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In the recent years, inter-organisational cooperation has been one of the organisational strategies most used to compete and become adapted to the exigencies of the global market. In this context, internal business processes of the cooperative enterprises should interact to pursue common objectives that will be profitable for all parts. Therefore, it is necessary to measure the performance of these business processes under a strategic approach and in a twofold manner, from a global perspective (inter-enterprise) and from an individual or partial perspective (intra-enterprise). Performance Measurement Systems (PMSs) described in the literature that discuss this context are very different in their conception and broadness. This paper describes the basic characteristics that PMSs should fulfil to cover interoperability requirements and a literature review of the PMSs that deal with business process interoperability in order to gain detailed insight into PMS definition for these contexts. From the literature review, a comparison of the PMSs is obtained with regard to eight core characteristics for these contexts: business process representation, business process measurement, business process lifecycle management, PMS intra and interorganisational levels measurement, process-decomposition approach, intra-inter-process connection measurement, interorganisational coordination measurement, and common interorganisational strategy.

Keywords: Interoperability; Extended Business Processes; Collaborative Performance Measurement.

1. Introduction

Inter-organisational cooperation has been one of the most used organisational strategies to compete and become adapted to the exigencies of the global market. Thus, collaboration is becoming more a necessity than an option (Matopoulos *et al.*, 2007). For this reason, the internal business processes of the cooperative enterprises should interact to pursue common objectives that will be profitable for all the parts. However, although the importance of supply chain relationships is widely acknowledged, seamless coordination is rarely achieved in practice (Trkman *et al.*, 2007).

Enterprises look for organisational models and tools able to manage these processes at both inter and intra-organisational levels. In this context, it is necessary to measure the performance of these business processes in a twofold manner, from a global perspective (inter-enterprise) and from an individual or partial perspective (intra-enterprise). The business processes acquire an extended nature, in which two or more enterprises or organisations participate. One of the definitions in Interop (2008) characterises process

interoperability as the "ability of different processes to work together and exchange information, data, control information, etc.". Therefore, solving the problem of interoperability becomes essential, as it will favour the evolution of organisations towards interoperable environments. Thus, it appears the concept of collaborative performance which must be measured and managed.

This paper describes the basic characteristics that PMSs should fulfil to address process interoperability requirements as well as a literature review of the PMSs that have to do with business process interoperability. The purpose of the literature review is to compare and analyse the contents of the PMSs based on the characteristics that they should comply to deal with business process interoperability for identifying main strenghts and gaps for future research. This type of interoperability framework refers to all those actions carried out with the aim that two or more processes share, exchange and use different types of resources (informational, human, etc.) for the benefit of the global system. The methodology used for the literature review follows a constructivist approach (Kasanen et al., 1993; Coughlan and Coughlan, 2002). The initial stages, when applying this approach, consist of the identification of a problem of practical relevance, its theory connection and acquisition of main postulates. For performing the search, keywords such as 'performance measurement system', 'supply chain collaboration', 'collaborative performance measurement system' were used on relevant publisher databases such as Emerald (www.emeraldinsight.com), Elsevier (www.sciencedirect.com), Taylor & Francis (www.tandf.co.uk/journals) and other library databases (https://tais3.cc.upv.es/V?RN=206089182). The time period covered is from 2000 to 2008. The papers resulting from the search were reviewed by the authors for selecting those meeting the objective of this paper. After reading through the selected papers, few additional materials were obtained from bibliographic scans.

The structure of this paper is as follows. The next section presents the background. Section 2 describes the characteristics that a PMS should present to deal with interoperability of the business processes. Section 3 presents a literature review of PMSs that have to do with business process interoperability. Section 4 exposes an analysis and comparison of the PMSs reviewed based on the business process interoperability characteristics that they cover. Finally, conclusions and research implications are exposed.

1.1. Background

In the recent past, different concepts that aim to approach both the business processes interoperability issue and associated mechanisms that help to measure its performance (collaborative performance) have been in use. As starting point, it is considered necessary to review some definitions and descriptions of the terms most frequently used within this context. Concepts such as extended business process, inter-organisational process, or collaborative process, among others, are indistinctly used. Besides, "collaboration" is an amorphous meta-concept that has been interpreted in many different ways by both organisations and individuals, and when it is put in the context of the supply chain it needs yet further clarification (Barrat, 2004).

However, in most occasions, all these terms are used to refer to contexts of (i) *extended and/or virtual enterprises*, (ii) *supply chain management*, and (iii) *enterprises networks*, which are widely shared in the literature. One of the concepts most used is that of

extended business process, which, according to Bititci *et al.* (2005) is "the integration of the business processes of individual enterprises" (Figure 1). In this definition, the term integration might leave the concept of extended business process too broad, raising some questions: What are the implications of business process integration for individual enterprises? Is it enough to ensure collaboration between these processes? Is the participation of all the enterprises in the design of one business process necessary?, etc.

Figure Caption. Figure 1. The extended business process. Source: Bititici *et al.* (2005)

It is not the purpose of this work to establish a limitation to the concept of extended business process but to detail the scope of this concept to approach the issues derived from the measurement and management of these processes. Another definition that is not opposed to the one mentioned above states that extended business process is "a process where two or more enterprises participate, independently of the degree of cooperation/collaboration existing between them". Figure 2 shows a representation of this concept that illustrates an example with 4 extended business processes among three enterprises (A, B and C).

Figure 2. Concept of extended business process

It is necessary to briefly comment about the efforts that some authors are making in order to try to clarify what is the level of compromise or collaborative degree between the enterprises that take part in these extended business processes (extended enterprise and/or collaborative supply chains), and determine the degree of interoperability of these processes. In any of these versions of collaborative organisations the aim is that several processes of different enterprises collaborate following given procedures and rules commonly accepted in order to reach common goals and objectives. Then, the design of the PMSs will be tailored to the specific context by a given degree of compromise or collaboration. In this area, the works of Matopoulos et al. (2007), Barrat (2004), Angerhofer and Angelides (2006), Childerhouse *et al.* (2003) and Zdravcovich (2006) stand out.

Matopoulos *et al*. (2007) suggest an overall framework for supply chain collaboration. Two pillars are distinguished within the framework which deals with the design and the government of supply chain activities, and the establishment and maintenance of supply chain relationships, respectively. Barrat (2004) develops a model that characterises supply chain collaboration in three main blocks: strategic, implementation and cultural elements. Angerhofer and Angelides (2006) expose that there are three levels to differentiate: operational, managerial and strategic. Childerhouse *et al.* (2003) distinguish the following five phases when looking at the maturity of the degree of collaboration of the enterprises participating in the extended process or processes: ad-hoc, defined, linked, integrated and extended.

However, it could be simpler and more comprehensible to use three possible scenarios where the extended business process can interact: (i) cooperative scenario, (ii) collaborative scenario; and (iii) cooperative and collaborative scenario. Enterprises working within the cooperative scenario carry out their activities and/or sub-processes and their aggregation forms the extended business process. Even though there is an awareness of when such a process starts and ends, it is not necessary for the participating enterprises to have a global knowledge about it. On the other hand, enterprises operating under the collaborative scenario have, to some extent, participated

in the design of the process. Finally, enterprises under both cooperative and collaborative scenarios present both types of extended business processes depending on the relationship established with their partners. In addition to the scenario in which the enterprises operate, the process can be more or less complex to manage and, therefore, to have its performance measured. Thus, the extended business process represented in Figure 3 is far less complex in terms of execution, management and measurement than the one in Figure 4. Such differences in complexity are evident when Figures 3 and 4 are graphically compared.

Figure 3. Concept of low complexity extended business processes. Source: Adapted from Franco and Ortiz (2006)

Figure 4. Concept of high complexity extended business processes. Source: Adapted from Franco and Ortiz (2006)

It is also interesting the reasoning exposed by Blanc *et al.* (2007) regarding the problem of interoperability/heterogeneity and how the systems should evolve to reach it. The complexity of an inter-organisational context, and consequently, the complexity of the extended business processes are, from the majority of points of view, much higher than the complexity of an intra-organisational context and business processes, as it is its organisational structure (Bititci *et al.*, 2003). Hence, the definition of key performance indicators presents different difficulties to be taken into account (Lambert and Pohlen, 2001; Rafele, 2004). Recently, Camarinha-Matos and Abreu (2007) have introduced an interesting approach for the analysis of benefits in collaborative processes by introducing a number of performance indicators.

Among the most cited PMSs that deal with the interoperability of business processes, in a higher or lower depth, are the following: Supply Chain Balanced Scorecard Framework (Brewer and Speh, 2000); Gunasekaran Framework (Gunasekaran *et al.*, 2001); Integrated Measurement System (Bullinger *et al.,* 2002); Process-Based Framework (Chan and Qi, 2003); Supply Chain Performance Metrics Framework (Gunasekaran *et al.*, 2004); Extended Enterprise Performance Measurement System (Folan and Browne, 2005); Extended Enterprise Performance Measurement Model (Bititci *et al.*, 2005); Communications Framework for Extended Enterprise Performance Measurement (Folan *et al.*, 2006); Model and a PMS for Collaborative Supply Chain (Angerhofer and Angelides, 2006) and Framework to Analyse Collaborative Performance (Gruat La Forme *et al*., 2007).

Some authors have tried to classify the existing frameworks following some logical criteria. The classification (see Figure 5) performed by Folan and Browne (2005) distinguishes two typologies of performance measurement frameworks: procedural performance measurement frameworks and structural performance measurement frameworks.

Figure Caption. Figure 5: Frameworks for inter-organisational performance measurement. Source: Folan and Browne (2005)

However, it is still necessary to gain detailed insight into the definition of extended business processes environment and context; interoperability of the extended business processes; and the way of measuring the extended business processes performance. In this sense, Busi and Bititci (2006) define a research agenda for the following years

whose essential points are: understanding the structure and dynamics of collaborative enterprises, understanding extended processes structures and operations, developing a structured methodology to design the PMS, and specification of integrated /interoperable collaborative computing technologies.

2. Characteristics of PMSs to tackle business processes interoperability (collaborative environments)

The characteristics of a PMS for collaborative environments are related to the requirements that should be covered by the PMS in order to be considered solid and integrated. This implies that the PMS should provide all the necessary functionalities to approach the context for which it was developed. Additionally, this PMS should support the decision-making process of the enterprises and entities that participate in the extended business processes.

One of the basic elements that helps to improve the interoperability of the extended business processes is the correct design of their lifecycle. In this sense, Lockamy and McCormack (2004) link the lifecycle to the "process maturity". The concept of process maturity proposes that 'a process has a lifecycle that is assessed by the extent to which the process is explicitly defined, managed, measured and controlled'. Therefore, an adequate connection between the engineering scope (definition, representation, design and construction) and the operational scope (execution and analysis) of the process should be addressed. Figure 6 shows four extended business processes belonging to three enterprises that are performed at the intra-organisational (white area) and inter-organisational (represented by a grid) levels as well as their lifecycle phases. The process lifecycle must be designed following a global functional framework; i.e, it is necessary to think about the extended business process and its necessary interoperability. In this sense, it is usual that organisations firstly establish the engineering scope as if it belonged to a single enterprise and then, assign the tasks to be performed by all the enterprises participating in the extended business process according to their abilities and roles. However, this procedure is not convenient, as it implies to separate the engineering scope from the operational one, being the link between these two scopes essential to close the extended business process lifecycle.

Figure 6. Business process lifecycle: Scopes

PMSs that tackle business process interoperability should include performance indicators that provide relevant information about the status of the business process during all the phases of its lifecycle. This characteristic is necessary to be able to manage the whole process lifecycle and avoid some issues that may occur. For example, if the execution phase has got a long duration, the analysis phase will start after it and results obtained from the analysis may be probably available too late to provide useful feedback. Another common example is the incorporation of a new partner within the business process. In this case, the extended process has not only to be reviewed to accommodate the new set of activities and roles but it should also check the applicability of the performance indicators used by all the enterprises. Therefore, if PMSs are to manage business process interoperability, they should tackle the dynamics of the business processes by considering their lifecycles.

Another basic element that helps to improve the interoperability of extended business processes is to find out to what extent the process is efficient and effective with respect to the interoperability criteria established. It is therefore necessary to measure the performance of these business processes from a global perspective (inter-enterprise) and individual perspective (intra-enterprise).

Regarding the extended business processes management scope, the PMS should cover the following basic requirements: measuring both inter and intra-processes connection (interoperability environment); measuring the degree of coordination between activities belonging to the extended business processes (which is necessary as linking an intraorganisational process to an interorganisational process does not imply that this link is performed in a coordinated manner. Coordination is intended to ensure that performance of the interorganisational process is maximised towards the achievement of the goals); measuring the performance of the activities involved within each extended business process (which implies that the PMS follows a process-decomposition approach) so that performance can be monitored following a top-down deployment path until reaching the activity/ies that excel or present any shortcoming. Regarding technology, measuring the degree of implication, efficiency and effectiveness of the IT used for managing the extended business processes at different levels. It should be pointed out, as suggested by some authors (Bourne, 2001; Garengo *et al.*, 2007), that one of the main barriers to have an adequate PMS is due to the lacking of an inappropriate information system. Finally, the PMS must evaluate the contribution of each enterprise to the objective/s of the extended business process.

In addition to the specific process lifecycle requirements, it is important to remind that the characteristics of the PMSs have evolved according to the growing complexity of both organisations and competitive environments. Thus, the requirements to be covered by a PMS have been widely treated within the academic literature. Bititci *et al.* (1998) defined those basic requirements necessary to be covered by a PMS in order to be robust, efficient, effective and integrated. These requirements were later completed by other authors (Alfaro *et al.*, 2002; Alfaro, 2003) in order to adapt the PMS to current environments. The added complexity of business processes interoperability, in which two or more enterprises participate, entails the following extra difficulties: higher difficulty in establishing objectives and strategies common to all the enterprises that participate in the extended business processes and selecting the partial and global indicators of these processes; treatment of the information (standardisation) coming from the different enterprises in order to manage the global environment; higher difficulty in establishing links and equity relationships that facilitate the necessary trust to collaborate in order to reach a proportional distribution of risks, investments and rewards among the all parts. If equity does not exist among the enterprises participating within the extended business process, it is practically impossible to create an environment of trust that enables the information exchange necessary to reach an adequate degree of efficiency from a global point of view. The work of Leseure M. *et al.* (2001) is in the same line.

3. PMSs that deal with business processes interoperability

The amount of PMSs that deal with business process interoperability is not vast in the literature, although there has been an increasing interest during the last years. Brewer and Speh (2000) present an adaptation of the Balance Scorecard (BSC) (Kaplan and

Norton, 1992), initially developed for individual enterprises, for measuring SC performance. The BSC considers four perspectives in order to measure performance: customer, financial, internal business process, and innovation and learning. The work exposes the need to link the individual enterprise BSC to the SC BSC. In the SC BSC, four generic SC goals (waste reduction, time compression, flexible response and unit cost reduction) are pursued by the business process perspective. Examples of business process interoperability measures are provided for achieving these goals.

Gunasekaran *et al.* (2001) develop a framework of metrics for SC performance evaluation. The framework associates metrics to measure the basic SC business process (plan, source, make/assemble and deliver) interoperability. The measures are classified into strategic, tactical and operational management levels as well as financial and non-financial. In Gunasekaran *et al.* (2004), the framework by Gunasekaran *et al.* (2001), is used to develop an empirical study in British companies that categorises the importance of the framework metrics. The result of the study is a SC performance metrics framework that classifies the metrics in order of importance within two dimensions: SC business processes and management levels. Bhagwat and Sharma (2007) present a BSC for supply chains that categorises the SC metrics framework by Gunasekaran *et al.* (2001) within the four perspectives (financial, customer, internal business, and innovation and learning) by Kaplan and Norton (1992). As in the work of Brewer and Speh (2000), the internal business perspective collects the metrics to measure SC business process interoperability.

Bullinger *et al.* (2002) expose an integrated measurement methodology for supply network logistics process performance that integrates SCOR (Supply Chain Operations Reference) metrics (SCC, 2001) into the supply network (SN) BSC (Kaplan and Norton, 1992). The aim of the network scorecard is to monitor logistics business objectives by measuring management performance. The SCOR metrics aims at measuring material and product flow performance. The methodology considers that three levels of interoperability must be measured: function unit, process and supply chain/network.

Chan and Qi (2003) develop a process-based approach for measuring SC performance. The approach starts by considering the SC strategy in order to define the SC core processes. The SC core processes are decomposed into sub-processes and then, sub-processes are decomposed further into activities. A board of metrics is associated to each process unit (core process, sub- process and activity) comprising different dimensions such as cost, time, capacity, capability, productivity, utilisation and outcome metrics. Theeranuphattana and Tang (2008) present a SC PMS by combining the work by Chan and Qi (2003) and the SCOR process approach and metrics (SCC, 2006).

Bititci *et al.* (2005) expose the EE PM model that is composed of three functional levels: EE, business unit and business process level. At the business process level, the performance of the different extended processes is measured. For each extended process, there are two types of scorecards: sub-process and extended business process scorecards. The sub-process scorecard is the one used for measuring the operational performance of the part of the extended process (or sub-process) under the responsibility of every enterprise belonging to the EE. The extended business process scorecard intends to measure the operational performance of the overall extended process through the whole EE.

Chalmeta and Grangel (2005) develop a PMS methodology for virtual enterprises (VEs) considering two levels: virtual and individual enterprise. The methodology comprises: definition of the VE mission and values; identification of VE strategic objectives; selection of cause indicators for VE; selection of effect indicators for the identified cause indicators and establishment of cause-effect relationships. Once the VE is defined, their aspects have to be deployed into individual enterprises, departments, processes and activities. The authors present a case study where the VE PMS considers different perspectives including the internal business process perspective.

Folan and Browne (2005) present a PMS for Extended Enterprise (EE) performance measurement composed of two levels: individual node of the EE and EE levels. The PMS is based on a balanced scorecard approach, containing four perspectives for each individual node: internal, supplier, customer and EE perspectives. The EE perspective at each node is intended to measure the contribution of each node to the EE. The measures in this perspective at each node will be aggregated upon an EE level. The combination of the different EE perspectives from each node will provide the whole EE PMS. In this work, a case study is presented where the EE PMS considers process perspectives such as control process quality, inbound logistics and outbound logistics and some selected performance measures; although a process-based decomposition approach is not explicitly defined within the PMS.

Angerhofer and Angelides (2006) develop a model and a PMS for measuring collaborative SC performance that consist of six interacting elements: stakeholders, levels of collaboration, business strategy, processes, enabling technology and topology. Each element possesses a set of performance variables quantified by their corresponding indicators. In this work, the structure of the business is also taken from SCOR (SCC, 2001).

Alfaro *et al.* (2007) present a PMS for enterprise networks (ENs) comprising a methodology and a framework. The framework consists of three dimensions: functional level (individual enterprise, supply chain and enterprise network), BSC performance perspectives (financial, customer, process, and learning and growth) and performance structure (philosophical planning, stakeholder requirements, objectives, strategies, critical success factors and key performance indicators). For each core process defined from the strategy, the four perspectives provide the elements to monitor performance under a balanced approach while coherence is to be maintained through the three functional levels. This fact is shown by graphics of global and partial deployment.

Gaiardelli *et al.* (2007) develop a PMS for the automotive after-sales service network that is composed of four functional levels: business, process, activity and organisational unit, and development and innovation. The process level is measured by three dimensions: customer satisfaction, flexibility and productivity.

Gruat La Forme *et al.* (2007) expose a framework to analyse collaborative SC performance that considers ten main business process according to the position of each enterprise within the SC: supplier collaboration and supply logistics (downstream); lean manufacturing (internal); customer driven SC, transport and distribution, and demand driven sales planning (upstream); reverse logistics, integrated supply chain management, product design, and product development and evolution (cross-supply

chain). Process performance is evaluated by a set of performance indicators and a perceived collaboration-oriented performance profile.

4. Analysis of PMSs

From the literature review of PMSs (section 3) and the characteristics of PMSs to tackle business processes interoperability exposed on section 2, a comparison of the reviewed PMSs is presented on Table 1. Evaluation remarks are presented in the remaining of this section. For performing the comparison, eight relevant characteristics that deal with business process interoperability have been considered: 1) business process representation (BPR), 2) business process measurement (BPM), 3) business process lifecycle management (BPLM), 4) PMS intra and interorganisational levels measurement (PMSII), 5) process-decomposition approach (PD), 6) intra-inter-process connection measurement (interoperability environment) (IIPCM), 7) interorganisational coordination measurement (CM), and 8) common interorganisational strategy (ST). The criteria followed to evaluate the PMSs comprises three levels: 1) PMS does not include the characteristic (blank space), 2) PMS includes the characteristic in low detail (represented by '√'), and 3) PMS includes the characteristic in high detail (represented by '√√').

Brewer and Speh (2000) provides a SC scorecard framework that considers process measurement in the business process perspective, links the SC scorecard to the individual enterprise scorecard and provides some SC coordination measures in the innovation and learning perspective. However, this approach does not make explicit the representation (mapping) of the processes what would establish a sound understanding of the process (within the engineering scope) as a basis for defining performance indicators or process decomposition into activities that would give a deeper characterization of the processes implemented and to be measured. Gunasekaran *et al.* (2001) and Gunasekaran *et al.* (2004) provide a top level process decomposion into the SC plan, source, make/assemble and deliver processes considering SC performance indicators (e.g. total cycle time within the plan process) and specific-process measures (e.g. production/process cycle time within the production process). In addition, coordinating measures are introduced in the framework such as 'mutual assistance in solving problems' within the source link. However, the framework does not make explicit process mapping or further decomposition of the processes into activities. In addition, a common strategy for the SC is introduced in the work as well as the level of strategic performance indicators but it is not detailed within the structure of the PMS what would allow to deploy SC common strategy (top level) into lower levels. Similarly, Bhagwat and Sharma (2007) include the performance indicators of Gunasekaran's work into a balance scorecard for the SC but does not consider the strategic goals as the initial step to derive the performance indicators of the perspectives. In addition, SC process mapping is not considered as a starting point to define the PMS and process decomposition is not used.

One of the strenghts of Bullinger *et al.* (2002) is providing a general framework for SC performance analysis that comprises three stages: identification (including process description and representation by SCOR model), measurement and conclusion (analysis of performance). All three stages cover various of the stages of the process lifecycle although the work does not make explicit consider the inclusion of performance indicators for providing the status of the processes during all the stages of its lifecycle.

In addition, the PMS follows a process-decomposition approach. Similarly, Chan and Qi (2003) and Theeranuphattana and Tang (2008) provide a process representation and decomposition into subprocesses and activities and, by following this approach, present tools for the measurement of both intra and inter-process connection. One of the main strenghts of Bititci *et al.* (2005) is that it makes explicit within the structure of the PMS the definition of performance indicators for measuring coordination through the interorganisational processes at both strategic and operational levels. However, process mapping is not considered as a starting point for process performance indicators definition. Chalmeta and Grangel (2005) consider that processes have to be decomposed into activities although a process decomposition structure is not made explicit. Similarly, interorganisational and intraorganisational process representation/mapping is presented as an initial activity for the virtual enterprise integration project, however how this stage is related to PMS definition is not specified. In addition, in the case of study that they present, one of the perspectives is designed as 'virtual enterprise integration' which intends to analyse the level of integration reached by the different enterprises. However, further description will be needed to detail how and where integration is to be measured.

One of the noticeable aspects of Folan and Browne (2005) is the consideration of a perspective within each node intended to measure the contribution of each node to the EE what is difficult to find in the literature. However, the work does not made explicit to follow a process approach in the definition of the PMS structure. Angerhofer and Angelides (2006) include the first level of SCOR processes decomposition within the PMS. Nevertheless, process mapping and further decomposition of processes into activities is not specified. It has to be noted that one of the measures that they expose measure strategic coordination through the definition of a performance indicator called 'level of alignment' which intends to measure the alignment of the individual company strategies with the SC strategy. Alfaro *et al.* (2007) provide a PMS that follows a top-down methododology from strategy to core process decomposition and ends with the staeg of follow-up and monitoring. This methodology cover some of the stages of the process lifecycle measurement, however the work does not make explicit the inclusion of performance indicators for providing the status of the processes during all the stages of its lifecycle as in the case of Bullinger *et al.* (2002). In addition, coordinating measures are defined in a case of study such as 'number of meetings regarding collaboration issues between actors of the supply chain', however the PMS does not specify the introduction of coordination measures within its structure. Gaiardelli *et al.* (2007) define one level within the structure of the PMS for process measurement which is deleveloped further into activities (a lower PMS level). However, the need of representing these activities and the inclusion of the strategy within the PMS could be further detailed. Gruat La Forme *et al.* (2007) define one dimension for ten SC processes to measure one relevant factor of coordination: 'information sharing'. However, mapping in detail these processes and a process decomposition approach could be considered to enrich process measurement. In addition, a common strategy for the SC is considered in the work as well as the level of strategic performance indicators but it is not made explicit within the structure of the PMS, as in Gunaserkaran's works.

Table 1. Summary of PMSs that deal with business process interoperability

References	PMS structure for measuring business process interoperability	BPR	BPM	BPLM	PMSII	PD	IIPCM	CM	ST
Brewer and Speh (2000)	Business process perspective (SC BSC)		√		√√		√	√	√√
Gunasekaran *et al.* (2001)	Main four SC processes: plan, source, make and deliver and classification of key metrics for these processes		√		√	√	√	√	√
Gunasekaran *et al.* (2004)	Main four SC processes: plan, source, make and deliver and classification of key metrics for these processes		√		√	√	√	√	√
Bhagwat and Sharma (2007)	Business process perspective (BSC for SC)		√		√		√	√	√
Bullinger *et al.* (2002)	Combination of SN BSC and SCOR metrics	√√	√√	√	√√	√√	√√	√	√√
Chan and Qi (2003)	Process-based decomposition and assignation of metrics to each process unit (core process, sub-process and activity)	√√	√√		√√	√√	√√	√	√√
Theeranuphattana and Tang (2008)	PMS methodology by Chan and Qi (2003) and assignation of SCOR process decomposition and metrics	√√	√√		√√	√√	√√	√	√√
Bititci *et al.* (2005)	Extended business process and sub-processes scorecards		√√		√√	√√	√√	√√	√√
Chalmeta and Grangel (2005)	Business process perspective	√	√√		√√	√	√	√	√√
Folan and Browne (2005)	Perspectives of process quality control, inbound logistics and outbound logistics. Not explicit process-based and decomposition approach within the PMS structure		√		√√		√	√	√√
Angerhofer and Angelides (2006)	SCOR process decomposition and assignation of a set of metrics to process measurement		√		√	√	√	√	√
Alfaro *et al.* (2007)	Three dimensions: process framework decomposition, BSC perspectives and performance structure (objectives, strategies, critical success factors and key performance indicators)		√√	√	√√	√√	√√	√	√√
Gaiardelli *et al.* (2007)	Process functional level measured with three dimensions: flexibility, customer satisfaction and productivity		√√		√√	√√	√√	√	√
Gruat La Forme *et al.* (2007)	Ten SC processes measured through a set of performance indicators and a collaboration-oriented performance profile		√√		√	√	√	√	√

Notes: √ indicates low degree of consideration, √√ indicates advanced degree of consideration
BPR = Business process representation, BPM = Business process measurement, BPLM = Business process lifecycle management, PMSII = PMS intra and interorganisational measurement, PD = Process decomposition, IIPCM = Intra-inter-process connection measurement, CM = Coordination measurement, ST = Common interorganisational strategy

4. Conclusions and research implications

In the recent years, various papers have appeared with the aim of measuring the performance within an inter-enterprise context and/or collaborative environment. The analysed frameworks approach this issue under different concepts, as not all the authors share either the same concept of collaboration among enterprises or the scope associated with this concept. From a scientific point of view, the extended business processes to be managed are frequently treated in low detail.

This paper has presented the basic characteristics that those PMS should have to successfully cover interoperability issues. PMSs that follow the developed recommendations will better help to manage within all their different facets the extended business processes between several enterprises. However, it was not an objective of this paper to offer a designed PMS but to propose the foundations for defining it through its main characteristics.

From the analysed literature review, several observations can be concluded. The PMSs present different structures and elements to measure business process interoperability although they also present common aspects. For example, the SCOR model process decomposition and/or metrics is used in 3 out of 14 PMSs (Bullinger *et al.* (2002); Angerhofer and Angelides (2006); Theeranuphattana and Tang (2008)). In the table can be observed that some works develop greater insight into the degree of consideration of business process interoperability characteristics. For example, the business process decomposition approach is treated in more detail by Bullinger *et al.* (2002), Chan and Qi (2003), Bititci *et al.* (2005), Alfaro *et al.* (2007), Gaiardelli *et al.* (2007) and Theeranuphattana and Tang (2008). Nevertheless, other characteristics such as the management of the business processes life cycle is hardly found (see Bullinger *et al.* (2002) and Alfaro *et al.* (2007)). In these cases, only some stages of the extended business process lifecyle are covered.

The number of reviewed works indicate the increasing interest that PMSs that deal with business process interoperability have recently received in the literature. However, some research implications are have to be noted to make concrete design proposals for PMS that further help organisations to measure the degree of interoperability of their business processes. Regarding the management of business process lifecycle, representation of the processes is gaining attention as 3 out of 14 PMSs consider it in high degree in their structure. Process representation is a fundamental activity as it allows to understand process broadness and (intra and inter organisational) links among the activities that the process involve. Therefore, mapping will aid to design effective measures to manage these processes. In addition, process measurement is encountered in lower or greater extent within all PMSs. 8 out of 14 PMSs consider process measurement in great detail by defining different performance dimensions to measure the whole processes within a solid PMS. However, PMSs should be able to know the status of the business process during all the stages of their lifecycle but only two works (Bullinger *et al.* (2002) and Alfaro *et al.* (2007)) and in low detail consider a procedural framework (as classified by Folan and Browne (2005)) to manage processes. Therefore, if business process interoperability is to be managed broadly and efficently by a PMS, there is a need to research further the consideration of the stages of their whole lifecycles when designing PMSs.

The measurement of the connection between intra and interorganisational processes (interoperability environment) is relevant for knowing the real level of interoperability achieved beetwen the members that participate in the extended processes. 6 out of 14 works consider in great detail this characteristic. But it is not only the connection but also effective coordination what makes interorganisational processes excel at performance. Although all the PMS acknowledge the need to measure coordination within the partners that take part in the collaborative enviroment, only one work (see Bititci *et al.* (2005)) makes explicit coordination measurement within the whole interorganisational processes that take part in the PMS structure. However, the authors do not specify the extent of the relationship attributes to be covered by these type of measures. Therefore, further detail is needed to understand further which coordinating measures are to be integrated within a PMS.

Finally, it has to be noted that defining a common strategy is a main task when defining an interorganisational PMS but also the inclusion of mechanisms that measure the degree of contribution of each partner to the partnership. This is not an easy task but it is necessary as sustainable relationships are based on equity of investments and rewards for all the members. Only one work (Folan and Brown (2005) present a structured PMS for approaching this issue and present a case study where this approach is followed. Further empirical/case study research is needed to validate this structure and enrich theoretical foundations.

Acknowledgments

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Figures

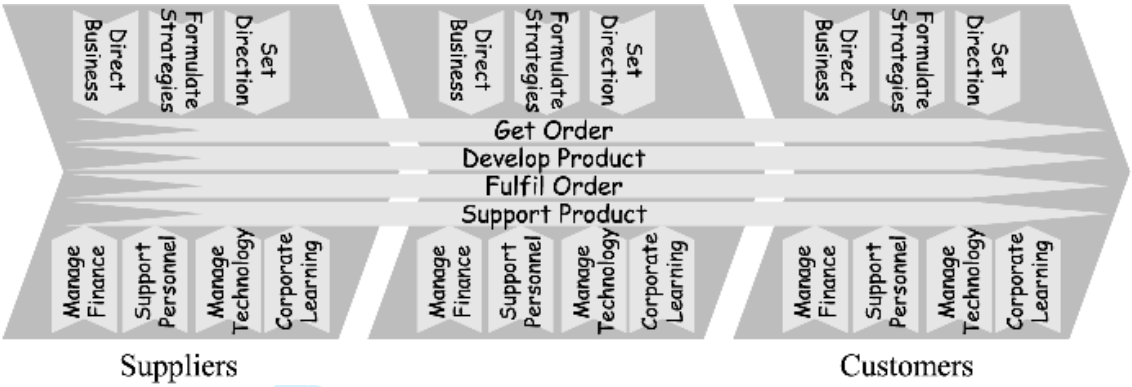

Figure 1. The extended business process. Source: Bititici *et al.* (2005)

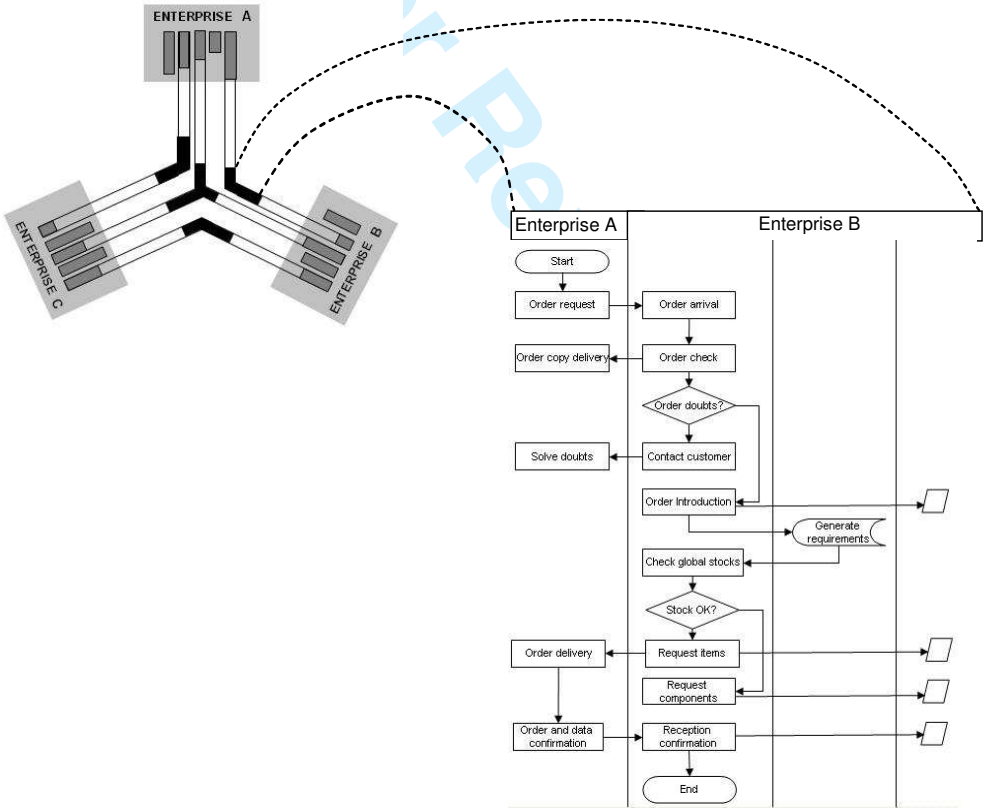

Figure 2. Concept of extended business process

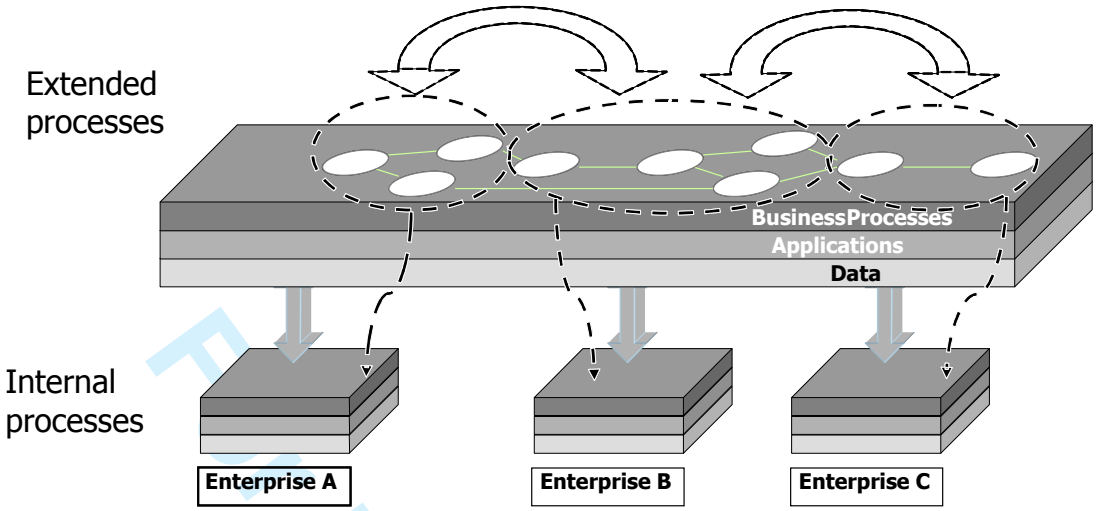

Figure 3. Concept of low complexity extended business processes. Source: Adapted from Franco and Ortiz (2006)

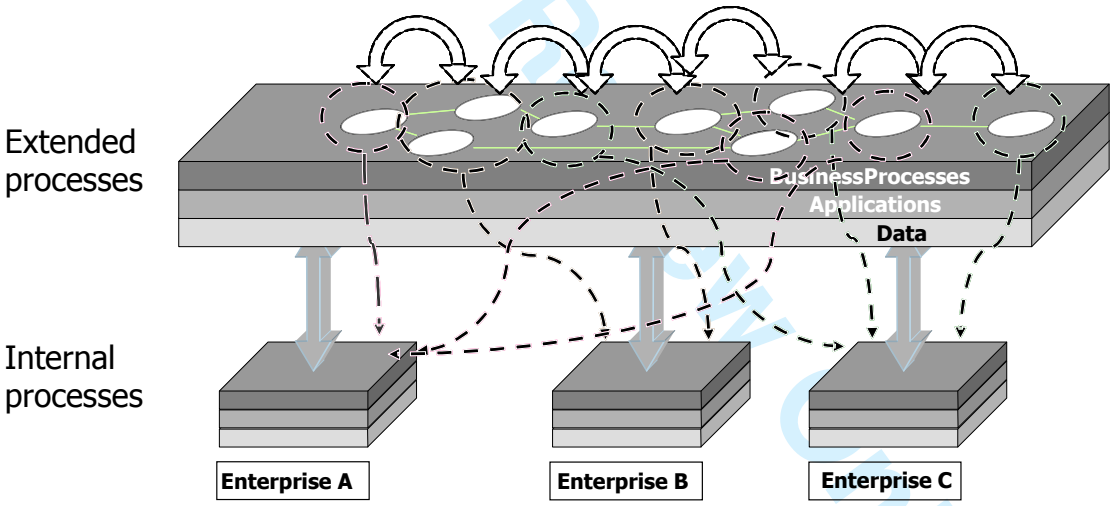

Figure 4. Concept of high complexity extended business processes. Source: Adapted from Franco and Ortiz (2006)

Framework	Researcher	Framework typology	Dimensions of measurement (if any)
Beamon's framework	(Beamon 1999)	Structural	Resources; output; flexibility
Supply chain balanced scorecard framework	(Brewer and Speh 2000)	Structural	Customer perspective; internal business perspective; innovation and learning perspective; financial perspective
Lapide's framework	(Lapide 2000)	Structural	Executive-level metrics; managerial-level metrics
Dreyer's framework	(Dreyer 2000)	Procedural	—
Gunasekaran *et al.*'s framework	(Gunasekaran *et al.* 2001)	Structural	Plan performance; source performance; production performance; delivery performance; customer service and satisfaction
Six step framework	(Basu 2001)	Procedural	—
Integrated measurement system	(Bullinger *et al.* 2002)	Structural	Financial perspective; customer perspective; organisational perspective; innovation perspective; supply chain perspective; process perspective; function perspective
Process-based framework	(Chan and Qi 2003)	Structural	Suppliers; inbound logistics; core manufacturer; outbound logistics; marketing and sales; end customers
Supply chain performance metrics framework	(Gunasekaran *et al.* 2004)	Structural	Plan; source; make/assemble; deliver; strategic; tactical; operational

Figure 5: Frameworks for inter-organisational performance measurement. Source: Folan and Browne (2005)

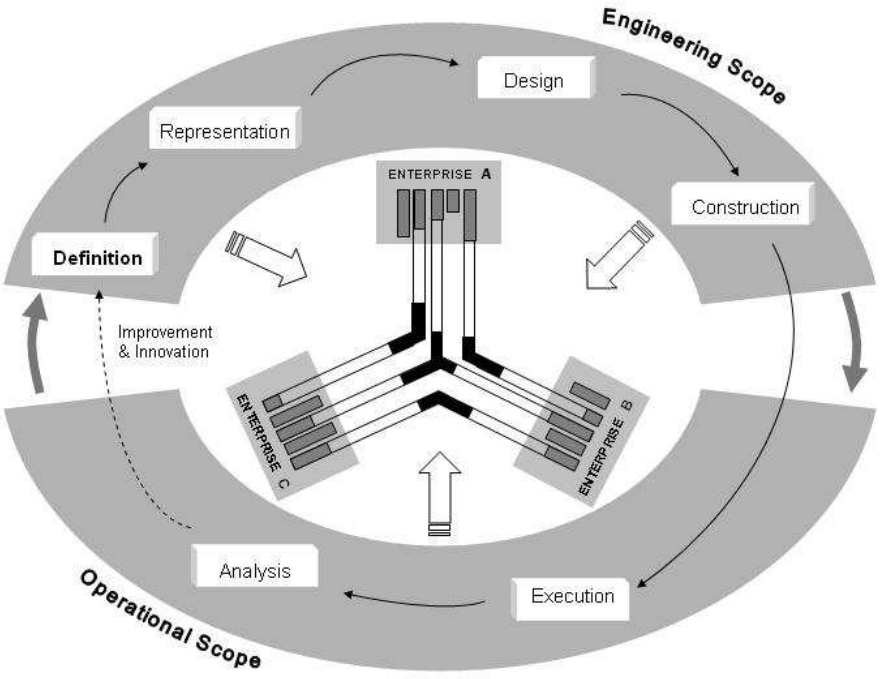

Figure 6. Business process lifecycle: Scopes

Business Process Interoperability and Collaborative Performance Measurement

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