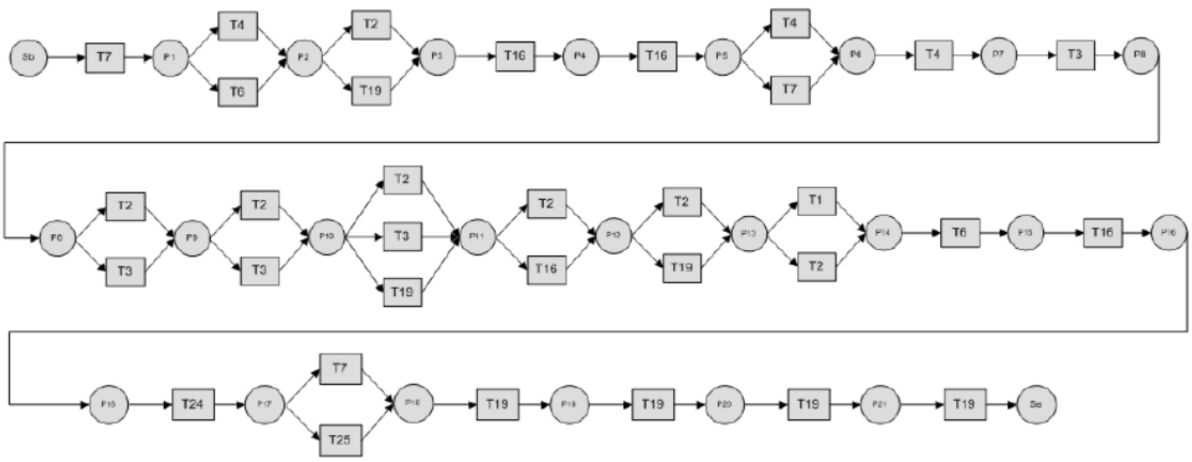

Figure 2 GLR 12 DAC workflow net

Second step: reduction of the dependency and frequency graph. In this step the D/F values are placed in the workflow. The result is a representation of an existing workflow, complete with D/F values between tasks. For the example shown in Figure 2 this analysis is applied to that example and the outcomes are shown in Figure 3.

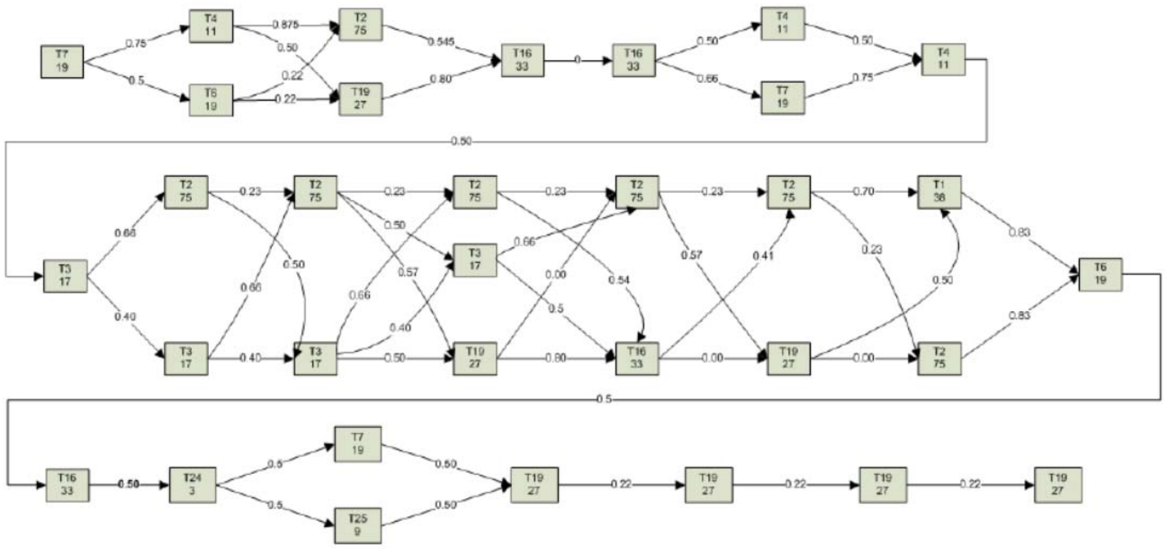

Figure 3 GLR 12 DAC workflow net – modified by application of between task relationships measurements

Third step: New workflow net generation. This is the process of generating the new workflow net in which only high D/F values between tasks are contained. The new workflow net can then reflect simpler processes and be more optimal as shown in Figure 4.

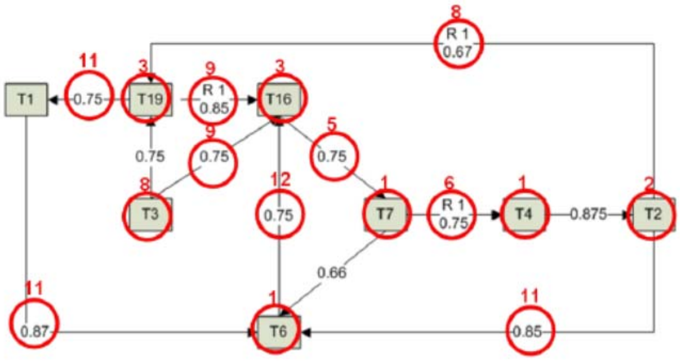

Figure 4 GLR 12 DAC workflow net modified for efficiency

However, statistically one exemplar is insufficient for any valid analysis. As a result the researchers undertook 13 such product business analyses, aggregating the results iteratively until a point of no change was reached. The major result from expanding the amount of cases and instances in the application of the process mining was improvement in both dependency and frequency values for many of the paired relationships. The researchers then used the D/F values for links in each example and built a complex model which reflected all links between tasks of values greater than 0.6. How this was done can be explained in this way: in GLR 12 MTC there is a relationship between T6 to T3 at 0.75; in the inducted form of GLR 12 DAC there is no relationship between T6 and T3. Therefore the researcher added this link to a cumulative model from T6 to T3 and then repeated this process through all links in the model for GLR 12 MTC resulting in the more complex model shown in Figure 5. This model is derived from eliminating all relationships in the business design and build process that are insignificant, keeping only those with values that demonstrate significant value add to the process. This model demonstrates those tasks that alone need to be performed and in what order to make the process more efficient and increase the speed of delivery of new products to market.

As part of the research process, the researchers tested these new relationship propositions with the design engineers involved. Their testing of the outcomes confirmed the applicability of the model the analysis produced.

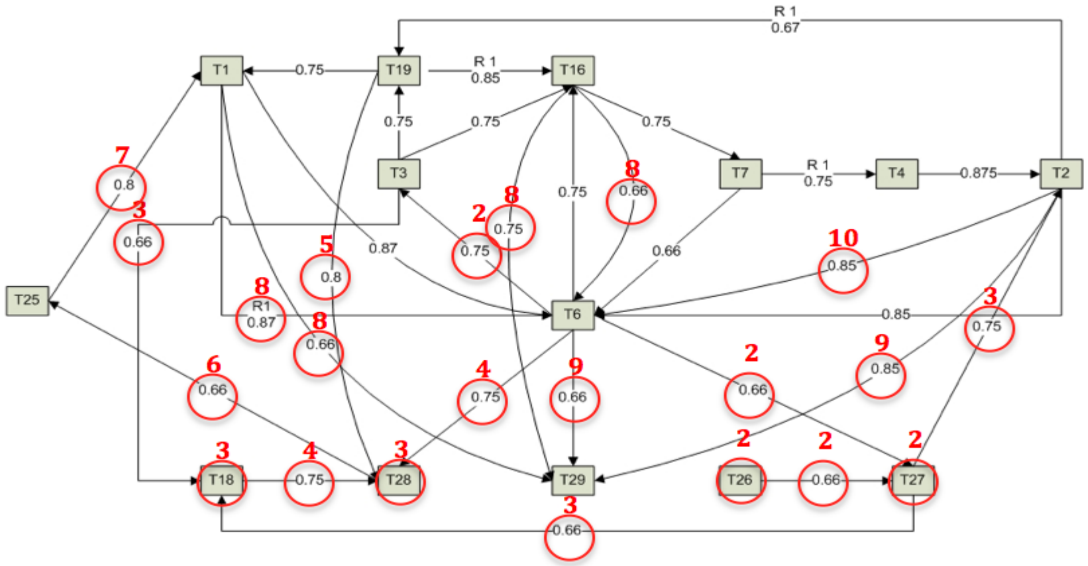

Figure 5 Inducted workflow models of both GLR 12 DAC and GLR 12 MTC.

The analysis of the design and build process for the 13 exemplar products made and sold by the Company across all of its range showed that there were, in total, 41 modification tasks that were performed by the design engineers. Some of the Company workflow instances were procedural. These tasks were static and required to meet required Australian Standards. Most of them have sequences that they have to follow. However, the ordering of the instances is dynamic. These tasks could be executed at any time in the process without sequential restriction. Practically the engineers performed modification task A and then they had 41 modification choices to select from for task B, including repeating task A again. If we considered only one single modification task per procedure the possibility to choose task B and further would be 41! This is equal to process instances and means there were far too many tasks to choose from in the process to modify the design of a new or re-engineered refrigerated cabinet. This did not include multiple modification tasks that often occurred in one day and happened many times during the whole process. The engineers noted that in their practice the maximum number of the multiple modifications per day was five tasks. The number of the process instances was even bigger. However, the engineers argued that they knew by experience that if they did task A, they knew what task B will be. However, they could not describe that. There were a large number of different processes task A and task B that may, or may not, follow each other. This resulted in the testing logs showing that what they had been doing was unsystematic.

The possible solutions to these issues can be found in the models developed in this research, based on the heuristic mining algorithm used. This process defined the dependency relationships between Task A and B in any sequence. The assumption made was that if the value was high, then Task A would cause Task B to be adopted. The higher D/F value meant the more significant the dependency of the modification relationship. On the other hand, if the D/F value between tasks A and B was low, it was plausible that A has got little to do with B. This meant that if the new testing process, based on the modelling undertaken, contained only relatively high D/F values, the engineers did not have to waste their time performing tasks that were not related, or did not contribute any effect to the end product of designing and testing the various cabinets. The new cabinet testing process contained the highest D/F value throughout the process. This can be assumed as the best possible candidate process which reflected the shortest possible design and testing time.

An example of the new possible design/testing process showed that the engineers often started the testing process with task 2: ‘modify cut out temperature’. Data from the collective model derived from the analysis showed that if the engineers started the cabinet design/testing process with T2, the next best task B is T5 because it has the highest D/F value. Then T5 is now task A, and therefore the best next task B is T1 with the highest D/F value together with T5. T1 is now task A and the next task B is T6 with a D/F value 0.87 and this is repeated five times. T6 is now task A and the next task B is either T16 or T18 because they have the same value. For example, if task T16 is selected as the next task in this process, T16 is now task A. Therefore T1 becomes the following modification task. T1 has been done already at the third step of the new testing process meaning the new testing process is now complete. Selecting T18 as task B on the sixth step of the process, T18 now becomes task A and task B becomes T28; T28 is now task A and the next task B becomes T2. Up to this stage the task T2 is now repeated as it has been done in the first step of the process with the new testing process now ended. The best possible solutions derived are shown in Figure 6 below.

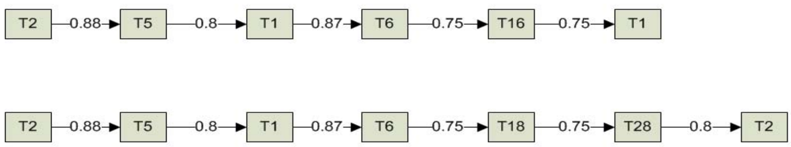

Figure 6 Examples of best possible solutions.

Using this same logic, there are other possible solutions that can be extracted from the D/F matrix, depending on the model being developed and the product purpose of the model. For instance changing the starting step in the process to another task will give different results from the first 2 examples (Figure 6). Such variation is necessary as the start point will vary by model but the dependency relationship should not change so the start point will then determine the following sequence of tasks (Figure 7).

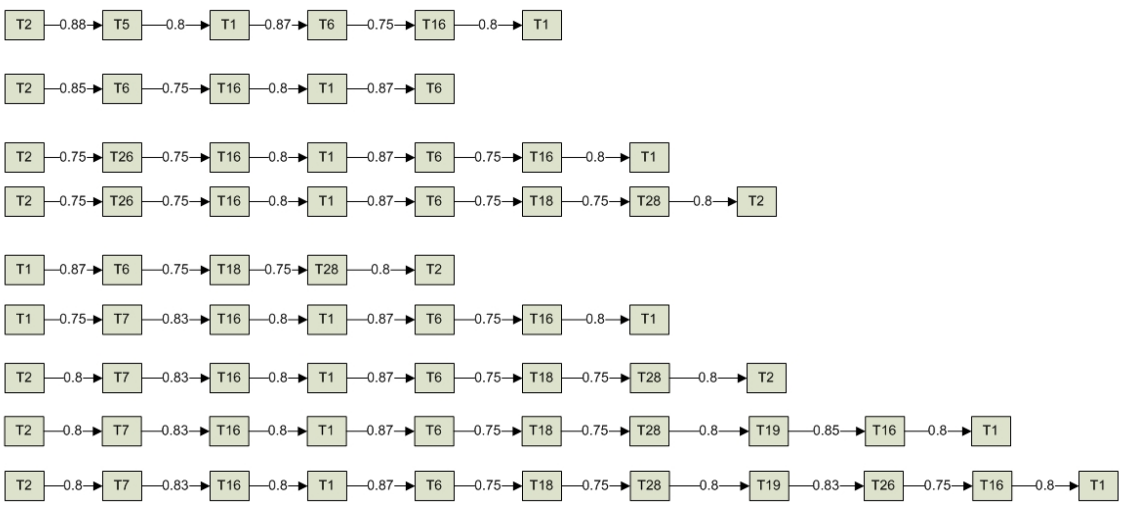

Figure 7 Examples of other possible solutions for new design/testing process.

Our analysis of the Company workflow nets based on application of a heuristic mining process showed the potential solutions available to resolve the Company make-span problem. This could be done by eliminating irrelevant tasks that the engineers perform and transforming their strategy to meet key business objectives and as such improve their positioning in the marketplace. The analysis eliminated 22 out of 41 tasks that had little dependency relationships in the design/testing process. The analysis also showed that the numbers of relevant tasks that could be selected were therefore limited. For example, in the D/F matrix it showed that if the engineers performed T1 they would have only two tasks, which are T6 and T7, to choose from. Another example, T2 had seven relevant tasks B, which were T5, T6, T7, T14, T26, T29 and T35. This helped the engineers to make decisions more easily in their product development meetings. Instead of having the choice of another 41 tasks to perform, the D/F matrix developed here limited the number of tasks for them.

HPM allowed the researchers to identify dependency and frequency values between tasks in the workflows and then eliminate tasks with insignificant dependency and frequency. The application of the results means the engineers would only perform cabinet testing processes that contained relevant tasks. However, the real results of the outcomes of the HPM analysis lay in its utility and applicability in the Company.

Our analysis shows that the Company's make-span process can be reduced through an analysis of the tasks involved by identifying tasks which are redundant, or less significant, to the actual process. The essential data for this analysis required the knowledge deposited and organised in the Company knowledge management system. The analysis identified a knowledge gap which needed to be addressed to resolve the strategy gap.

5 Discussion

Research shows that a targeted analysis of stored information in an information system (Authors, 2013) can be used for modelling make-span reduction and, through a transformative strategy, improve competitiveness. The application of a Heuristic Process Mining technique enabled the Company executives and engineers to see what knowledge was hidden or overlooked in the cabinet design/testing process and transform their work processes. This allowed the executives and engineers to then addressing the strategic issues identified. The analysis verified an early observation of the researchers that the engineers had been doing their job intuitively. The analysis also enabled the engineers and the company executives to gain a real understanding of what was actually going on in the cabinet design/testing process. In particular, the HPM analysis showed that there were irrelevant tasks being performed throughout the design/testing process. Results from the HPM analysis also identified patterns in their work which helped the engineers to make decisions to eliminate irrelevant tasks from the process. Once the irrelevant tasks were eliminated and only relevant tasks were left to be performed by the engineers, the make-span for new products decreased. Interestingly this emerged as an indirect effect of the researcher working with the engineers, iteratively showing them what they were doing and then questioning them as to what their own knowledge processes were showing. In their words, operational effectiveness had increased and enabled the engineers to deliver new products to market in a shorter time (Details of the direct impact of the modelling are in Authors (2011).

This research has confirmed some key issues that Porter (1979, 1991, 1993, 2008) highlighted regarding where competitive advantage can be gained. Porter argues that competitive advantage can be gained by performing similar tasks differently, or faster and more effectively (Porter 1979, 1993, 2008). The HPM technique, applied to the information system, resulted in real change by the engineers. They were, in their opinion, being more effective and were changing how they worked in ways that produced shorter time to market product development. This is akin to Nonaka's knowledge-creation cycle (Nonaka 1994) in that through iterations in the research process in collaboration with the engineers, one side effect was that the engineers understood more. That new knowledge enabled them to better address the strategic needs of the company and get new products to market faster. The iterative cycle of design and re-use of domain knowledge is also another method of organizational learning which is a powerful way of developing innovative thinking in an organization. Learning from previous design concepts and physical components (knowledge utilization) helped the engineers in the Company to produce products quicker and therefore more cost effectively. This led to the Company taking a shorter time to get new products to market, confirming previous research and provides a real example of what Nolan (2012) called product-driven transformation. An information system, developed initially by the researchers Authors (2013), holds the information and knowledge in this example. This enabled the company, through application of HPM by the researchers, to transform their product development business processes and meet their strategic goals of change and improvement.

Again, the knowledge-based theory of the firm concept can be applied. The theory argues that integration of employees' knowledge in the organization through their coordination improves outcomes (Grant 1996; Nickerson et al. 2004). The theory focuses on the employees as the actor in knowledge creation and the principal of repository of knowledge. The knowledge then can be managed and shared. There was a significant amount of organizational knowledge created by the engineering team working together in the Company. However, they had not effectively captured their knowledge. The missing element was a system that can act as an organizational knowledge repository and enable business strategy transformation. The information system as an outcome of this research filled that gap. It integrated employees' knowledge and improved its coordination. The Company, in collaboration with the researchers, applied this knowledge to improve outcomes in terms of design and testing processes to achieve their business goals.

The captured knowledge stored in the information system enabled the engineers to re-use their knowledge during their operation. This information and knowledge re-use helped the engineers acknowledge what they must know. Because the information system built was dynamic and designed for the engineers to enter more knowledge into the system, the expansion of the system meant that the knowledge gap decreased. The engineers knew more about the processes and could use their knowledge better Authors (2013). On the strategy gap side, the application of the Heuristic Process Mining and its' result showed that the existing operations can be improved through using the stored and classified knowledge. The participation of the engineers through the HPM analysis also helped the organization to realize that their cabinet testing process can be improved. Once the

Company knew what they had to do with their product testing process the strategic gap was decreased. In essence the research showed the transformative effects and impacts of the information system on strategic outcomes.

6 Conclusion

This paper shows that a targeted analysis of stored information and knowledge in an organisational information system can be used for transformative strategic purposes through, in this case, manufacturing make-span reduction and improved competitiveness. Confirming the call from Peppard et al. (2014) the research shows that there is considerable value at looking at micro processes in the description and evaluation of strategic solution development. The researchers analysed the collected data and organized both information and knowledge located in the information system to find possible shorter cabinet design/testing processes. The application of a Heuristic Process Mining technique by the researchers enabled the Company executives and engineers to see what knowledge was hidden or overlooked in the cabinet design/testing process. The analysis verified an early observation of the researchers that the engineers had been doing their job intuitively. The analysis enabled the engineers to gain a real understanding of what was actually going on in the cabinet design/testing process. The HPM analysis showed that there were irrelevant tasks being performed throughout the design/testing process. Results from the HPM analysis also identified patterns in their work which helped the engineers make decisions to eliminate irrelevant tasks from the process. Once the irrelevant tasks were eliminated and only relevant tasks were left to be performed by the engineers, the make-span for new products decreased. Interestingly, this emerged as an indirect effect of the researchers working with the engineers, iteratively showing them what they were doing and then questioning them as to what their own knowledge processes were showing. In their words, 'operational effectiveness had increased' and enabled them 'to deliver new products to market in a shorter time'. The result emerged because the required information and knowledge was stored and located in a company information system, and was able to be extracted.

In future work the application of HPM also could be applied to other types of dynamic workflow logs embedded in information systems. Industries often record their work logs, however rarely use what they have recorded strategically. The outcomes of this research provide a useful model that can be applied to other organizational workflow contexts. The previous research in HPM mostly applied this technique to static process, for example, business process, health care and public work. This research has shown that the technique is applicable to dynamic process such as cabinet testing processes. Future research could apply the technique to other dynamic processes. In future research, outcomes from HPM analysis should be quantitatively evaluated when applicable, especially in large-scale operations. Importantly the analytical use of an information system in a business context can, as this case study has shown, assist a business to transform their strategy and meet strategic goals.

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