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THE EVOLUTION OF PROCESS MODELS IN IS RESEARCH: FROM A PUNCTUATED SOCIAL PROCESS MODEL TO A SOCIO-TECHNICAL PROCESS MODEL

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Abstract

The implementation of information technology and its association with organizational change has been an important theme in the Information Systems (IS) literature over the past 30 years. The progression of variance and process theories provide an in-depth overview of the emergence of richer accounts of IS change. In this paper we chronicle the evolution of process models and related theory. We also show how the application of process thinking in IS research has improved our understanding of complex IS change. These models depict more faithfully actors' lived experiences and preserve the details and essential effects of critical events. An emerging benefit the process models is the capability to identify common patterns in a project's evolutionary trajectory.

Keywords: Information systems change, variance theory, process theory, PSIC model

1 Understanding organizational change

The implementation of information technology and its association with organizational change has been an important theme in the IS literature over the past three decades (Markus and Robey, 1988). The two most commonly used definitions of change encapsulate also its modes of explanation (Van de Ven and Poole, 2005). First, change has been defined as, "an observed difference over time in an organizational entity on selected dimensions" (Poole *et al.*, 2000) which represents the call to use variance theory to account for change. Secondly, the definition of change as "a narrative describing a sequence of events on how development and change unfold" (Poole *et al.*, 2000) highlights some of the key elements of a process theory. The evolution of theses theories provides an in-depth understanding of the emergence of accounts of change in organizational studies (Van de Ven and Poole, 2005; Poole, 2000). In addition, variance and process theories offer different ways to explain change (Mohr, 1982; Markus and Robey, 1988).

In variance studies, "antecedent" or "independent" variables are identified and causally linked with measures of outcomes (dependent or criterion variables) (Mohr, 1982; Sabherwal and Robey, 1995). In this type of research, change is represented in terms of a change in dependent variables (Van de Ven and Poole, 2005). Process studies, rather than considering the effects of variables, focus on sequences of events and seek to explain how and why these events occur and how their sequences affect the outcomes (Mohr, 1982; Sabherwal and Robey, 1995). In this type of study, events are derived from historical narratives as interpretive acts of what happened (Van de Ven and Poole, 2005; Poole, 2000; Pentland, 1999). With variance theory, there is thus an inclination to view static relationships between variables as change whereas in process theory the diachronic nature of events accounts for change (Mohr, 1982). These significantly different methods of viewing and analysing change data contribute the intensity of the debate.

	Variance Theory	Process Theory
Definition	The cause is necessary and sufficient for the outcome	Causation consists of necessary conditions in sequence; chance and random events play a role
Assumption	An outcome (s) will invariably occur when necessary and sufficient condition are present	Outcomes may not occur (even when conditions are present)
Basis of explanation	The basis of explanation is efficient causality	The basis of explanation is final, formal and path dependent
Elements	Variance theory deals with variables	A process theory deals with discrete states and events. (discrete outcomes)
Role of time	Snap shots, cross-sectional and static	Longitudinal and dynamic
Generalization	Depends on uniformity across contexts. Statistical	Depends on versatility across cases
Time-ordering (sequence)	Immaterial to outcome	Critical to outcome. Path dependency

Table 1: Characteristics of variance theory and process theory (Mohr, 1982; Markus and Robey, 1988; Poole et al., 2000)

Because of this fundamental divide there are several differences between variance and process theories (Table 1). The first one, the association between inputs and outputs, involves how the precursor and outcomes relate respectively. In variance theory the precursor is a necessary and sufficient condition for the outcomes (Mohr, 1982) whereas in a process theory the precursor is a necessary condition for the outcomes. While both of these associations engage in understanding how outcomes come to be, variance theory incorporates variables while process theory accommodates necessary conditions in explaining its emergence (Mohr,

1982). Outcomes can be understood based on the knowledge of the sequence of events rather than the value of prediction in explaining variance (Markus and Robey, 1988).

Efficient cause forms the heart of the variance theory by identifying that "the force that makes it what it is or changes it from what it was" (Mohr, 1982). This notion of causality creates the association between the necessary and sufficient precursors to produce outcomes (Mohr, 1982). Within process theory, the rearrangements of elements (necessary conditions or objects) are required to achieve outcomes. Rearrangement refers to the joining or separation of two or more specified elements (Mohr, 1982). The joining or separation constitutes a probabilistic process where these combinations are to some degree affected by the external forces or the context. The notion of probabilistic processes refers to the path of events which are subject to the probability of the outcomes (Shaw and Jarvenpaa, 1997).

The final difference between variance and process theory is the concept of time-ordering. Variance theory rejects time ordering because the process of predicting and testing within variance theory only: 1) considers snap shots of events and 2) requires certain variables to remain constant at any point of time (Mohr, 1982). Process theory, on the other hand, supports the ordering of time where events (joining or separation of elements) that occur, happen in sequence (or in parallel sequences) and the form of the sequence is vital to understanding of outcomes.

Why should one engage in process studies? Most research follows variance theory (sometimes referred to as a factor study approach), by probing relationships between variables and searching for the degree of association between critical factors and outcomes. For example, a variance study can look at the impact of an ERP system implementation outcomes through surveys of projects across companies. This type of research is not able to address the nature and complexities of the change process as the inquiry excludes contexts, histories, and processes (Scapens and Jazayeri, 2003). In contrast, process studies provide an in-depth analysis of events within a specific context. Markus and Robey (1988) identified further benefits of process theory. Process theories make identification of new patterns within empirical data possible. The identification of the events, their paths and their sequences permits pattern generation. Also, the prediction of these patterns over time is one of the goals of process theories (Markus and Robey, 1988).

Mohr (1982) identifies several attempts to combine both models in explaining organizational behaviour. Mohr (1982) favours the co-existence rather than a combination of these approaches. Newman and Robey (1992) also argue that variance and process theory mutually inform during theory triangulation but they are not amenable to integration (Mohr, 1982; Newman and Robey, 1992). Factor studies and process studies are complimentary where findings from one study can be further elaborated through the other tradition (Newman and Robey, 1992). This complimentary feature was further elaborated in Sabherwal and Robey (1995) where they discuss the feasibility for reconciliation, the method of reconciliation and the benefits of such reconciliation.

In this paper we will attempt to understand the evolution of process models in IS research. By comparing variance and process models, we aim to answer the question of how process model can improve our understanding of IS implementation and its connection with organizational change.

The next section will elaborate the evolution of process models within IS research stream. The subsequent section will position the process models within IS research streams, followed by a conclusion.

2 Evolution of a process model

Newman and Robey elaborated the process modelling in information systems research through their articulation of a social process model (Newman and Robey, 1992). Their research looked at the relationship between the users and analysts during an IS development

project. They made an analytical comparison between the variance based models and process based models and concluded that the factor model and the process model are complementary but should not be combined due to their differing forms (Newman and Robey, 1992).

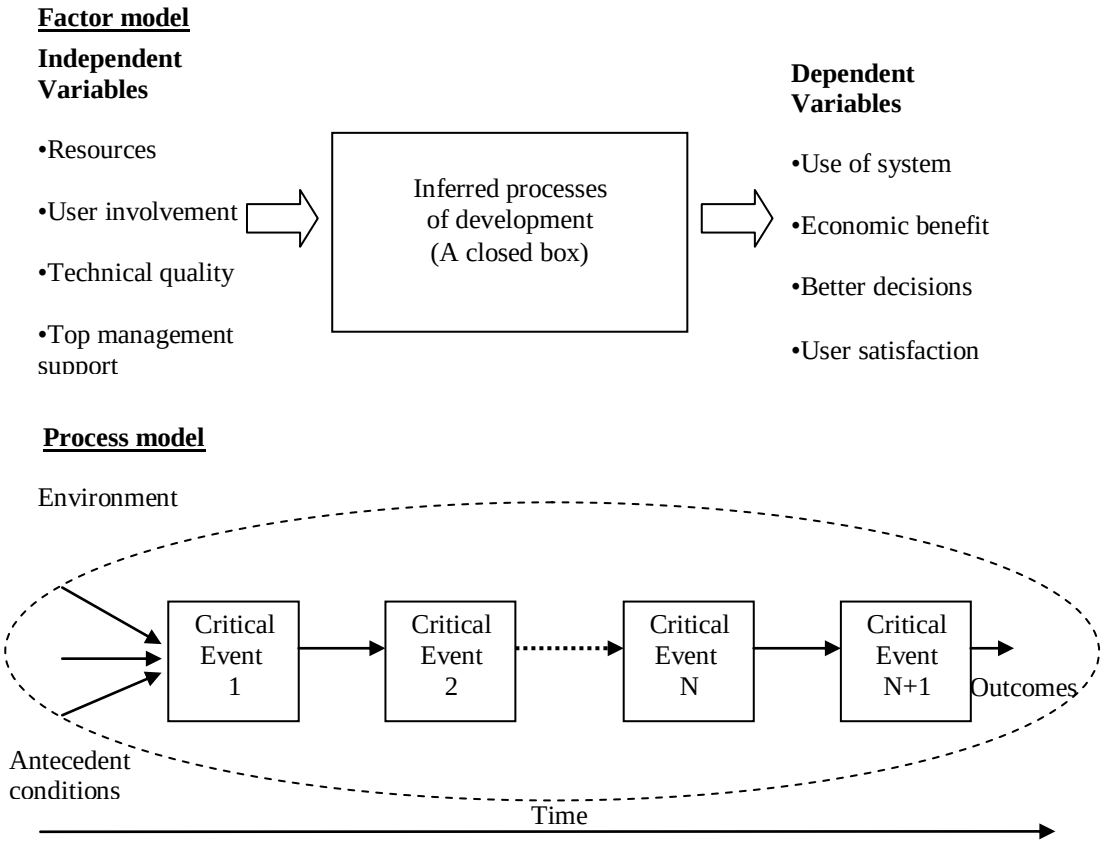

Figure 1: Factor and process model of system development (adapted from Newman and Robey (1992) and Lyytinen and Newman (2008))

In their view, factor models identify the ISD process as conclusive and static (Newman and Robey, 1992), and the process is treated as a closed box. Within process research, focus is placed on "critical" events and their sequence (Mohr, 1982) (Figure 1). This approach enables a better understanding on the dynamics of social change and also provides an in-depth explanation of how and why outcomes are generated (Mohr, 1982; Van de Ven and Huber, 1990). According to Kling (1987) and Markus and Robey (1988), this type of model provides a more faithful account of actual experiences of what really happens during a IS development project.

As the name suggest, the social process model was compliant to the process theory (Van de Ven and Poole, 1990) approach. It starts with the notion of events which is derived from observation or retrospective reconstruction of events from empirical studies (Newman and Robey, 1992). There are two types of events: encounters and episodes (Figure 2). Encounters occur at a specific point in time at the beginning and the end of an episode, whereby an episode is a stable set of activities over a longer period typically (Newman and Robey, 1992; Robey and Newman, 1996).

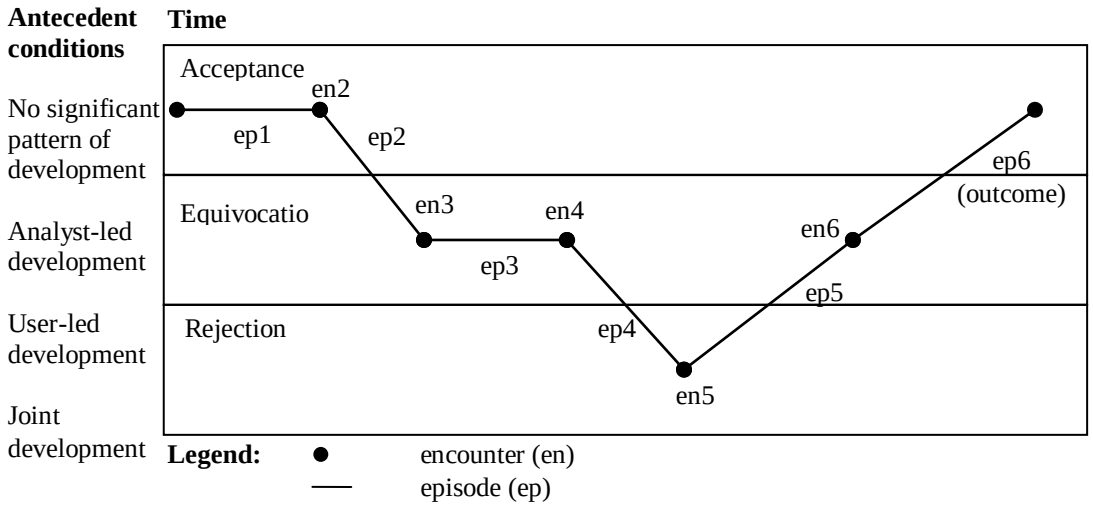

Figure 2: Mapping events in a social process (Newman and Robey, 1992)

To understand the nature of IS change, the model is further elaborated by the concept of punctuated equilibrium (Gersick, 1991). According to Gersick (1991), there are two levels of IS change which are described as first and second order change. First order change occurs when the change is continuous and incremental over time or during periods of stable infrastructure with incremental adaptations (Gersick, 1991). Second order change involves episodic punctuations or brief periods of revolutionary upheaval (Gersick, 1991). Although not specifically stated by Newman and Robey (1992) the social process model tries to elaborate the relationship between the users and analysts. It elaborates the evolution different lines of work between the users and the analyst and shows how activities of one party affect the others within the project trajectory.

The process model (Figure 1) also integrates an understanding of the antecedent condition or the history of the IS development project and how it affects outcomes. Antecedent conditions usually encompass prior projects outcomes and their influence upon new projects (Newman and Robey, 1992). In other words, users and analysts involved in the current project will transfer their experience and expectations from prior projects, which, in turn, affect how they will perceive their current project.

Any episodes of user-led, analyst led or joint development will be considered as first order change where the development is incremental. Changes from user-led to analyst-led or even joint development will still be considered as first order change if it does not create a punctuation or upheaval e.g. resistance by either users or analyst towards the project. The second order change on the other hand will usually result in punctuation. It will cause the project to either continue incrementally or be in a state of equivocation, or even be abandoned.

In relation to the outcomes, the model restraints itself from viewing IS development through the success or failure dichotomy. Rather, the outcome is being conceptualized as a state of relationships either user-led, analyst-led or joint development (Newman and Robey, 1992). When a state of equivocation occurs, the future project will be surrounded by high level of risk or uncertainty due to lack of commitment from project teams (Newman and Robey, 1992).

There is no specific method or approach identified as a means of event identification. This happens rather through an observation of incidents, usually mediated through the narratives of the interviewees. It is up to a researcher and her interpretive judgement of what counts as an event (Newman and Robey, 1992; Robey and Newman, 1996).Yet, since the model represents a ISD as simplified model of reality in terms of events, the identification of the events is a critical for adequate explanation.

Robey and Newman (1996) have further elaborated the model by focusing on the capability of the model's project trajectory to support alternative theoretical interpretations: the rational and segmented institutionalist perspectives (Kling, 1980). The application of these perspectives extends its applicability in making sense of the complex social process of ISD (Robey and Newman, 1996). According to Sabherwal and Robey (1995), the process model by Robey and Newman (1996) "enables preservation of detailed information about specific events and their temporal order". This observation is made in comparison to the stage model which is shown to restrict the details of events (Sabherwal and Robey, 1995).

Several applications of the social process model illuminate its benefits in accounting ISD outcomes. It has been methodologically used as a 'lens' to understand the relationship structure between project team members (Holmstrom and Henfridsson, 2006; Holmberg *et al.*, 2008) or assisting in viewing large project datasets by condensing them into project trajectories (Heiskanen *et al.*, 2008; Holmberg *et al.*, 2008).

3 The punctuated socio-technical information systems change (PSIC) model

An extension of this model, later named the punctuated socio-technical information systems change (PSIC) model, was elaborated by Lyytinen and Newman through various working papers from 2004 to 2006 and completed in 2008 with their article published in EJIS in 2008 (Lyytinen and Newman, 2008). This model has been applied empirically in a variety of settings (see Newman and Zhu, 2007; Newman and Zhao, 2008 and Newman and Zhu, 2009). The most significant extension of the social process model is the incorporation of Leavitt's (1964) socio-technical model and layering of the change in several levels of change (Figure 3).

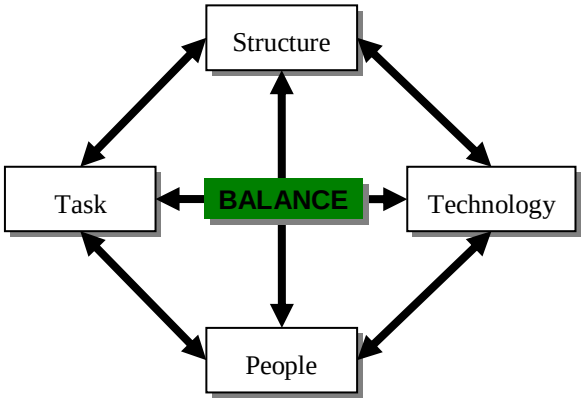

Figure 3: Leavitt (1964) socio-technical model

The incorporation of the socio-technical model is based on Lyytinen's prior work on software risk management (see Lyytinen *et al.*, 1996). The application of the socio-technical theory in the extended process model was "*to characterize the content and the engine"* of the IS change (Lyytinen and Newman, 2008). Within the Leavitt model, it is assumed that at anytime, the relationship, alignment or interrelation (Keen, 1981) between the four organizational elements (task, structure, technology and people) are always in equilibrium and mutually adjusting (Keen, 1981). According to Leavitt (1964), the four elements are highly interdependent and a change in any one of the elements results in a compensatory (or retaliatory) change in the other elements. According to Lyytinen and Newman (2006), the reason for adopting the Leavitt model was due to its *"open system model of change"* that is "simple, extensive, well defined and grounded in the extant theory" (Lyytinen and Newman, 2008). The model can also be easily extended or adapted across different contexts to include other categories for a richer vocabulary (see Kwon and Zmud, 1987). The Leavitt model also easily connects with

or adapts to other related concepts within the model. The elements of interaction, alignment and adaptation to changes correspond to Gersick's (1991) punctuated equilibrium concept (Lyytinen and Newman, 2006). Following Lyytinen *et al*. (1996), the adoption of the Leavitt model provided a more systematic way to identify events and their socio-technical components in ISD trajectory.

The extended model also further elaborates the multi-level work system concept. A work system is a view of work occurring through a purposeful system (Alter, 2002) and IS development as a change agent will re-configure the work system (Lyytinen and Newman, 2008). Accordingly, within an IS development process there are multiple, complex processes. In fact, information systems development constitutes a special case of work systems change. Alter (2002) further clarifies the overlap between work and information systems and suggests that information systems can be characterised as part of work systems within the organisation. A process model, however, which captures the development of a new information system, cannot be considered as part of the work system.

Therefore, following Alter (2002) and building on recent research (Lyytinen and Newman, 2006; Lyytinen and Newman, 2008; Newman and Zhu, 2009), a new work system called the building system that specifically illustrates the ISD change, is erected. Like the work system, the building system will require resources, as it carries out the change. This concept of multi level (Lyytinen and Newman, 2008), parallel processes (Newman and Zhu, 2005) or a hierarchical (Lyytinen *et al.*, 1996) approach in IS development process has its origins in Newman and Robey's (1992) paper. In their paper, they segregate the task of the user from the task of the analyst through the identification of boundary conditions (Newman and Robey, 1992). In Lyytinen *et al.* (1996), a three layers software development framework can then be formulated to depict ISD environment which intertwines change processes at the levels of systems, project and management environment.

The extended model incorporates / introduces the external environment of the project (Lyytinen and Newman, 2008). This environment is further divided into organizational context which include resource, authority, culture and political systems and environmental context that includes the organization's social, economic, political, regulatory and competitive environment (Pettigrew, 1990; Lyytinen and Newman, 2008).

The development of these multi level systems suggests new analytical opportunity that would improve our understanding of IS change. Lyytinen and Newman (2008) argue that two modes of analysis need to be incorporated into the model: vertical and horizontal analyses (Figure 4). Vertical analysis captures the interactions and interdependencies between different system levels. It answers the question: how the activities or events that occur in one level subsequently affect other levels. The horizontal analysis permits the tracking of temporal interactions (Lyytinen and Newman, 2008) that capture the path dependencies of events and activities within the work and the building systems.

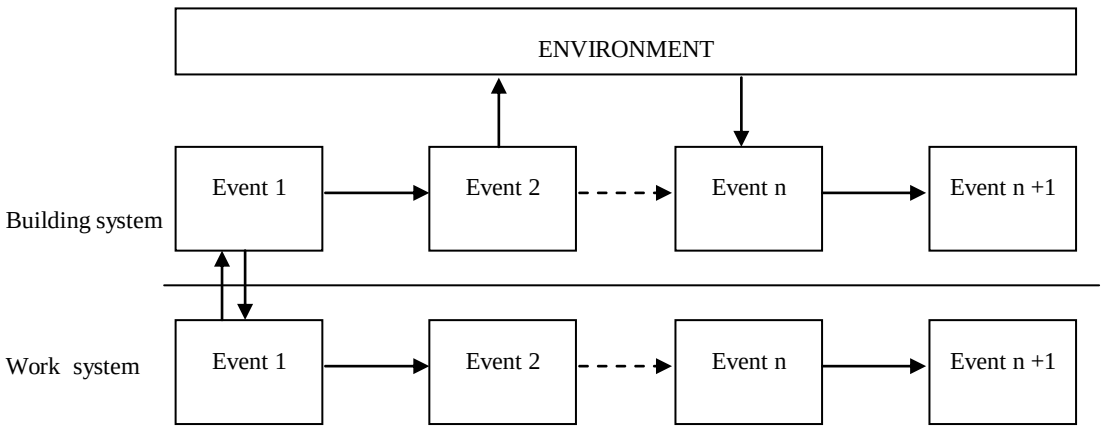

Figure 4: Multi-level IS change (adapted from Lyytinen and Newman, 2008)

This model helps elaborate the notion of punctuated equilibrium (Gersick, 1991) underlying the social process model (Newman and Robey, 1992; Robey and Newman, 1996). The social process model only touches the multi-level explanation of change which is defined at the first order level to constitute incremental adaptations and at the second order level to involve short periods of revolutionary upheaval (Newman and Robey, 1992). In their elaboration, Lyytinen and Newman (2008) recognize the other three characteristics (Gersick, 1991) of a punctuated change and its relevance to IS change. The first characteristic is the notion of deep structure. Within IS, change embeds a deep structure which according to Gersick (1991) is *a network of fundamental, interdependent choices* where *units are organized* and *activities are maintained* which ensure the existence of the system (Gersick, 1991; Lyytinen and Newman, 2008). This is followed by the concept of equilibrium periods (Gersick, 1991) or periods of stability (Lyytinen and Newman, 2008). While deep structure refers to sets of choices, the equilibrium period is where these choices are chosen and maintained (Gersick, 1991). According to Tushman and Romanelli (1985), the equilibrium or stability is due to inertia derived from routinization, cognition, motivation and obligation of organizational environment. Lyytinen and Newman (2008) however argue that the system will not always be in equilibrium. It will drift and change throughout the period but still maintain its deep structure. In Gersick's (1991) opinion, systems make incremental adjustment without changing their deep structure. The final characteristic is the notion of system upheaval (Lyytinen and Newman, 2008), or revolution (Gersick, 1991). According to Gersick (1991) the revolutionary change dismantles the deep structure. In a revolutionary period, the change is not incremental but occurs through wholesale upheaval (Gersick, 1991). Lyytinen and Newman (2008) argue that there is nothing revolutionary or radically new about the punctuations, but that it is a brief period of sudden change or upheaval. These changes will cause the system to erect a new deep structure which combines elements of the old and offer a new set of choices (Gersick, 1991; Lyytinen and Newman, 2008). Occasionally, the system upheaval also fails and the system returns to its original deep structure, or it can become continuously disarrayed (Lyytinen and Newman, 2008) leaving the system worse off (Gersick, 1991).

Figure 5 depicts how the notion of a system upheaval can be applied in the process modelling (Lyytinen and Newman, 2008). The interim state of punctuation caused by project change creates gaps between the project elements which were previously in balance. This punctuation is produced by critical events (Lyytinen and Newman, 2008). In this case the critical event will cause the deep structure to be dismantled. Actors will intervene to stabilise the deep structure or to align the interaction between project elements (Lyytinen and Newman, 2008). These interventions sometime fail and create further gaps between the elements (Lyytinen and Newman, 2008, p. 600).

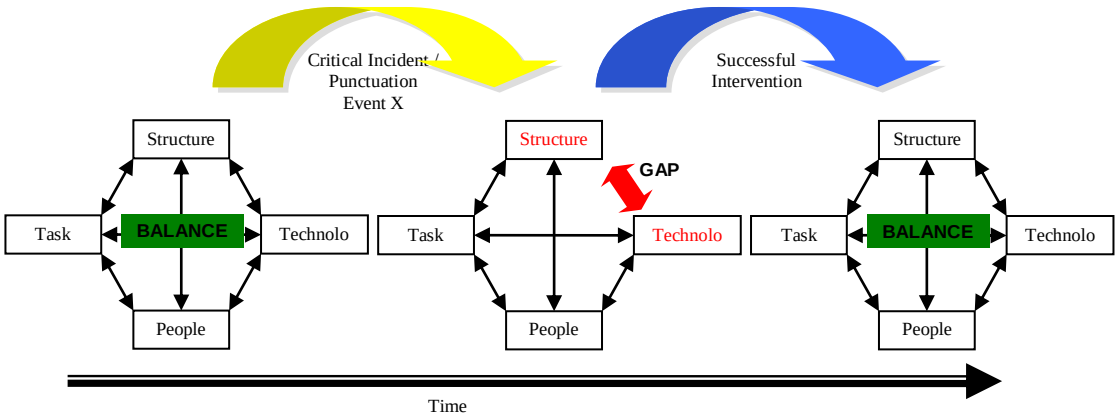

Figure 5: Event model of socio-technical change (adapted from Lyytinen and Newman, 2008)

The adaptation of process theory (Mohr, 1982; Pentland, 1999; Van de Ven *et al.*, 1999) consists of two parts. The first part encapsulates the notion of process as a sequence of events (Mohr, 1982). It provides an understanding of how history affects the events and how events generate outcomes. The other part of process theory is the notion of a narrative explanation (Pentland, 1999) which is given less consideration in the development of the PSIC model (Lyytinen and Newman, 2008). Narrative explanation was used as a tool to contextualise the environment into the different layers of the PSIC model (Lyytinen and Newman, 2008). These narratives were based on the analysis of the sequence of events through out the change process.

Although process research was mentioned to be labour-intensive involving collecting vast amount of data (Van de Ven and Poole, 2005), the elegance of the PSIC model lies in its capability to compress vast data sets providing a clear graphical depiction of the project trajectory (Lyytinen and Newman, 2008). This is supplemented by the explanation of the processes through narratives or story telling which is considered as a difficult undertaking due to the depth and complexity of the process data (Van de Ven and Poole, 2005). Pentland (1999) has provided features to be included in the process narrative or stories which include identifying the chronology of events, focal actors or actors that established events, narrative voice, frame of reference and substance and context of the stories. Further, to this critical explanation of the relationships and patterns of events can be made through different theoretical lenses. For example, Bob-Jones *et al.* (2008) applied actor-network theory to explain the relationship between the different network of stakeholders in a IS development project (Bob-Jones *et al.*, 2008). Following the PSIC model, Lyytinen *et al.* (2009) applied institutional theory to make sense of how ERP systems are adopted and institutionalised.

4 Position of the PSIC model within diverse research streams

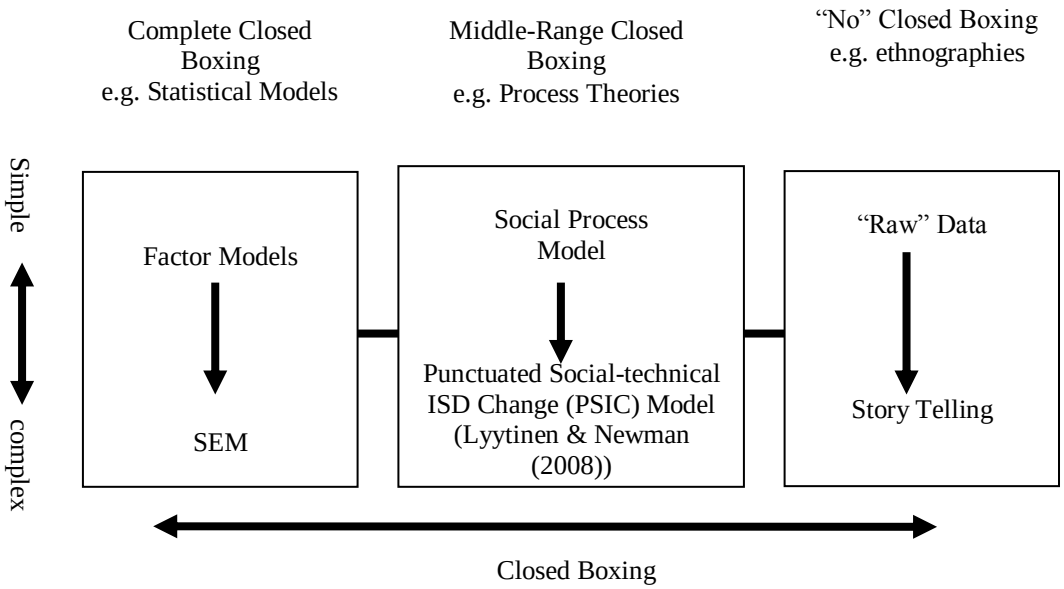

Figure 7: Position of the PSIC model within IS research stream (adapted from Lyytinen and Newman, 2008)

While identifying the position of the PSIC model within different position of relating data in theory in process accounts, we need to introduce the notion of closed-boxing. Here, the closed-box constitutes multiple elements (actors) and their complex associations viewed as a unitary whole (Callon, 1986).

Adapted from actor-network theory (where it was called black-boxing), the idea of closed-boxing plays an important role in simplifying the complexity in IS phenomena (Tatnall,

2003). Within the process research context, closed boxing can be referred as the encapsulation of the change process. Following this, we can identify multiple research streams with regard to the degree of the closed boxing applied within them.

Figure 7 depicts the magnitude of closing or opening of the 'box' in IS process research. Variance based studies deploying e.g. Structural Equation Modelling (SEM) are an excellent example of a closed box scenario. As discussed in prior sections, variance research takes into consideration only the degree of association between the precursors i.e. independent variables, with the outcomes i.e. dependent variables. Therefore, it is observed that the processes within which the variables are tested are ignored or closed-boxed. At the other end of the spectrum, ethnography offers a means to identify and understand peoples' way of life, viewing it from "native" eyes (Spradley, 1979). These understandings are manifested through the researcher's detailed narrative and story telling. In this scenario, almost all processes or events are identified diachronically and explained. The stories produced are transparent enough for other people to understand the culture and the way of life.

The PSIC model or its simpler social process variants are neither completely closed boxed nor completely opened as a box. Within such process studies, critical consideration is given towards how and why an outcome is achieved by looking at the process as a series or sequence of events (Mohr, 1982; Markus and Robey, 1988). Therefore, it cannot be considered as closed boxed like variance or factor models. However, it cannot be seen as ethnographic research since not all events that occur are considered. Only critical events are identified from the multiple sources of evidence. Within this middle range closed boxing, multiple events that occur are thus conflated to denote episodes (Newman and Robey, 1992) to account for the first order (incremental) or the second order (revolutionary upheaval or punctuated) change (Gersick, 1991; Lyytinen and Newman, 2008).

5 Conclusion

The two definitions of change epitomise the duality of research about organizational change generally, and IS specifically. While it is agreed that both variance and process theories, are complimentary their combination is not advisable (Mohr, 1982; Newman and Robey, 1992; Sabherwal and Robey, 1995). The evolution of our process model from its inception has gone through major developments. It has evolved from a simple social process account into a more complete account of socio-technical change. We argue that these developments are in-line with the ever changing complexity of IS research. The PSIC model rejects the closed boxing of process, but limits its exploration to critical events only. The non-restrictive nature of the PSIC model ensures details of the critical events are kept intact (Sabherwal and Robey, 1995). As a model is "a simplified picture of a part of a real world" (Lave and March 1975), the articulation of the PSIC model attempts to collate vast process data sets into a structured trajectory of process events thus improving our understanding of complex IS change. At the same time it depicts subjects' experience more effectively (Kling, 1987; Markus and Robey, 1988) and preserves details of shared events (Sabherwal and Robey, 1995). A further benefit of these process models is the capability to identify patterns in the project trajectory. A more systematic identification of critical events is needed to improve the methodological aspect of the PSIC model. In future, we will refine the PSIC model and apply in a variety of settings.

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