Introduction

Research and practice in the area of project management maturity (PMM) is dominated by two main views: The process view and the organizational view. The process view defines project management maturity the degree to which project management activities are codified, measured and controlled (Cooke-Davies 2002; Cooke-Davies 2004) The organizational view presents maturity as an enterprises' receptivity to project management (Saures 1998) and examines the integration of project and organizational processes(Andersen and Jessen 2003). Current maturity models (Wendler 2012)which assess maturity in firms are based on evaluation of structured data which emphasises the process view over the organizational view. While these models vary by the numbers of measures (Fengyong and Renhui 2007), and the range of activities evaluated, for example, Project vs Project/Program/Portfolio (PMI 2008), the approach to administering assessments does not. However, recent advances in data collection and analysis enable us to advance our understanding of maturity by changing not just what we measure but how we measure it.

From data to "big data"

Organisations as part of operations create a significant amount of quantified or quantifiable structured data such as forms documentation and reports. As part of current maturity processes, assessors examine these documents or more accurately the indicators of these documents using one or more frameworks. However, organizations also generate a far larger amount of unstructured data (Boyd and Crawford 2011), which to date, has been ignored in Maturity assessment. Up to 2003, a total of 5 exabytes (10^{18}) of digital data were created and stored by humans(Lyman et al. 2005) By contrast, in 2011 alone, researchers have estimated that 13.7 exabytes of new data were created and stored (Bounie and Gille 2012). a. The scale of this phenomenon and the rate of growth have encouraged industry and researchers to refer to this trend as " Big data", defined by three main characteristics : volume, velocity and variety(Frankel and Reid 2008).

- Volume refers to the scale or amount of data as described earlier which can enable the creation of new insights but requires infrastructure to manage it(Zikopoulos and Eaton 2011).

- Velocity refers to the rate at which data may enter the organization (Sagiroglu and Sinanc 2013). As the amount of sensors and digitizing interfaces for data increase, this data is now real time or near real time, requiring an increased rate of response.

- Variety refers to the heterogeneous nature of big data , with a mix of structured,

quantified data and unstructured data that is difficult to incorporate into traditional organizational databases(Chen et al. 2012).

Big data evaluation paradigms

Our paradigms for evaluating maturity fit with traditional social science approaches of qualitative and quantitative research (Bryman 2012). In the qualitative perspective, detailed knowledge of a given setting is sought through unstructured or semi structured data collection from a small number of sources (Denzin and Lincoln 2011). Quantitative approaches create insights from analysis of associations between observed or latent variables (Groves 2011) creating insights that may be applicable beyond a given research setting. While existing research seeks to simulate the conditions in a general population through the extraction of a sample (Malhotra and Grover 1998), big data can eliminate the inherent trade offs of detailed exploration vs general trends by integrating a range of data linked to human interactions in natural settings (Dong and Srivastava 2013).

These trends can have significant effects on data collection, enabling automatic data collection, a real time perspective, census approach and geographical expansion. Existing approaches to organizational research generally require active elicitation of narratives (qualitative) or numerical responses (quantitative). However, a significant amount of big data is created automatically and can be gathered passively(Zaslavsky et al. 2013). This eliminates some of the limitations of using professionals in data collection including cost, bias and quality(Bowen and Wiersema 1999). The velocity dimension of big data speaks to the temporal shift in organizational data arriving in continuous flows rather than discrete packages. This facilitates the continual evaluation of entities , enabling a real time perspective that goes beyond processes, qualitative approaches that obtain historical time data from interviews and surveys that infer temporality by evaluating variables at discrete points(Van de Ven and Poole 2005) .

 Related to the shift in time is that it is now possible to take a census, rather than a sampling approach to organizational data. Data collection and evaluation constraints resulted in the use of sampling to obtain a representative slice of the entire population to be analysed(Reige 2003). However it is now possible to work with an increased level of granularity since the entire census of the population can be captured automatically and individual cases can be evaluated to a great level of detail. The locations in which this data is generated also extends

beyond the physical boundaries of the enterprise as individuals use remote and mobile devices to carry out the work of the organization(Park and Jex 2011). These devices may also enter other organizations and their data or transactions integrated into another's data collection systems. This raises another issue as data is distributed, stored in multiple locations. Existing approaches are based on a single point of data collection and analysis. However, as data is now distributed, it needs to be collated before analysis. A further requirement is that it needs to be secured.

Big Data and Maturity: Opportunity and Challenges

The ability to evaluate previously unstructured data provides an opportunity to apply new analysis approaches to create deeper insights in Project Management maturity. While a range of big data analytical techniques have emerged, two in particular have a high potential to develop understanding of maturity in organizations: Social Network Analysis and Text Analysis. Social Network Analysis is an approach that enables researchers to examine relationships between entities(Borgatti et al. 2009)including individuals, teams and organisations, individuals, . Once identified, SNA can then quantify quantified and visualize the network formed from these relationships in order to understand the underlying social processes in organisations. For maturity, SNA can be used to understand the degree to which PM is aligned with, and integrated into organizational activities through the examination of communication patterns within organizations. These can be compared to the intended or desired state for Project activities within the firm and the findings can then support the designs of interventions improve project performance.SNA has been previously applied to understand stakeholder networks around construction projects(Pryke 2004) and interactions in project teams (Mead 2001). However, in these cases, data was collected and analysed manually. Since a larger proportion of intra and inter organizational communications are digital, this technique can be applied using an ongoing, automated approach to provide near real time insights into PM Maturity.

Automated text analysis or Text mining is another approach that can be used to evaluate the extent to which project management is implemented within organisations(Gupta and Lehal 2009). Due to the constraints of cost and methodology, current maturity evaluation tools assess maturity based on the overall structure of project processes and documents. While

manual content analysis has been applied to understand project processes in organizations (Pasian 2011), tt is now possible to apply automated approaches to examining the content of project documentation in real time. Text-mining techniques enable the rapid review and summarization of large volumes unstructured text, including documents and emails(Sukanya and Biruntha 2012). It enables assessors to develop an understanding of the organization beyond the high level or summary view but based on the actual organizational discourse on project management.

Combined, these techniques can extend our existing knowledge of maturity by assessing the domains that are difficult to evaluate by conventional means, specifically those of organizational support for PM and receptivity of PM. Application of Text mining can identify the extent to which documents reflect project management processes and the degree to which it is embedded within the organization. Social network analysis can identify patterns of communication within organizations that can identify the extent to which all stakeholders engage with project management concepts and can be used to infer organizational support and receptivity. Together with existing qualitative and quantitative tools, they may be able to provide valid evidence of an organization's maturity in all domains: process, support and receptivity.

Challenges of Big Data

Big data's removal of the trade offs between breadth and depth brings the opportunity to extend knowledge but also comes with challenges. Data collection based on documents and relationships can be intrusive and reveal information that may not have been intended by the writer or creator(Wu et al. 2012). Further, aggregation of different types of data magnifies this issue as data can be correlated to create additional insights that may reveal confidential information(Pospiech and Felden 2012).

Approaches to managing this potential issue are still being debated (Bennett et al. 2013). Regulation, in the form of data collection laws have emerged to secure personal data , their application to interactions in public and quasi public domains is unclear (Boyd and Crawford 2011). Further, they may not be applicable to social and document based interactions within organizations. Additional research in this area may be required as digital data, once collected, does not degrade. Not only can analyses be performed at a given time, it remains available for future analysis by improved algorithms and data processing equipment,

revealing additional insights(Wong 2012). This advantage is not just available for the organization that have collected the data, but is available to any person who can gained access. This raises ethical concerns around collection and delivery which can influence the applicability of these techniques to maturity.

Future directions of Maturity and Implications for Project Managers

While the opportunities and drawbacks of this domain are still being negotiated, the lure of applying new types of data and new analytical approaches may be difficult to resist for researchers and practitioners. It suggests a path forward to new types of maturity models that can be holistic and adaptive. The ability to eliminate the current constraints between breadth and depth of insights raises the possibility of holistic maturity models. In this approach, all of an organizations' project management related interactions and content, not just structured content, can be accessed to assess its development. Based on a holistic view, it could be possible to design interventions or development initiatives that can be closer matched to the reality of the organization's context, not just the representation presented in structured documents.

The application of autonomous or ambient data collection and analysis approaches can create the possibility of near real time, adaptive maturity assessment. Organizations can implement systems that evaluate the flow of information and provide insights using visual displays to enable stakeholders to identify project management issues in near real time. Finally, automated data analysis systems can be reconfigured over time to adapt to organizational or environmental requirements.

Conclusion

While the field of project management maturity is still developing, the direction still seems to be focused on identification of new measures that are linked to structured data: enabling the examination of processes and judging their effectiveness. However in limiting ourselves to structured data, researchers and practitioners are ignoring the wider universe of information that is now available. Recent improvements in technology and in research methodologies provide new avenues for exploration and we can now feasibly examine interactions between individuals and organisations to a level of detail and a scale that was not imaginable 20 years ago. While care must be taken when developing these insights to ensure that privacy is not

violated, future maturity models may benefit from "big data" collection and analytics approaches.

REFERENCES

Andersen, E. S., & Jessen, S. A. (2003). Project maturity in organisations. *International Journal of Project Management, 21*(6), 457-461.

Bennett, P., Giles, L., Halevy, A., Han, J., Hearst, M., & Leskovec, J. Channeling the deluge: research challenges for big data and information systems. In *Proceedings of the 22nd ACM international conference on Conference on information & knowledge management, 2013* (pp. 2537-2538): ACM

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network analysis in the social sciences. *science, 323*(5916), 892-895.

Bounie, D., & Gille, L. (2012). Info Capacity| International Production and Dissemination of Information: Results, Methodological Issues and Statistical Perspectives. *International Journal of Communication, 6*, 21.

Bowen, H. P., & Wiersema, M. F. (1999). Matching method to paradigm in strategy research: Limitations of cross-sectional analysis and some methodological alternatives. *Strategic Management Journal, 20*(7), 625-636.

Boyd, D., & Crawford, K. (2011). Six provocations for big data.

Bryman, A. (2012). *Social research methods*: Oxford university press.

Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data to Big Impact. *MIS Quarterly, 36*(4), 1165-1188.

Cooke-Davies, T. J. (2002, May). Project management maturity models: does it make sense to adopt one? *Project Manager Today,* pp. 1-4.

Cooke-Davies, T. (2004). Project management maturity models. *The Wiley guide to managing projects*, 1234-1255.

Denzin, N. K., & Lincoln, Y. S. (2011). *The SAGE handbook of qualitative research*: Sage.

Dong, X. L., & Srivastava, D. Big data integration. In *Data Engineering (ICDE), 2013 IEEE 29th International Conference on, 2013* (pp. 1245-1248): IEEE

Fengyong, Z., & Renhui, L. Study on Framework of Construction Project Management Maturity Model. In *2007 International Conference on Service Systems and Service Management, Chengdu, China, June 9-11 2007*: IEEE

Frankel, F., & Reid, R. (2008). Big data: Distilling meaning from data. *Nature, 455*(7209), 30-30.

Groves, R. M. (2011). Three eras of survey research. *Public Opinion Quarterly, 75*(5), 861-871.

Gupta, V., & Lehal, G. S. (2009). A survey of text mining techniques and applications. *Journal of Emerging Technologies in Web Intelligence, 1*(1), 60-76.

Lyman, P., Varian, H. R., Swearingen, K., Charles, P., Good, N., Jordan, L., et al. (2005). How Much Information 2003?(2003). *School of Information Management and Systems, the University of California at Berkeley*.

Malhotra, M. K., & Grover, V. (1998). An assessment of survey research in POM: from constructs to theory. *Journal of Operations Management, 16*(4), 407-425.

Mead, S. P. (2001). Using social network analysis to visualize project teams. *Project Management Journal, 32*(4), 32-38.

Park, Y., & Jex, S. M. (2011). Work-home boundary management using communication and information technology. *International Journal of Stress Management, 18*(2), 133.

Pasian, B. L. (2011). *Project management maturity: a critical analysis of existing and emergent contributing factors*. University of Technology, Sydney,

PMI (2008). Organizational Project Management Maturity Model (OPM3). Project Management Institute.

Pospiech, M., & Felden, C. (2012). Big data–a state-of-the-art.

Pryke, S. D. (2004). Analysing construction project coalitions: exploring the application of social network analysis. *Construction Management and Economics, 22*(8), 787-797.

Reige, A. (2003). Validity and Reliability tests in Case Study Research. *Qualitative Market Research: An International Journal, 6*(2).

Sagiroglu, S., & Sinanc, D. Big data: A review. In *Collaboration Technologies and Systems (CTS), 2013 International Conference on, 2013* (pp. 42-47): IEEE

Saures, I. (1998). *A Real World Look at Achieving Project Management Maturity.* Paper presented at the Project Management Institute 29th Annual Seminars/Symposium, Long Beach, CA, October 9-15

Sukanya, M., & Biruntha, S. Techniques on text mining. In *Advanced Communication Control and Computing Technologies (ICACCCT), 2012 IEEE International Conference on, 2012* (pp. 269-271): IEEE

Van de Ven, A. H., & Poole, M. S. (2005). Alternative Approaches for Studying Organizational Change. *Organization Studies, 26*(9), 1377-1404, doi:10.1177/0170840605056907.

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and Software Technology*.

Wong, R. (2012). Big Data Privacy. *J Inform Tech Softw Eng, 2*, e114.

Wu, X., Zhu, X., Wu, G., & Ding, W. (2012). Data mining with big data.

Zaslavsky, A., Perera, C., & Georgakopoulos, D. (2013). Sensing as a service and big data. *arXiv preprint arXiv:1301.0159*.

Zikopoulos, P., & Eaton, C. (2011). *Understanding big data: Analytics for enterprise class hadoop and streaming data*: McGraw-Hill Osborne Media.