VALUEPOLE,
AN EX-ANTE PREDICTIVE REVENUE PERFORMANCE TOOL FOR NPD IN SMES

Corresponding Author:
Ann Sheahan,
ManOPT Systems Ltd., InnovationWorks, National Technology Park, Limerick. Ireland
Ann.Sheahan@ManOPT.com
Telephone: +353 61 503104

Ann Ledwith,
Dept. Manufacturing & Operations Engineering, College of Science & Engineering,
University of Limerick, Limerick, Ireland.
Ann.Ledwith@ul.ie

Con Sheahan,
Dept. Manufacturing & Operations Engineering, College of Science & Engineering,
University of Limerick, Limerick, Ireland.
Con.Sheahan@ul.ie

Abstract

Decision makers within SMEs face many competitive threats but also have a range of development opportunities available to them to advance the competitive position of their firm. These opportunities typically include development of new products and/or the improvement of their process performance. However it is very difficult to decide, ex-ante i.e. before-the-event, to which combination of new product development and/or improvement opportunities the SME should devote resources for the firm to maximise its economic performance. This is of strategic importance, given the limited resources available to SMEs. The ValuePOLE project addresses this challenge. ValuePOLE, a collaborative research project between academics and SME practitioners, is funded under the EU's Seventh Framework Programme, Research for the Benefit of SMEs. Its objective is to deliver a Model, an ICT Tool and a Methodology to answer this challenge for the SME decision maker so that they can maximise their competitive position with the minimum investment of resources. This paper describes the project as well as the results to date at the four SME case study firms.

Background

Competitive advantage and sustainability for European manufacturers require that they are competitive in many domains [Manufuture, 2006]. Traditionally a manufacturer would be competitive if they produced a product that met the quality, cost and delivery requirements of the market. Today and in the next decades, European industry in general, and SME firms in particular, are presented with many seemingly conflicting performance objectives:

1. improve efficiency in the entire value chain in order to meet 'better, cheaper, faster' competitive objectives,
2. meet 'greener, safer, securer' EU socio-technical policy objectives,
3. while simultaneously juggling strategies for incremental and breakthrough innovation in product and process development.

In order to thrive in the '*new real economy'* Small and Medium Sized Enterprises (SMEs) face two performance objectives; they need to be efficient ***and*** innovative to participate in the new knowledge based economy. [Factories of the Future, 2009]. There are very few economies that can compete on both manufacturing efficiencies and radical innovations. Japanese industry has developed highly lean efficient production systems but their innovation strategies are mainly based on continual modification and upgrading of existing components and products. Lam [2004] reports that Japan does not excel in sectors which require more than incremental upgrading of system components (e.g. aerospace; supercomputers) and or those in which fast-paced radical innovation are crucial for success (e.g. pharmaceuticals and biotechnology)". On the other-hand, Silicon Valley, Route 128 and other clusters in the US economy, are recognised for rapid innovation and commercialisation in fast growing technological fields such as microelectronics, semiconductors, computer networking and more recently biotechnology. Such firms however lag in operational efficiencies. While China, India, and Taiwan have become the 'factory of the world'; they have yet to attract significant manufacturing of knowledge based goods. This is primarily attributed to policies which require multinational companies to form joint ventures with indigenous firms [Pereira, 2004].

To address this problem the ValuePOLE project, funded under the EU's Seventh Framework Programme, is proposing a new model and methodology so that European SMEs can be both operationally efficient and innovative to maximise value in the entire lifecycle of products and processes in the extended value-chain.

Problem for the SMEs

An SME is fundamentally different from a large firm in both make-up and management philosophies [Randoy and Goel, 2003]. It is often dependant on a single decision maker for tactical and strategic decision making; typically an owner/manager [Feltham, 2005]. SMEs have limited resources, both financial and human capital [Hudson et al., 2001] [Garengo et al., 2005]. At an operational level, the SME needs to know how to mobilise their resources to deliver the best outcome for the firm [Sheahan and Sheahan, 2006]. At a tactical level, they need to know before they invest these limited resources in either new product development (NPD) or process improvement projects (PIP) what the likely impact will be on their enterprise. A key concern of SMEs is that they could commit resources to a new product or project at the expense of a better opportunity. Unlike larger enterprises, who often have a wider portfolio of new product

development projects, SMEs will have a limited number of projects / new product opportunities as well as limited resources. The enterprise consequence of the decision for an SME is therefore greater.

Project Selection for NPD and PIP

When SME decision makers review their NPD or PIP options, they currently rely on their own empirical knowledge and judgement about the impact that these projects could have on the strategic and operational performance objectives of the enterprise. Indeed, Allinson, Chell and Hayes (2000) report that owner-managers are more intuitive in their cognitive style than the general population of managers. However, research by Cooper (2001) has shown that the most successful approach for project portfolio selection, among large firms, is to select projects using a formalised hybrid selection model including financial, risk and project ranking factors. He found that firms that used formalised project selection techniques incorporating risk analysis as well as financial analysis were more successful. Relatively little research has been completed to test this approach in small firms. In one case, Lawson et al (2006) have built and tested a hybrid project selection method based on their prior research at Cranfield University. The hybrid model contains a filter step whereby the user scores the new project risk on six criteria (technical risk, corporate and strategic fit, regulatory risk, market risk, financial risk and application risk). A Cost Benefit Analysis (CBA) is then applied to the new project. The model was tested at a small UK aerospace engineering firm by applying it to a research programme previously undertaken by the SME. Management at the case study firm concluded that the risk analysis tool would not be used because their normal selection considerations were included in the tool without the cost of maintaining the tool. They did however see a benefit in linking cash flow to individual projects. Management wanted to see a tool whereby they could 'easily predict the cash flow consequences of a project running late over the initially estimated time schedule and budget'. The research is limited in that their model is designed to assess one project on its own and does not establish the best portfolio mix of projects. The research does confirm the need for a hybrid model for new product project selection using predictive financial measures.

The Lean Six Sigma methodology, and variants thereof which use scientific methods for problem solving, are the most widely used methods for gaining efficiencies in manufacturing processes. While many benefits are to be gained, Dinesh Kumar et al (2007) report on a survey among major aerospace companies where fewer than fifty percent of companies have been satisfied with the results from six-sigma projects. They conclude that 'wrong project selection' is the main reason for failure. Furthermore, they recommend a measurement system to measure the impact of the project on the financial performance of the firm. Similarly, Banuelas et al (2006) have concluded, following an extensive literature review, that project selection and prioritisation is a critical success factor for achieving benefits from improvement projects. Furthermore, since the projects compete for scarce resources, they should be closely tied to business goals. Similar to NPD project selection, they recommend, from a national survey in the UK, a hybrid model of top-down and bottom-up method for improvement project selection.

Performance Management in SMEs

The value of having an effective performance management process, focused around effective Key Performance Indicators (KPIs) has long been proven [Kennerely and Neely, 2003]. In general, it is accepted that in order to improve the performance of a firm it has to be measured.

Large firms adapt performance management systems such as the Performance Prism [Neely and Adams, 2001] and the Balanced Scorecard [Kaplan and Norton 1992]. While these tools are appropriate for larger enterprises, there is sufficient literature to suggest that the SME sector has been slow to adopt performance management systems [Wilson and Sheahan, 2006].

A performance management process that reviews the status of KPIs and then looks at ways to drive improvement towards a pre-defined target is an *ex-post* (i.e. after the event) system. While the targets for achievement are placed at some point of time in the future, the improvement initiatives based on actual (or past) performance are always going to be reactionary at best [Melnyk, Stewart, Swink, 2004]. This is a serious limitation of existing performance management theory and practice [Carlsson, Turban, 2002]. The challenge on business performance in a very competitive market place demands a future looking perspective to the business [Shapiro, 2004]. Success in the future often depends on decisions made today with incomplete information. Management within firms need a view of what the expected performance outcomes of their decisions are likely to be as well as diagnostic support in how to meet performance goals. Wouters and Verdaasdonk (2002) have examined how operation managers can use accounting information to examine the economic consequences of operational decisions on the firm before they make the decision. They thus define *ex-ante* (i.e. before the event) accounting information as information about the expected financial impact of a decision alternative on one or more financial criteria (e.g. net present value, profit).

Wouters and Verdaasdonk (2002) have described various cases where the team used simulation modelling at the case study firm. They reported that in general it was a complex task to gather the knowledge related to the decision from various people working in various functions at various hierarchal levels. They report that it 'usually took a lot of time to try to bring together such knowledge in one model of the decision'. This would be true for simulation modelling in general. Simulation modelling has been applied in the past in large production manufacturing operations to give decision makers a forward looking perspective on the potential impact of their decisions. Simulation has however been of limited use in small firms due to several factors. Modelling of the problem is an expensive and time consuming process that often requires skilled people knowledgeable in both the operations of the system as well as modelling and simulation techniques and software. The construction of the model is often a complex. The analysis of the data produced by a model can also be difficult and can require additional skills such as competency in statistical analysis. Simulation is thus not viable for most SMEs.

Wouters and Verdassdonk have demonstrated that *ex-ante* accounting information is useful in three different operational management decision situations, which are similar to decisions in new product development and process improvement projects. They are (1) when a decision is new or seldom taken, (2) when the decision is familiar but new considerations must be taken into account and (3) when knowledge about the various consequences is dispersed across different people or functions.

In the ValuePOLE project, we extend the concept of ex ante accounting information to ex-ante prediction performance for a suite of Key Performance Indicators. We also overcome the problems described above for simulation, by building one enterprise model for the firm that can be used to model decision scenarios for multiple problems for multiple KPIs.

Measuring New Product Development

The importance of measuring new product success is also widely recognised, yet it remains elusive particularly to SMEs. Huang et al [2003] suggest that the reasons are due to the multidimensional nature of success; the different levels of analysis that can be examined, and the multiple stakeholders who look for different things in the NPD process. The time lag between cause and effect is also a factor to be considered. This is particularly important for longer new product development cycles.

In a recent study of 106 small Irish firms, Ledwith and O'Dwyer [2009] examined the relationships among market orientation, new product performance, and organisational performance. They found that of three market orientation dimensions examined, only one, competitor orientation, was found to have a significant impact on new product performance. Additionally, of the five measures of new product performance only two, market-level and financial performance, were linked to organisational performance. One of the key recommendations from the study is that small firms need to put more effort into measuring the financial performance of their new products, for example, development costs, contribution, profitability, and return on investment (ROI) or internal rate of return (IRR).

We can make a number of conclusions from the literature.

i. Project selection is fundamental to the successful delivery of new products and performance improvement projects in small firms.
ii. The project selection model should be a hybrid model of financial and non-financial measures. Market level measures are also important.
iii. The model should promote data driven decision making within the small firm while also leveraging the intuitive decision making capability of typical owner managers in small firms.
iv. Performance management should drive decision making at different levels within the firm, meeting the needs of all the stakeholders.
v. The model should facilitate the decision maker in understanding the performance consequences for the firm before the decision is committed, i.e. provide for ex-ante performance prediction.
vi. The model should facilitate project portfolio selection.

ValuePOLE Project Objectives

In the remainder of this paper we discuss the design, development and implementation of a data driven project portfolio selection model using ex-ante performance prediction, ValuePOLE , which addresses the gaps identified in the above literature. The primary objective of the ValuePOLE consortium is to develop and implement an ICT tool, with a supporting model and methodology, which will prioritise the best value improvement opportunities for SMEs from a portfolio of potential new products or process improvements. This will enable the decision maker to rapidly identify the risk/reward position of any project or combination of projects vis-à-vis a suite of pre-defined key performance indicators.

The ValuePOLE project is a joint industry and academic collaborative research project funded under the EU's Seventh Framework Programme (FP7): Capacities Theme Research for the benefit of SMEs, FP7-SME-2007-1. A key feature of this EU research programme is that the requirements of SMEs in the consortium drive the research objectives of the research partners.

The ValuePOLE consortium (Annex 1) consists of three academic partners from three countries as well as five SMEs from three EU countries (Ireland, UK and Denmark). The SMEs include a software development company as well as four engineer-to-order and design-to-order manufacturing companies. The engineer-to-order and design-to-order small firms operate within Business-to-Business (B2B) value chains.

Research and Development Methodology

The traditional waterfall paradigm for software development, first proposed by Royce 1970, proposes that the stages of the software development process are performed in sequence: requirements gathering, specification, design, coding, and testing. This method has a number of drawbacks. In particular, it assumes that requirements are known at the start of the project and that there are no changes done during the project execution. This method is not suitable for cases where a higher level of end user involvement is needed. Instead, an iterative development model, [Basili 2005] was used in ValuePOLE. In an iterative process, software is developed, implemented, and delivered to the customer in phases, where the functionality of a new piece of software is usually an increment to the functionality of the previous delivery. This avoids the 'big bang' approach and facilitates change management at the small firm.

Based on user requirements, the first iteration of ValuePOLE focused on:

1. One financial KPI, Sales Revenue On-Time-in-Full (OTIF), and
2. Improving both the short-term operational decision making within the firm, and medium term selection and deployment of operational performance improvement projects, to improve the KPI.

Predicted Sales Revenue OTIF is a new performance indicator developed within the project. It measures the sales revenue that will ship on time in full to the customer. It is a hybrid metric which includes both financial and market level metrics. Financially, cash flow has always been critical to the viability of small firms. In the current economic crisis access to working capital is a key concern for small firms across Europe. Small firms need to prioritise their limited resources on sales orders, NPD projects and PIPs with the highest added value to the firm. ValuePOLE, as discussed later, facilitates the decision maker to prioritise highest added value activities within the firm. Small firms also need to focus on market level metrics to ensure the longer term sustainability of the firm. Supplying customers with products that they want, when they want them and at a price they are willing to pay is fundamental to any business. It is particularly important for small firms, such as the engineer-to-order and design-to-order firms within the project, which produce high value products and compete on delivery times to market. The 'OTIF' portion of the metric focuses on shipping customer orders to the customer on time and in full. The 'on time' data is the delivery date that the customer wants and that has been agreed to; not earlier, not later but on the day. The 'in full' data is the full order quantity; not short on either quantity or features.

Thus far, the ValuePOLE consortium has succeeded in developing a prototype tool that models and optimises SMEs' value streams required for the definition and efficient fulfilment of market demand. The tool generates predictive performance reports for future Sales Revenue, OTIF. We discuss the tool in the next section of this paper.

Prototype Development to-date

The ValuePOLE tool consists of three modules: an enterprise modeller, an optimiser and a performance manager as shown below in Figure 1.

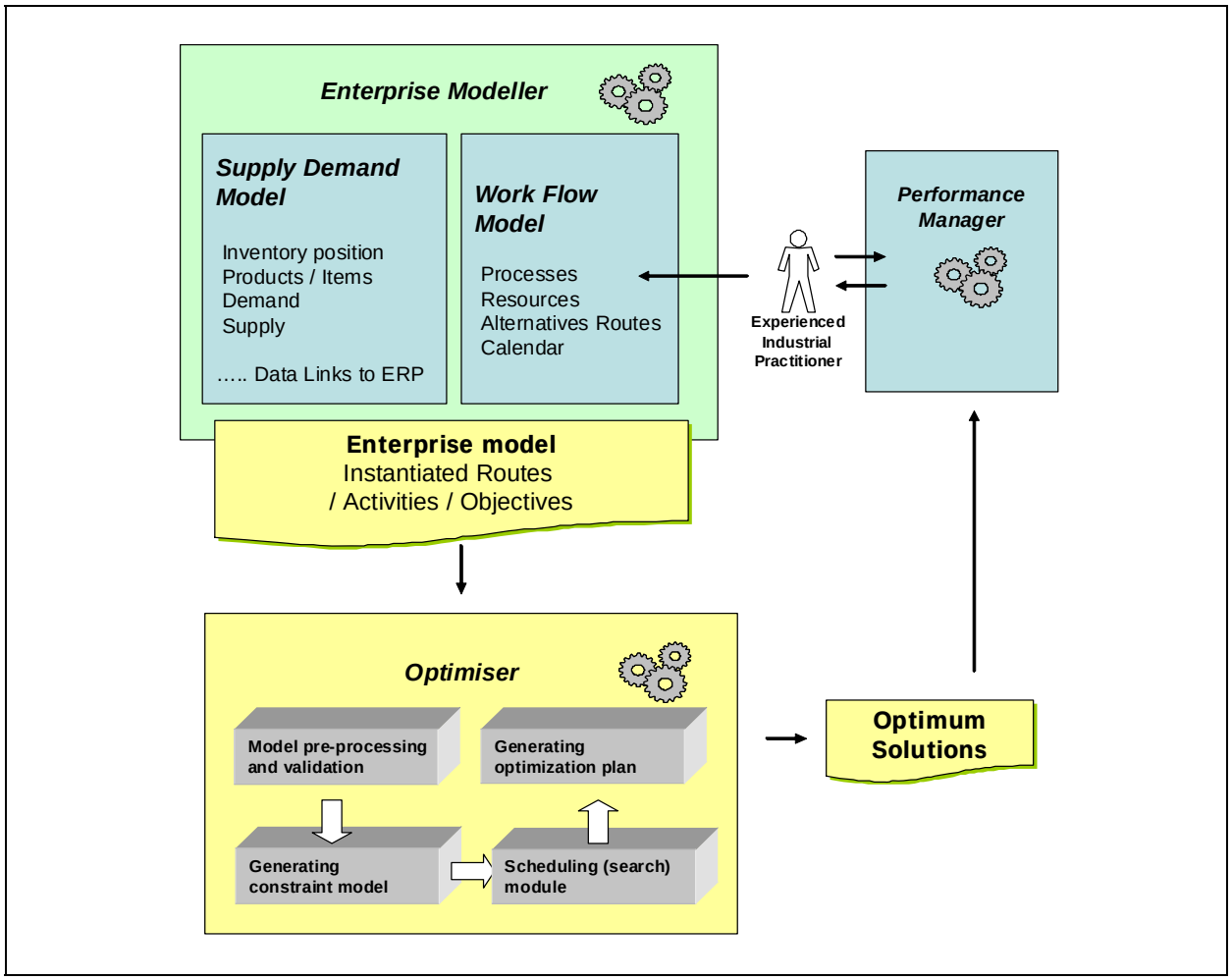

Figure 1: ValuePOLE Modules

(1) The end user interacts with the **Enterprise Modeller Module** to tell the system the, who, what, when, where and how their products are made i.e. describe's the entities in the organisation at enterprise level relevant to the main KPI. To make this task easier we've implemented a workflow editor. This tool allows the user to denote the states in a process flow and define the relationships between them. Alternative routes are catered for using split and join constructs – (also referred to as branch and merge). The data for the Supply-Demand Position is extracted real-time from the ERP system and / or databases such as spreadsheets.

A key feature of the modeller is that it is intuitive to use. Decision makers in small firms would not usually have the modelling expertise required to run advanced simulation-like tools. Using the ValuePOLE tool, decision makers can model their firm, trying out multiple 'what-if' scenarios before committing to a decision.

(2) Using this information the **optimiser** make's informed choices on how best to make the product to meet the constraints of the firm and the customer demand. The **Optimisation Module** then plans multiple resources using the KPI as the objective function. The advantage of using a hybrid metric such as Sales Revenue OTIF is that it provides a common language for both the decision maker and the mathematical optimisation functions. The optimisation algoithms developed for the ValuePOLE tool optimise multiple resources versus multiple KPIs.

A key feature of the optimiser is the speed of the solution. The optimiser can produce solutions in near to real-time (minutes) for a typical engineer-to-order small firm. This is imperative if the decision maker is to interact with the tool, using his/her intuitive capability to generate alternate scenarios / models.

(3) The **Performance Manager Module** shows the decision maker what is the best possible outcome for the firm given the inputs from the Enterprise Modeller. For example, it will show the decision maker the predicted Sales Revenue that will ship on-time-in-full in any given time period (e.g week) over any time horizon (e.g. quarter, year). This ex-ante prediction of Sales Revenue OTIF is based on optimisation algorithms for the current order books, (actual and forecasts), as well as the state of all resources within the firm. The decision maker is presented with diagnostic screens to rapidly identify which resources, entities and processes within the firm are constraining the firm from achieving Sales Revenue OTIF within the future planning horizon. This allows the decision maker to make improved decisions, typically on the allocation of resources, today that will affect future Sales Revenue OTIF. The decision maker is also given diagnostics of where the opportunities for improvement lie within the firm for organisational performance improvement. This allows the decision maker to prioritise improvement projects that will directly affect the KPI. The decision maker can also make decisions on new products based on the affect that the project will have on the Sales Revenue position of the firm given all the existing commitments of the firm.

A key feature of the performance manager is in the visualisation of the solution. The performance management tool has multiple 'drill down' features so that the decision maker can view the performance of each entity in the model and how it affects the overall performance of the firm.

Case Study Results To-Date

The prototype tool has been deployed and tested to various degrees at four small case study firms in the engineer-to-order / design-to-order firms in Ireland, the UK and Denmark. Each of the firms is a market leader in their respective countries and either export at present or are exploring export markets.

SME #1 is a specialist manufacturer of hydraulic cylinders for Original Equipment Manufacturers. SME #1 is a family owned company, based in Ireland and exports over 80% of all sales, with the German market accounting for 50% of these exports. SME #1 primarily concentrates on the construction and quarry Original Equipment Manufacturer, but also produces

for agricultural, automotive, construction and industrial OEM's. They have a policy of delivering directly to customers in all European countries on a 'Just in Time' basis. Prototype manufacture is seen as an opportunity rather than a problem.

SME #2 are a wood technology company based in rural Ireland. They manufacture kitchen and wardrobe cabinet doors and panels. They manufacture all products from MDF melamine or veneer board. They offer a complete range of standard and off-standard sizes available in all finishes. They supply both end users and distributors; typical customers are cabinetmakers & DIY stores, primarily in Ireland and the UK.

SME #3, based in the UK, design and manufacture high quality wooden products for the Playgroup, Nursery, Education and Retail Markets. Their range includes Play and Learn, Role-play, Pretend, Storage and Activity Equipment, Nursery Cots and Furniture and Children's Wooden Toys. The current business is centred on products for the Early Years Play and Learn education and nursery market, for up to 8 year olds. However, their broad experience and design and manufacturing techniques mean that they can diversify into other markets and areas of business that require the medium of wood and wood based boards - such as shop fitters display units, gifts, household and nursery furniture, garden furniture etc.

SME #4, based in Denmark, has almost 150 years of experience with the manufacture of wood-burning stoves and has always been at the forefront of developing new stove types. They offer significant variation to their customers in terms of design, size, stove type and output. They have a long tradition of product innovation. It was at SME #4 that the original cast-iron stove was created. Since then, they have become one of the world's leading suppliers of cast-iron wood-burning stoves and today exports stoves to all parts of the world, irrespective of the climate – from northern Scandinavia to South Africa, from the USA and Canada to Australia and Japan. Their stoves are used in over 25 countries.

The results to-date, both empirical and quantitative are given in Table 1. Overall, the most critical organisational performance improvement in ValuePOLE has been in the time based competitive capability of the end user SMEs. At the end of this project the SMEs using the tool have achieved the following performance outcomes:

1 Sales Revenue OTIF delivery performance (to the original order promise date) increased to over 95% from the previous estimated level of 40%. On-time-delivery is important for most manufacturing companies, it is critical in Engineer-to-Order and Design-to-Order firms. Such firms can compete, even in high wage economies, based on competitive delivery performance. It is important in measuring OTIF to use the first agreed order promise date with the customer i.e. the original order promise date. Many software tools do not have the facility to record changes made to the order promise date and will apply the last order promise date.

2 Sales Order Lead-time reductions of greater than 30%

3 Reduce planning time by greater than 60% and planning effort by greater than 50%.

SME #1 (Full Deployment)

- **reduced their sales order lead-time from a range to 2-16 weeks to an average of 4 weeks**
- **improved their on-time-in-full shipments from a range of 40-90% to an average of 85%**
- **reduced planning time from 2 days a week (with hours for replanning when perturbations occurred) to 0.5 days per week with updates possible in 5 minutes.**
- **Their planning effort was reduced from 3 people to 2 people freeing up the Purchasing Manager from routine planning tasks.**

SME #2 (Near Full Deployment)

- **reduced their sales order lead-time from 4 days to 3 days (while at the same time doubling their production volume).**
- **maintained their on-time-in-full shipments from a range of 95% to an average of 96%**
- **reduced planning time from 4 days a week continuous planning to 1 day per week with updates possible in 15 minutes. Their planning effort was reduced by 25% for both the operations and production manager.**

SME #3 (In the set-up phase, Full Deployment Planned)

- **Improved operator utilization via improved planning techniques.**
- **Additional training was provided in parallel to the project to create a more flexible work force to enable better departmental balancing.**
- **Jobs that could not be completed due to material shortages would not be started reducing WIP.**
- **The sales department has a much clearer view of what could be manufactured and when.**
- **Tracking of specific orders becomes much simpler through a manual tracking process.**
- **Team leaders roles are changed from reactive to proactive.**
- **Methods of tracking and agreeing change have been formalised and therefore become standard practice.**

SME #4, Contributed to Requirements Engineering and Evaluation of Demonstrations.

Table 1: Performance Impact on SMEs to-date

Summary and Conclusions

In order to thrive in the 'new real economy', SMEs face a number of performance challenges. They need to be effective in their operations as well as innovative in their new product and process development. However, resources are scarce in small firms. They need to know the potential impact of NPD or PIP decisions on their organisational performance before they firm commit limited resources to the project. Cooper (2001) has shown that large firms that use project portfolio selection techniques, based on hybrid financial performance and risk assessment criteria, are more successful at NPD. SMEs however rely on their intuition or empirical experience to select new product or improvement projects. Lawson et al (2006) have identified a need for hybrid approach in the selection of new product projects. 'Wrong project selection' is also found to be a reason for failure of Lean Six Sigma to deliver performance objectives Kumar (2007).

The SME sector has been slow to adopt performance management systems [Wilson and Sheahan 2006]. Performance management systems report performance after an activity, or set of activities, has been completed. They are said to be ex-post. Wouters and Verdaasdonk have proposed how operations managers can use ex-ante accounting information to examine the economic consequences of operational decisions before the decision alternate is chosen. They thus define *ex-ante* (i.e. before the event) accounting information as information about the expected financial impact of a decision alternative on one or more financial criteria (e.g. net present value, profit). Simulation technology is one method of prediction, it is however of limited use to small firms. The modelling effort is considerable and requires simulation expertise.

Measuring new product success has also remained elusive, particularly to SMEs, [Huang, 2003]. Ledwith and O'Dwyer have proposed that small firms put more effort into measuring the financial performance of their new products, as well as market level measures, as these two measures were found to correlate well with overall organisational performance.

We extended the concept of ex ante accounting information to ex-ante prediction of a suite of KPIs in the ValuePOLE project. Based on user requirements, the first iteration of ValuePOLE focused initially on one KPI, Sales Revenue On-Time-in-Full (OTIF). It is a hybrid metric which includes a financial metric (sales revenue) as well as a market level measure (on-time-in-full delivery performance to the customer). The focus to-date in the project has been on the improving both the short-term operational decision making within the firm, and the medium term selection and deployment of operational performance improvement projects. We also overcome the problems with simulation, by building one enterprise model for the firm that can be used to model decision scenarios for multiple problems for multiple KPIs.

The prototype tool has been deployed and tested at four small case study firms in the engineer-to-order / design-to-order firms in Ireland, the UK and Denmark. Each of the firms is a market leader in their respective countries and either export at present or are exploring export markets. They have achieved significant performance improvements in their Sales Revenue OTIF delivery performance.

We can conclude from the prototypes deployments to-date that small firms will use, and benefit from, data driven data decision tools that compliment their intuitive capability. We also conclude that performance management is of benefit to small firms where it can be applied ex-ante to compliment decision making capabilities.

Future Work

In order to thrive in the '*new real economy'* Small and Medium Sized Enterprises (SMEs) face two performance objectives; they need to be efficient ***and*** innovative to participate in the new knowledge based economy. The work completed to date has focused on decision-making for efficient, effective and sustainable manufacturing process. We have focused on one KPI, Sales Revenue OTIF. We have also focused on incremental innovations on the current configurations of products and processes. Future work, within the ValuePOLE project, will focus on the extension of the predictive performance concept to a suite of KPIs.

We will now focus on extending the model to include decisions related to the innovation of new products, processes and supply-chains. A conceptual framework has been developed based on our existing work, see Figure 2. In order to predict the potential impact of a new product on the performance of the firm, we need to model potential market demand. We are currently developing a diagnostics method to establish if the accumulated demand for new products can be based on the past performance of similar products. With this diagnostics tool in hand it is now possible to diagnose whether or not the in-period demand profile is independent as assumed in theory, or in fact depends on previous accumulated demand profiles.

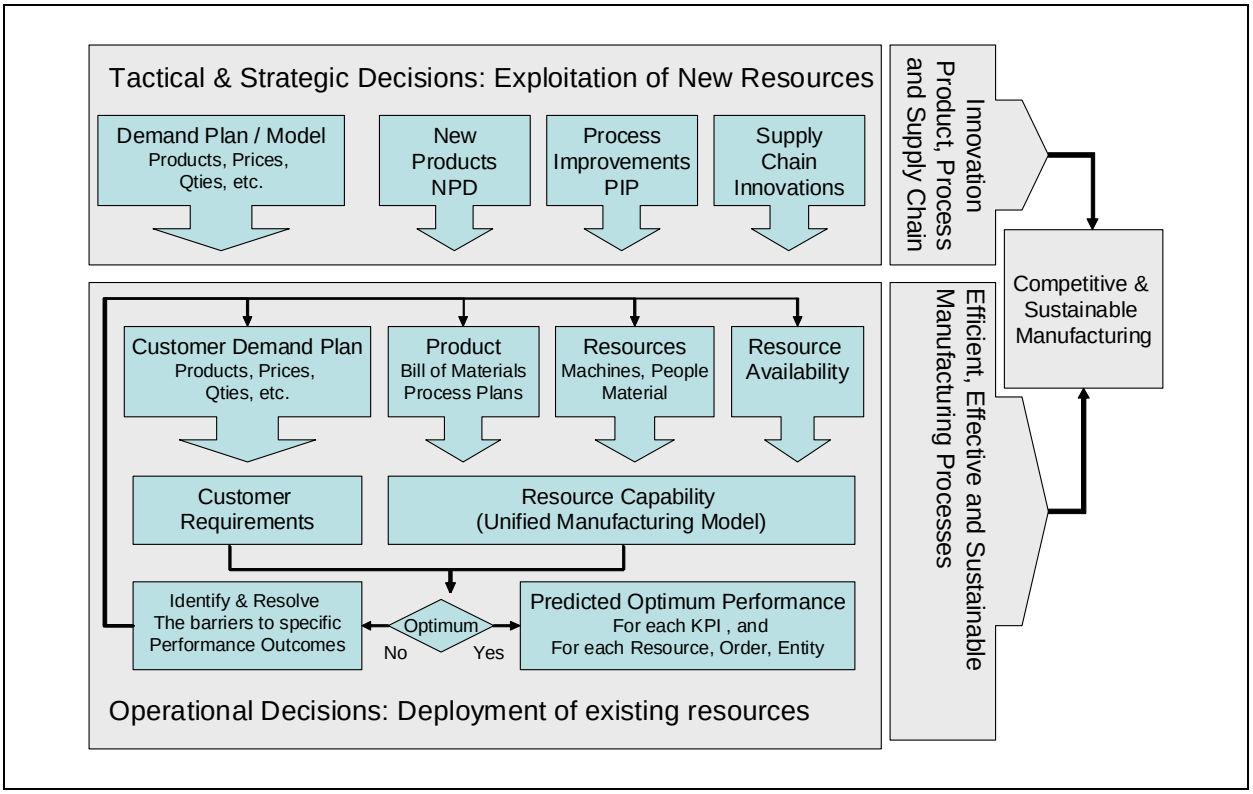

Figure 2: ValuePOLE Model

Annex 1:

Partners in the ValuePOLE Consortium

Name	Short name	Country
1. UNIVERSITY OF LIMERICK	UL	Ireland
2. UNIVERZITA KARLOVA V PRAZE	Karlova	Czech Republic
3. AALBORG UNIVERSITET	Aalborg	Denmark
4. MANOPT SYSTEMS LTD.	ManOPT	Ireland
5. TIPPO INTERNATIONAL LTD.	Tippo	Ireland
6. BURNSIDE EUROCYL LTD.	Burnside	Ireland
7. MILL HOUSE MANUFACTURING DESIGN LTD.	MillHouse	United Kingdom
8. MORSØ JERNSTØBERI A/S.	Morsoe	Denmark

References

Allinson, C. W., Chell, E., & Hayes, J. (2000). Intuition and entrepreneurial behaviour. *European Journal of Work and Organizational Psychology, 9*(1), 31-43.

Banuelas, R., Tennant, C., Tuersley, I., and Tang, S. (2006). 'Selection of six sigma projects in the UK', *The TQM Magazine,* Vol 18, No. 5, 514-527.

Basili, V.R, and Turner, Iterative enhancement, a practical technique for software development, *IEEE Transactions on Software Engg.*, 1(4), Dec 1975.

Carlsson, C., Turban, E., (2002), 'Introduction: DSS: Directions for the next decade', *Decision Support Systems*, 33 (2), 105-110.

Factories of the Future PPP – Strategic Multi-annual Roadmap, November 2009

Feltham, J. B. (2005). "The Dependance of Family Business on a Single Decision Maker." Journal of Small Business Management.

Garengo, P., Biazzo, S., Bitica, U. S. & Venezia, V. (2005) Performance measurement systems in SMEs: a review for a research agenda. *International Journal of Management Reviews,* 7**,** 25-47.

Hudson, M., Smart, A. & Bourne, M. (2001) Theory and practice in SME performance measurement systems. *International Journal of Operations and Production Management,* 21**,** 1096-1115.

Jerrard, R. N., Barnes, N., & Reid, A. (2008). Design, risk and new product development in five small creative companies. *International Journal of Design, 2*(1), 21-30.

Kaplan, R.S., and Norton, D.P., (1992). *The balanced scorecard: measures that drive performance*. *Harvard Business Review* Jan – Feb pp71-80.

Kennerley, M., Neely, A., (2003), 'Measuring performance in a changing business environment', *International Journal of Operations & Production Management*, 23 (2), 213-229. Neely, A., Gregory, M. Platts, K., (1995), 'Performance measurement system design: a literature review and research agenda', *International Journal of Operations & Production Management*, 15 (4), 80-116.

Lam, A. (2003). 'Organizational learning in multinationals: R&D networks of Japanese and US MNEs in the UK', *Journal of Management Studies*, 40/3: 674-703.

Lam, A (2004). Organizational Innovation, BRESE, School of Business and Management, Brunel University, April 2004

Lediwth, A; O'Dwyer, M; *"Market Orientation, NPD Performance, and Organizational Performance in Small Firms"*, Journal of Product Innovation Management 2009; 26:652-661

Manufuture Platform full report n° 1/2006

Melnyk Steven, A.,Stewart, D. M., Swink, M., (2004) 'Metrics and performance measurement in operations management: dealing with the metrics maze', *Journal of Operations Management*, 22, 209-217.

Neely, A., C. Adams, et al. (2001). *The performance prism in practice*. Measuring Business Excellence 5(2): 6-12.

Pereira, A. (2004) State Entrepreneurship and Regional Development: Singapore's Industrial Parks in Batam and Suzhou, *Entrepreneurship and Regional Development* 16: 129-44.

Randøy, T. and Goel, S., (2003). *Ownership structure, founder leadership, and performance in Norwegian SMEs: implications for financing entrepreneurial opportunities*. Journal of Business Venturing 18(5): 619-637.

Royce, (1970) Managing the development of large software systems, *IEEE Wescon*, Aug. 1970, reprinted in *Proc. 9th Int. Conf. on Software Engineering (ICSE-9)*, 1987, IEEE/ACM, pp. 328-338.

Dinesh Kumar, U., Saranga, H. (2007). Six Sigma Project Selection using data envelopment analysis. *The TQM Magazine*, Vol 19, No. 5, 419-441.

Shapiro, J. F., (2004), 'Challenges of strategic supply chain planning and modeling', *Computers & Chemical Engineering*, 28 (6), 855-861.

Sheahan, A; Sheahan, C. (2006) "Enterprise Modelling and Performance Optimisation for SMEs", (PMA) *Performance Measurement and Management: Public and Private 25-28 July 2006*, Cranfield School of Management, London, UK.

Wouters, M., Verdassdonk, P. "Supporting Management Decisions with Ex ante Accounting Information", *European Management Journal* Vol. 20, No. 1, pp. 82–94, 2002