Towards the identification of the influence of SPI on the successful evolution of software SMEs

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December 18th, 2009

Abstract

Software development requires multi-stage processes in order to organise the software development effort. Each software development project should implement a development process that is appropriate to the project setting. Since business needs and technologies are subject to change, software process improvement (SPI) actions are required so as to harmonise the process with the emerging business and technology needs. SPI frameworks such as CMMI and ISO-15504 have been designed to support SPI efforts. While SPI frameworks have been shown to be beneficial for large organisations, they are not widely implemented in small to medium sized enterprises (SMEs), where evidence of the positive influence of SPI on business success is weak. This paper is proposing that a new measure, the SPI Key Performance Indicator (SPI-KPI), is developed to investigate the association between SPI and business success in SMEs, with the objective of demonstrating that SPI is positively associated with business success in SMEs.

1 Introduction

The software process has been defined as "*the sequence of steps required to develop or maintain software"* (Humphrey 1995 p4) and owing to the differences that exist between individual software development settings, there is no one ideal software development process that is generally applicable to all software development efforts (Sommerville 2007, Jones 2008). Moreover, within individual software development settings, critical items such as the development technologies, personnel, requirements and clients are continually undergoing change and as a result, an effective development process is one that is not set in stone but rather one that dynamically responds to environmental feedback (Zahran 1998). Consequently, software development teams and managers may reflect on the development process and undertake SPI so as to "*create more effective and efficient performance of software development and maintenance through structuring and optimising of processes*" (Van Solingen 2001 p455).

Software process maturity reference frameworks such as (CMMI) (Chrissis, Konrad and Shrum 2003) and ISO-15504 (ISO/IEC 1998) have been developed so as to support SPI efforts, and these frameworks have been shown to be beneficial for large organisations (Herbsleb and Goldenson 1996, El Emam and Birk 2000, Lebsanft

2001, Gibson, Goldenson and Kost 2006, Wegelius and Johansson 2007). However, studies have reported that these reference frameworks are less well suited to the needs of SMEs (Cepeda, Garcia and Langhout 2008, Staples et al. 2007, Khurshid, Bannerman and Staples 2009, Jung et al. 2001, Laporte et al. 2005, Oktaba 2008) and although efforts to tailor these frameworks for use in small projects and small companies have met with some success (Leung and Yuen 2001, Serrano, Montes de Oca and Cedillo 2005), other research has reported that process maturity reference frameworks are not suitable for small-scale implementation (Miluk 2005).

Concerns in relation to the suitability of process maturity reference frameworks for SMEs may offer an explanation for the reported gap between theoretical best practice for SPI and actual practice (Ludewig 2001, Saastamoinen and Tukiainen 2004). Perhaps of greater concern is the finding that SPI in SMEs is largely implemented in response to negative experiences (Coleman and O'Connor 2008). This finding would suggest that although effective management of the software process is a factor in business success, there exists a weak focus on SPI in SMEs. Indeed, it has been noted that SMEs require greater evidence of the benefit of SPI prior to authorising SPI investments (Niazi 2006).

Given that the software development process impacts on the cost and quality of software development, and given that the software development process must adapt to best meet the emerging business needs, it is logical to hypothesise that SPI initiatives can assist the successful evolution of software SMEs. However, to date, no study has explicitly chartered the influence of SPI on the successful evolution of software SMEs. This research proposes the development of a new measure of SPI activity, the SPI-KPI, to establish that SPI has a positive influence on successful software SME evolution, while also profiling the influence of specific SPI actions. If this research is successful in demonstrating that SPI is positively associated with the successful achievement of business goals then the case for SPI in software SMEs would be strengthened, and this would represent a valuable contribution to the field of SPI.

This paper is organised as follows: section two discusses the related research, section three presents the research objectives, section four outlines the envisaged research approach, section five discusses some of the research challenges and outlines the plan to completion and finally, a discussion is presented in section six.

2 Related Work

There are many direct and indirect benefits from SPI (Zahran 1998), and often these can be difficult to measure (Rozum 1993, Mathiassen, Ngwenyama and Aaen 2005). They include increases in productivity, product quality and customer satisfaction, improvements to budget and schedule adherence and decreases in costs, cycle times and process complexity. Rico (2004) presents an approach for translating these benefits into monetary terms and comparing the investment with the return, or in other words calculating the financial Return On Investment (ROI). However, in practice, ROI is inconsistently calculated, resulting in confusion and general scepticism (Erdogmus, Favaro and Strigel 2004). In spite of this, some research has investigated the ROI associated with SPI, with Van Solingen (2004) presenting a review of several such studies – determining that the average ROI for SPI is 7, i.e. for every one dollar invested, seven dollars are returned.

Much of the literature of SPI-related financial ROI is centred on studies in large organisations – as demonstrated by the company listing presented by Van Solingen (2004). While comparable information for small software development companies is less evident, they can derive benefits from SPI (Kautz 1998). Sanders (1998) presents an account of the benefits accruing to small software development organisations from SPI while another study of SPI in small companies concludes that "*it is possible to define and implement software processes in a beneficial and cost-efficient manner considering their specific business goals, models, characteristics, and resource limitations*" (Von Wangenheim et al. 2006 p900). While Sanders (1998) and Von Wangenheim et al. (2006) demonstrate that SPI can make a significant contribution to improving software development in small companies, there is no attempt to determine the relationship with successful business evolution. In a related study by Cater-Steel and Rout, presented in chapter 11 of Oktaba (2008), process improvement is reported to have a positive long-term effect on businesses. However, although Cater-Steel and Rout find that there is "*no necessary link between success in implementing improvement and survival of the organisation*" (Oktaba 2008 p238), they also stress that, owing to the involvement of the key stakeholder (the owner), traditional views of success and failure may not apply to small companies. It is the objectives of the owner that are important when determining success – therefore, viewing improvement initiatives in tandem with owners' objectives is a powerful approach to examining the impact of SPI in SMEs.

Other studies also demonstrate the benefits of SPI in small organisations. Ferreira, Santos, Cerqueira, et al. (2007) show that *BL Informatica* successfully grows its headcount through the successive implementation of quality management standards and process maturity reference models, including ISO-9000 and CMMI. However, these approaches may not be well suited to the needs of small companies (El Emam and Birk 2000, Miluk 2005) and evidence suggests that SMEs have not widely adopted such approaches (Coleman and O'Connor 2008, McConnell 2002). Moreover, the work presented in Ferreira, Santos, Cerqueira, et al. (2007) does not investigate the SPI activities in multiple SMEs and does not attempt to examine the relationship between SPI and the achievement of business goals. Other studies also present the benefits of SPI to individual SMEs (Fleck 2004) without examining the influence on business success.

While the benefits of SPI to SMEs have been demonstrated through studies such as Sanders (1998), Biro, Ivanyos and Messnarz (2000), Fleck (2004), Von Wangenheim et al. (2006) and Ferreira et al. (2007), Niazi (2006) concludes that more evidence in favour of SPI for SMEs is required in order to justify a commitment to SPI programmes. The planned research that is presented in the next section has been designed to provide evidence of the business benefit of SPI for SMEs, by demonstrating that SPI has a positive association with the successful achievement of business goals.

3 Research Objectives

The premise of this study is that SPI has a positive influence on the successful evolution of software SMEs. On this basis, the following research questions have been formulated for exploration:

- What is success for software SMEs?
- Is SPI positively associated with successful software SME evolution?
- Which SPI actions are exerting the most influence on successful software SME evolution?

Together, these research questions will help to provide an understanding of what success is for software SMEs, and will profile the relationship between SPI actions are the achievement of business goals.

4 Research Approach

The study will establish two parallel channels of investigation in a set of participating SMEs. The first channel will determine the degree to which the business is successful. This will involve at least two engagements with the executive management team, initially establishing the business goals and later determining the extent to which the goals have been achieved. By determining the business objectives in advance, it is possible to avoid the issues related to erroneous recollection of earlier objectives and hence, there is more certainty regarding the extent to which business goals have been achieved. The second channel of investigation will be undertaken in the software development team and will use a new measure, the SPI-KPI, to determine the SPI activity in the firm. Finally, using the data obtained from the investigations in the participating SMEs, an evaluation of the influence of SPI on SME business success will be performed.

In order to conduct the research, two separate measures must be determined: one for business success and another for SPI activity.

4.1 Measuring Business Success

In the business literature, the term *success* is used interchangeably with the term *performance* and in a very general sense they both represent the achievement of something desired, planned or attempted (Maidique and Zirger 1985). However, beyond this general description, controversy exists in relation to what exactly is meant and understood by business performance (Morgan and Strong 2003). Businesses measure performance for a variety of different reasons including, the identification of improvement opportunities, determinations in relation to customer satisfaction, to enhance understanding of their own processes and to assess the degree of success achieved (Parker 2000). This variety of reasons for measuring performance has given rise to a variety of different performance measures that can be classified as financial or non-financial (Hart 1993 p30).

4.1.1 Financial Views of Business Success

Traditionally, business performance has been measured in purely financial or accounting terms (Jennings and Seaman 1994). Profitability, usually measured by ROI, has by convention, been used to assess performance and is widely regarded as the ultimate bottom line test of success (Morgan and Strong 2003). In addition to ROI, other financial measures of business performance include return on sales, sales per employee, productivity and profit per unit production (Ghalayini and Noble 1996). The financial perspective has been reported as having a significant impact on performance – with Reid and Smith (2000) concluding that the pursuit of the highest rate of return on investment is a primary consideration for owners and managers. This view is long established in the business success domain with Ansoff (1965) asserting that "*return on investment is a commonly and widely accepted yardstick for measuring business success*" (Ansoff 1965 p42).

While financial return is an important indicator of business success, "*profits are not necessarily the sole purpose of a firm*" (Nonaka and Toyama 2005 p420) and it has been observed that it is far from the only important measure (Maidique and Zirger 1985), with claims that short term financial measures of performance that emphasise a quick return on investment can come at a cost to long term growth (Hayes and Abernathy 1980). Financial measurement can be considered as tangible evidence of performance but other important performance measures should also be assessed so as to prevent the "*inadequate handling of intangibles*" and the "*improper valuation of sources of competitive advantage*" (Bharadwaj, Varadarajan and Fahy 1993 p87). The measurement of customer satisfaction demonstrates the importance of intangible measures and highlights the danger of focusing solely on financial data: a company that posts successful financial returns might appear to be performing well but, if all of the clients are dissatisfied, the future profitability prospects for the company will be at risk. As a result of the shortcomings of purely financial performance measurement, there has been a "*shift from treating financial measures as the foundation for performance measurement to treating them as one among a broader set of measures*" (Eccles 1991 p131) and this has given rise to a multidimensional of performance measurement frameworks.

4.1.2 Multidimensional Views of Business Success

A number of multidimensional performance management frameworks have been created, each trying to unlock the vital measurements that would best provide a complete view of the business performance. The performance pyramid (Lynch and Cross 1990) contains a pyramid of measures aimed at integrating performance through the hierarchy of the organisation. The macro process model (Brown 1996) identifies links between the five stages in a business process, *inputs*, *processing system*, *outputs*, *outcomes* and *goals*, arguing that each stage is the driver of the performance of the next. Kanji's Business Scorecard (KBS) defines four fundamental dimensions to be managed and measured: *organisational value*, *process excellence*, *organisational learning* and *stakeholder delight* while the performance prism (Neely, Adams and Kennerley 2002) consists of five interrelated perspectives: *stakeholder contribution*, *stakeholder satisfaction*, *strategies*, *processes* and *capabilities*. However, it is the Balanced Scorecard (BSC) (Kaplan and Norton 1992) approach, with it's four performance perspectives: *financial*, *customer*, *internal business processes* and *learning and growth*, that is the most popular multidimensional performance measurement framework (Kennerley and Neely 2002) and which has exercised the most influence in the domain of performance management (De Waal 2003).

While the BSC approach could be applied to any business type, the software development business, often characterised by high levels of dynamism and uncertainty, requires a broader approach to performance measurement (Sureshchandar and Leisten 2005). Consequently, Sureshchandar and Leisten (2005) have adapted the BSC approach, rendering a strategic performance measurement and management framework for the software development industry, the Holistic Scorecard (HSC). The HSC comprises of six perspectives, *financial*, *customer*, *business process*, *intellectual* *capital*, *employee* and *social*. While the initial three perspectives are broadly similar to the BSC, the latter three – *intellectual capital*, *employee* and *social* – are new considerations and they reflect some of the key items that may affect the performance of a software business.

The HSC (2005) is a software-development specific extension of the most popular multidimensional performance measurement framework, the BSC (Kaplan and Norton 1992). Therefore, this research will adopt the HSC as the reference framework from which to establish the extent of business success. Rather than implementing a full scorecard, which can be administratively heavy, this research will use the HSC as a frame of reference for addressing general strategic issues and business goals – an approach that has proven beneficial for SMEs implementing the BSC (Andersen, Cobbold and Lawrie 2001).

In parallel with the measurement of business success, a separate channel of inquiry will examine the SPI activity in the participating SMEs.

4.2 Measuring SPI Activity

According to Poulin (2007), in relation to software process management, establishing an organisation's ability to optimise the development process may provide a better approach than traditional audits. While measuring the extent of process management would appear to be important for software development companies, there is no established method for determining this characteristic of a software development enterprise. Therefore, this research proposes the use of a new KPI, the SPI-KPI, as a vehicle to measure the activity in relation to process improvement. Since it will indicate when the process focus is weak, the SPI will act as a catalyst for SPI. This will help to bring the important area of software development process management more centre stage for software SMEs.

There are two dimensions to the SPI-KPI. Firstly, the extent of SPI actions is determined and secondly, this is compared to the estimated need for SPI action. By comparing the actions to the estimated need for action, it is possible to incorporate organisational context into the SPI-KPI rating. Therefore, two organisations that are carrying out the same amount of SPI activity can have different SPI-KPI ratings, meaning that the SPI-KPI is a measure that can be used to compare the performance of different organisations in relation to software process management. Any assessment of a company's process improvement activity should be counter-balanced against the need for such improvement, and it is only by harmonising these two dimensions that the company can determine if it is applying adequate or inadequate SPI effort.

The SPI-KPI is represented in the following formula:

(Extent of SPI Actions) / (Estimated need for SPI)

4.2.1 Extent of SPI Actions

In order to determine the extent of SPI actions, it is necessary to use an established, comprehensive reference of all possible process actions that may be required by a software development organisation. ISO-12207 (ISO/IEC 2008) provides a comprehensive software development process reference list, though it also recognises that "*particular projects or organizations may not need to use all of the processes provided*" (ISO/IEC 2008 p2), and it offers guidance to companies on how process tailoring may be effectively implemented – depending on items such as team size, organisational policy and project criticality.

ISO-12207 (ISO/IEC 2008) comprises of 43 individual process groups that are categorised under 7 different headings and offers a suitable reference model for the process investigation as "*it describes continuing responsibilities that must be achieved and maintained during the life of the process… the functions to be performed rather than organizations to execute them*" (Moore 1998 p328). This research seeks to determine the process improvement activity independent of the organisation or the underlying process approach. As well as having been used as the basis for process definition (Calero, Ruiz and Piattini 2004, Duran, Benavides and Bermejo 2004), ISO-12207 (ISO/IEC 2008) has also been used as a model for process examination: being described as offering "*general guidelines which can be used by software practitioners to manage and engineer software*" (Satpathy et al. 2001 p95) and providing a "*meta-model that defines common software engineering activities independently of a particular life-cycle model*" (Tilley et al. 2005 p251). While ISO-12207 (ISO/IEC 2008) offers an ideal reference framework from which to determine the first dimension of the SPI-KPI measure, the extent of SPI actions, no such readily available reference framework exists for determining the second dimension of the SPI-KPI, the estimated need for SPI.

4.2.2 Estimated Need for SPI

When estimating the need for SPI, it may be necessary to merge aspects of several different models in order to build a comprehensive reference point. Models that offer some overlap with the need for SPI include various project management models and the Boehm-Turner agility/discipline model (Boehm and Turner 2003). One project management model, the PMBOK (Project Management Institute 2000), outlines the general areas of concern for projects in any business discipline and involves managing projects around the areas of *scope*, *time*, *cost*, *quality*, *integration*, *human resources*, *communications*, *risks* and *procedures*. These areas of concern are items that are considered important to the health and success of any project and may therefore represent a good starting point in the determination of factors that affect the need for SPI. However, project management models, such as PMBOK (Project Management Institute 2000), will likely require strengthening in order to offer a reliable mechanism for estimating the need for SPI and in this regard, the Boehm-Turner model (Boehm and Turner 2003), which examines the *criticality*, *personnel*, *requirements stability*, *size* and *customer* dimensions, could provide additional software-specific substance. Therefore, the Boehm-Turner model (Boehm and Turner 2003) could supplement the use of a general project management model.

While the PMBOK (Project Management Institute 2000) and the Boehm-Turner (Boehm and Turner 2003) models are likely to cover a significant portion of the spectrum of factors for the software development process, there remain other broader concerns that are beyond the scope of these frameworks. For example, basic business realities such as increasing/decreasing profitability and up- or down-turns in the economy could translate into a need for software process evaluation and SPI. Therefore, the construction of a reference framework for estimating the need for SPI is one of the challenges facing this research.

5 Research Challenges & Plan to Completion

Along with the need to construct a credible reference framework for estimating the need for SPI, a number of other research challenges have also been identified. Firstly, in examining the relationship between SPI and the successful evolution of SMEs, the research must adopt an approach that offers an appropriate level of control for other factors that may also affect business success. One recognised approach to improving the certainty of research findings is to increase the sample size (Lee and Baskerville 2003) – in the case of this research, this will necessitate an undertaking to include a sufficiently large number of companies in the study so as to bring more certainty to the results. The question therefore becomes: what is a sufficiently large number of companies? In short, there is no definitive answer to this question – it is the view of the researchers that one to five companies would be insufficient for the type of study that is envisioned; however, fifteen or more companies should offer adequate breath in order to identify trends and support the generalisability of findings.

The resolution that fifteen companies or more are required gives rise to a second challenge: how can the researchers gain access to the requisite number of companies? Prior to commencing the research, the primary researcher worked in the software industry for a period of thirteen years, during which time an extensive network of software development business connections was established. By tapping into this pool of software industry professionals, it will be possible to command the requisite number of companies for the research.

The extensive period of elapsed time required in order to carry out the research has been identified as a third challenge. Business objectives can take time to realise and therefore, a period of a least one year is considered to be required for the successful business evolution dimension. While this consideration may result in a prolonged study duration, the researchers can accommodate the increase in required time and believe that it will ultimately improve the quality of the research findings.

At present, the broad plan to completion for the research is as follows: The initial engagement with companies will take place in Q2-2010, at which time the business objectives will be determined. Subsequently, the SPI-KPI will be defined in detail in the period Q3-2010 to Q1-2011, after which the companies will be revisited in order to deploy the SPI-KPI and extract the SPI activity measurement from the participating organisations. The final engagement with companies will take place in Q2-2011, at which time the extent of successful business evolution will be determined. Following the completion of the field-based component of the research, the data will be evaluated in order to determine the influence that SPI has on the successful evolution of software SMEs.

6 Discussion

The software development process has a direct influence on the quality and cost of software development. The factors affecting the composition of the software development process are in flux and therefore, active management of the software development process via SPI is required in order to optimise the process for any given setting. While SPI reference frameworks have been designed to assist with the SPI effort, and they have been shown to offer benefits for large organisations, there is a lack of adoption of these frameworks in SMEs. Moreover, SMEs have been shown to have a weak software development process focus, only making modifications to the process in response to negative events, and it has been noted that SMEs need more evidence that SPI is a worthwhile investment. This research will correlate SPI activity, as determined using a new measure, the SPI-KPI, with the successful achievement of business goals – with the objective of demonstrating that SMEs that are better at managing and optimising their software development process are more likely to be successful in realising their business objectives.

Demonstrating that SPI assists the successful evolution of SMEs would provide a valuable contribution to the field of SPI, and it would strengthen the case for SPI in software SMEs. These outcomes would encourage additional SPI research for the SME domain as well as enhancing the potential for the successful evolution of SMEs.

Acknowledgements

This work was supported, in part, by Science Foundation Ireland grant 03/CE2/I303_1 to Lero, the Irish Software Engineering Research Centre (www.lero.ie).

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