HAL
open science

An enterprise meta model for the assessment and improvement of sustainability and mass customization performance

Khaled Medini, Catherine Da-Cunha, Alain Bernard

To cite this version:

Khaled Medini, Catherine Da-Cunha, Alain Bernard. An enterprise meta model for the assessment and improvement of sustainability and mass customization performance. 9th International Conference on Modeling, Optimization & SIMulation, Jun 2012, Bordeaux, France. hal-00728579

HAL Id: hal-00728579

https://hal.science/hal-00728579v1

Submitted on 30 Aug 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

9th International Conference of Modeling, Optimization and Simulation - MOSIM'12
June 06-08, 2012 – Bordeaux - France
"Performance, interoperability and safety for sustainable development"

AN ENTERPRISE META MODEL FOR THE ASSESSMENT AND IMPROVEMENT OF SUSTAINABILITY AND MASS CUSTOMIZATION PERFORMANCE

K. MEDINI, C. DA CUNHA, A. BERNARD

LUNAM Université, Ecole Centrale de Nantes
IRCCyN UMR CNRS 6597
1 Rue de la Noë, Nantes, France
{khaled.medini, catherine.da-cunha, alain.bernard}@irccyn.ec-nantes.fr

ABSTRACT: *In a mass customization and sustainability context, enterprises are endeavouring to provide customized products, gain new markets while enhancing social, economic and environmental sustainability. Moreover the performance of the firm needs to be measured in order to control the progress towards the above mentioned goals. At this point, all performance inductors have to be considered in order to ensure a complete assessment. In this paper, a meta-model of the enterprise that takes into account these considerations is presented. The meta-model attempts to depict all enterprise components and factors arising from its environments in order to provide a global vision of the Sustainable Mass Customized (SMC) enterprise model which in turn will be exploited in farther steps for the assessment and performance improvement of such firms.*

KEYWORDS: *Enterprise meta-model, sustainability, mass customization, performance assessment.*

1 INTRODUCTION

Enterprises are faced by big demand and variety of customer preferences that require the delivery of customized products with important quantities using efficient production systems. These requirements form the essence of mass customization which presents opportunities for new markets holding and improvement of firm's competitiveness.

Nevertheless, additional factors emerged from governments' pressure and customer consciousness about sustainability issues. Such factors need to be considered in order to survive the nowadays market competition while satisfying all stakeholders. Accordingly, sustainable mass customized (SMC) enterprises gain more competitive advantages against traditional enterprises.

Moving towards a SMC enterprise suggests the deployment of processes and resources to provide customized products, gain new markets while enhancing social, economic and environmental sustainability. Moreover, the performance of the firm needs to be measured in order to control the progress towards the SMC model. At this point, all performance inductors have to be considered in order to ensure a complete assessment.

In this paper, a meta-model of the enterprise that takes into account these considerations is presented. The meta-model attempts to depict all enterprise components (i.e. processes, etc.) and factors arising from its environments (i.e. social, economic, and ecological) in order to provide a global vision of the SMC enterprise model which in turn will be exploited in farther steps; performance assessment and improvement of such firm.

The rest of the paper is organized as follows; section 2 highlights the requirements of sustainable mass customized enterprise assessment which were used to build up the model components presented in section 3. Section 4 describes the SMC-E model. Research perspectives are discussed in section 5.

2 MASS CUSTOMIZATION AND SUSTAINABILITY ASSESSMENT REQUIREMENTS

Mass customization literature is quite consistent and full of case studies and theoretical analysis. Most of the studies are focused on some specific enablers of mass customization. More complete views of all mass customization enablers can be found in literature surveys (Da Silveira, 2001; MacCarthy, 2003; Daaboul et al., 2009).

In terms of assessment, different levels are distinguished; first, the evaluation of the applicability of mass customization as a strategy (Daaboul et *al.*, 2009). Second the evaluation of mass customization enablers through analysis of processes and/or design customizability, for instance (Yang and Li, 2002; Jiao and Tseng, 2004; Welborn, 2009), this stream involves the mechanisms of MC. Third; assessment may focus on the results of mass customization in terms of customer requirements satis-

faction (Jiao and Tseng, 2004). Accordingly the mass customization evaluation involves stakeholders such as suppliers, customer in addition to the enterprise processes and products. This suggests that a modelling of the enterprise meant to provide data for the assessment must include all the above mentioned components.

In terms of sustainability, several authors highlighted that such concept embraces different levels of the organization (Labuschagne, 2004; Laine, 2005; Jayal et *al.*, 2010). It can be concluded from the findings of the aforementioned authors and sustainability literature review that the levels are; product, process, and organization and supply chain. In the following examples are given to illustrate the need for these levels for each of the sustainability dimensions.

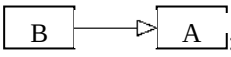
Economically speaking, the product Bill-Of-Material (BOM), production processes, suppliers cost, all impact the overall cost of the final product. For the environmental impact, let us take the example of resource use, this latter depends on the product material, processes use of auxiliary materials, etc. In terms of social sustainability (which involves the labour and society), the organization level (or company level) is the main driver of such dimension. This has also been pointed out by authors whose researches involve the social dimension of sustainability such as Jørgensen et *al.* (2008) and Dreyer (2009).

A consequence of this analysis is that product, process, organization and supply chain levels are inevitable for the indented meta-modelling. Moreover social, economic and ecological environments of the enterprise need to be considered, even indirectly; without being depicted as parts of the meta-modelling.

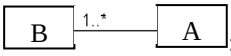
3 MODEL COMPONENTS

This section presents the components of the meta-model deducted from the previous section. For the sake of understandability, the components are depicted separately in this section before presenting the complete meta-model in section 4.
UML class diagrams have been used to depict the objects of the meta-model. Following indexes give short explanation of the used associations' meanings:

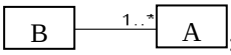
: A is comprised of B.



: B type is of type A.



: A is associated to 1 or more Bs.



: B is associated to 1 or more As.

3.1 Enterprise

This sub-section involves the enterprise objects and organizational level. Enterprise is depicted as a central element of the model. In (Labrousse and Bernard, 2008) enterprise objects include product, process, resource and external effect (PPRE). The current model follows the same logic except for the external effect object. This latter has been extended to depict environmental, economic and social environments constraints. In other terms, the equivalent of "External Effect" is *Enterprise Environment* which strongly impacts the *Organization Policy* that will be described in section 3.1.1.

3.1.1 Organizational level

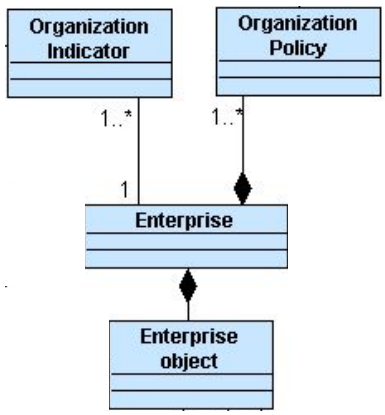


Figure 1: Organizational level

Being associated to the enterprise, organizational level is not a physical object. It can be perceived through organization policies depicted by *Organization Policy*. This latter refers to enterprise strategies and management rules of labour, resources, investments, etc. (Fig. 1).

3.1.2 Product

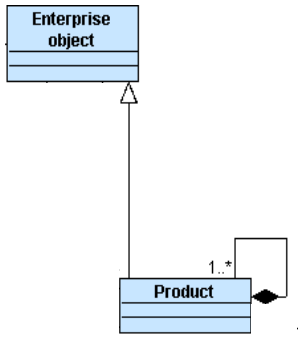


Figure 2: Product

In addition to the product itself, *Product* model comprises components and raw material, each of which is a product in turn. This relationship between product and

components and raw materials is depicted by the composition (Fig. 2). The *Product* is an *Enterprise object*.

3.1.3 Process

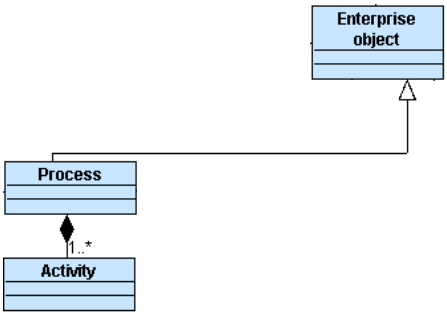


Figure 3: Process

Process, as an enterprise object, is the set of activities involved in the production of a good. Processes range from the raw material extraction to the end of life of the product or delivery of the service (Fig. 3).

3.1.4 Resource

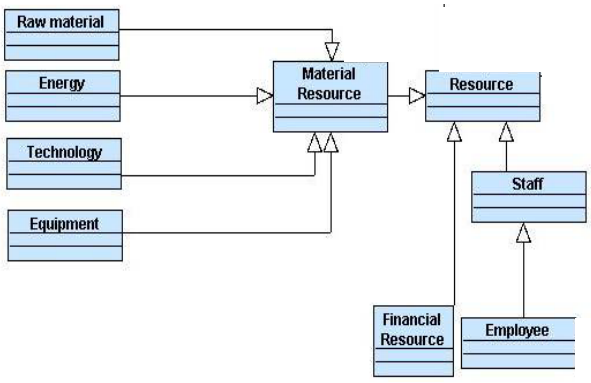


Figure 4: Resource

Resource is a generic enterprise object that may have different types namely, staff, material and financial resources. *Staff* refers to *Employee*. *Material Resource* can be *Raw material, Energy, Technology or Equipment*. *Financial Resource* refers to all money forms that enterprise possesses (Fig. 4).

3.2 Enterprise environment

3.2.1 Economic environment

Enterprise is a stakeholder within the supply chain; it can also play the role of Customer.

Supply Chain consists of all processes and flows involved in providing a product to the customer (Supply Chain Council, 2010).

Market is a place where Suppliers of a given product and Customers meet to make transactions.

Economic environment is comprised of both *Market* and *Supply Chain* stakeholders where relationships differ. In fact, in the former we speak about competitiveness between enterprises, while in the latter what counts is mainly partnership and coordination between supply chain actors (Fig. 5).

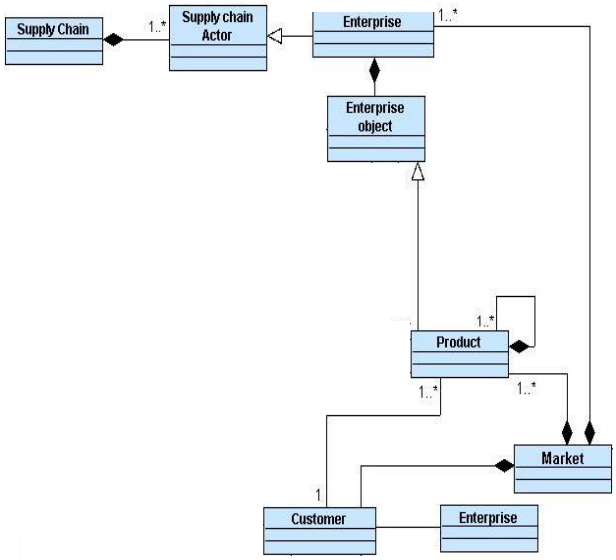


Figure 5: Economical Environment

3.2.2 Social environment

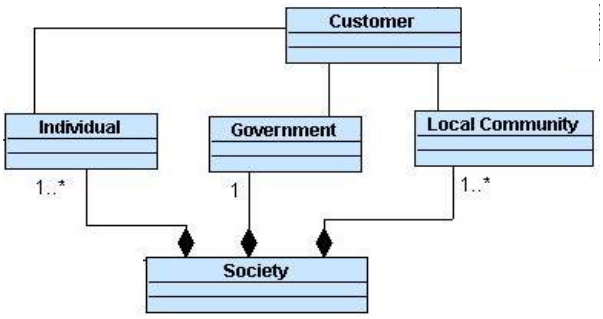


Figure 6: Social Environment

Society is comprised of *Individuals*, *Local communities* and *Governments* (Fig. 6). *Customer* is a role which can be taken by any of society components (and the enterprise). Society with all its components urges the enterprise to carry out sustainable development, thus such impact is important for the SMC firm. *Customer* includes also the requirements that have to be fulfilled by the customized product. These requirements involve sustainability (i.e. emissions thresholds, cost, etc) and mass customization as well (i.e. required speed, size, etc).

3.2.3 Ecological environment

Ecological environment is considered as a set of resources namely *Mined*, *Air*, *Land* and *Water* resources (Fig. 7). This classification is inspired from the Life Cycle Assessment method (CML et *al.*, 2001; Rebitzer et *al.*, 2004) where environmental impact is often assigned to four Areas of Protection (AoP) namely; Air Resources, Land Resources, Water Resources and Mined Resources (Mangena and Brent, 2006).

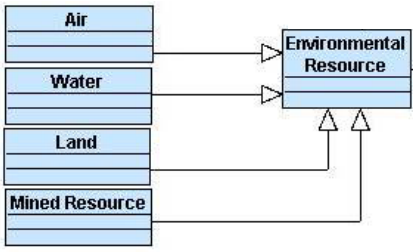


Figure 7: Ecological Environment

3.3 Indicators

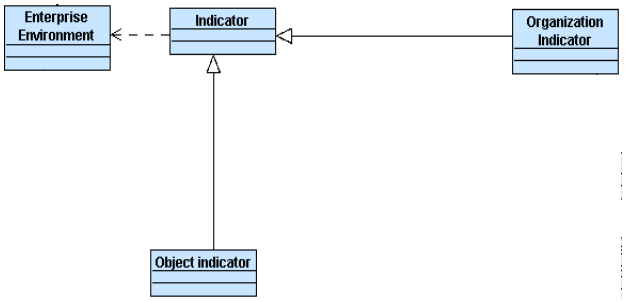


Figure 8: Indicator

Indicators fall under the standardized models category used to evaluate sustainability (Todorov and Marinova, 2010) but they are also a very used technique in the field of mass customization assessment - even if this latter is not well established. Accordingly, an indicator allows measuring the performance of customization and / or sustainability. *Indicator* as a component of the model, measures the sustainability and/or mass customization performance for a given aspect (i.e. process customizability, emissions to ecological environment, etc). *Indicator* depends on *Enterprise Environment* that includes *Economic, Social and Ecological* ones. It depicts the impact of these latter on the Enterprise and vice-versa (Medini et *al.* 2011). *Indicator* is of different types, it can be associated *to Organizational level* (i.e. labour management) or enterprise objects including, *Product* (i.e. material cost, etc.), *Process* (i.e. process customizability, etc.) and *Resource* (i.e. energy consumption, etc.) (Fig. 8).

4 META MODEL OVERALL SHAPE

The meta-model is depicted in Figure 9. It groups all the above mentioned components to provide a complete vision that spans enterprise components and stakeholders. To put together puzzles, following associations are required;

Product – Resource: Characterizes the resources used to provide a given product (that can also be a component or raw material).

Activity – Resource; Characterizes the resources used by a given activity that is a part of a process.

Product – Process; for a given product, only a definite set of process sequences is possible. This link defines the possible *Process*es and/or activities apt to perform a given *Product*. This is particularly important during the process planning for a product variant.

Individual – Employee; Employee of the enterprise is actually an individual in the society.

Environmental Resource – Material Resource; Material resource is a part of environmental resources.

Customer – Product; the product functionalities have to fulfil certain requirements of a given customer.

In Figure 9, associations are represented with the continuous line. The class *Enterprise* is depicted twice for the sake of clarity, it depicts the same object.

Social, Economic and Ecological environments fall all under the *Enterprise Environment* category. The impact of these environments is taken into account by introducing the *Indicator* object whose calculation uses information about the Enterprise Environment (i.e. characterization of the emissions, purchasing price, customer requirements, investments in society, etc.). The dependencies of *Indicator* and *Organization Policy* (mentioned before) on *Enterprise Environment* are depicted by the arrow broken lines.

5 CONCLUSIONS

In this paper a meta-model of the SMC-E has been built upon the requirements of a complete assessment of sustainability and mass customization performance. It was concluded that different components inherent to the enterprise and external stakeholders (i.e. Supply chain actors, Enterprise Environment) need all to be modelled. Each of these components has been described separately. Together, the meta-model components define the scope of an effective SMC-E assessment allowing the analysis and improvement of sustainability performance of a mass customization solution space. The specifications herein established provide the basis of following tasks:

- Development of sustainability and mass customized assessment model starting from instances of the present meta-model.
- Development of simulation models by adapting the proposed meta-model and creating instances for the simulation.

- Analysis and improvement of sustainability performance of mass customized solutions.
- Analysis of the links between mass customization and sustainability.

Nevertheless, the meta-model validation needs to consider several case studies by at least having interviews with or questionnaires to be filled by managers.

ACKNOWLEDGMENTS

This work has been partly funded by the European Commission through S-MC-S (Sustainable Mass Customization - Mass Customization for Sustainability) project (Grant Agreement No: FoF.NMP.2010-2 260090 - S-MC-S).

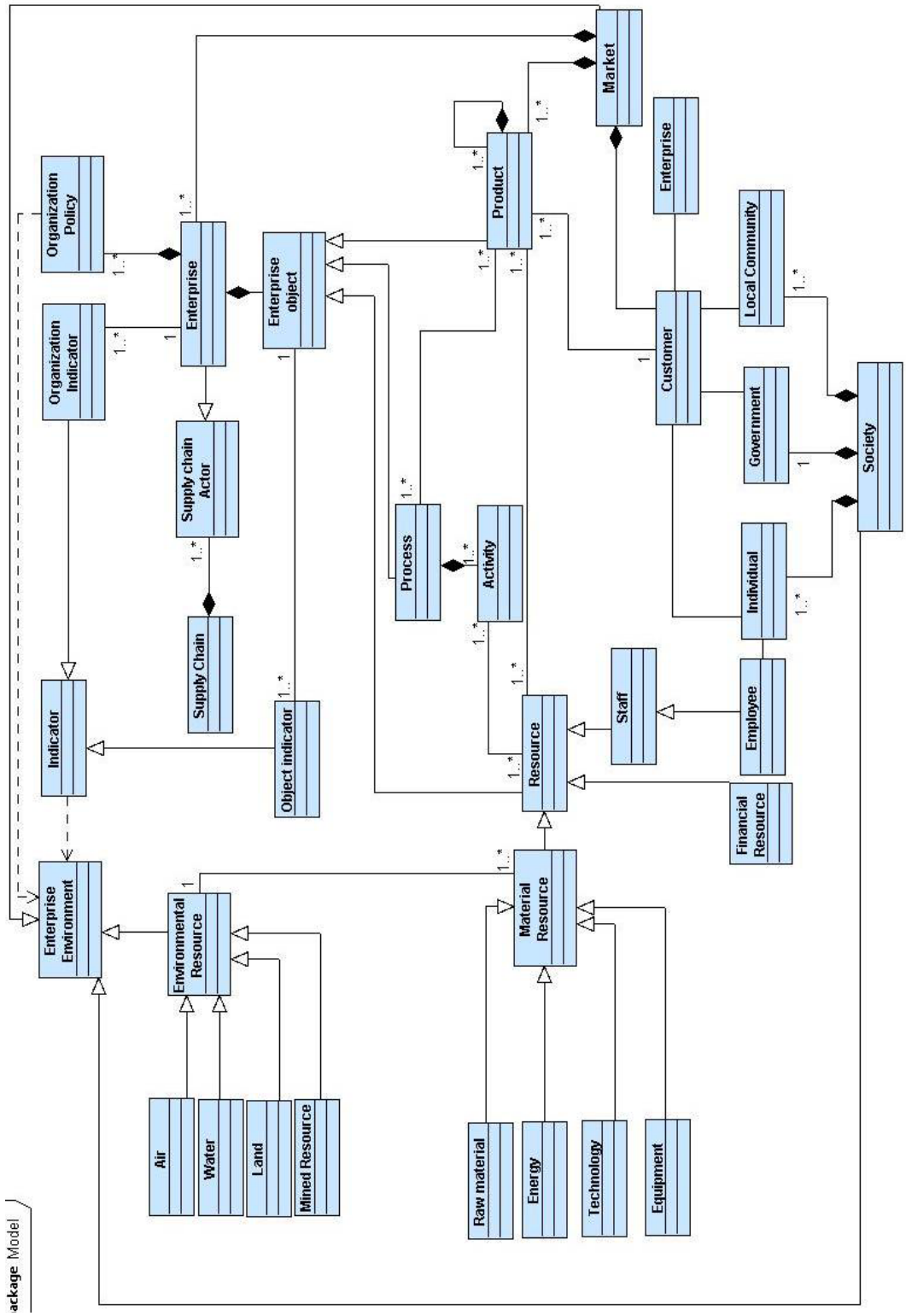


Figure 9: SMC-E Meta model

REFERENCES

Centre of Environmental Science (CML) and University of Technology (TUD/TB), Fuels and Raw Material Bureau (Bureau B&G), University of Amesterdam (UVA), IVAM-Environmental Research (IVAM-ER), Netherlands Organization for Applied Scientific Research (TNO), 2001. *Life Cycle Assessment: An operational guide to the ISO standards - Part 1: LCA in Perspective* [online]. Available from: http://cml.leiden.edu/research/industrialecology/researchprojects/finished /new-dutch-lca-guide.html.

Daaboul, J., A. Bernard and F. Laroche, 2009. Implementing Mass Customization: Literature Review. *5thWorld Conference on Mass Customization and Personalization*, Helsinki, Finlande.

Da Silveira, G., Borestein, D., Fogliatto, F.S., 2001. Mass customisation literature review and research directions. *International Journal of Production Economics*, 72(1), p. 1-13.

Dreyer, L., 2009. *Inclusion of Social Aspects in Life Cycle Assessment of Products*. PhD Thesis, Technical University of Denmark, Danemark.

Jayal, A. D., F. Badurdeen, O.W. Dillon and I.S. Jawahir, 2010. Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*, Volume 2, Issue 3, 2010, p. 144-152.

Jiao, J. and M. M. Tseng, 2004. Customizability analysis in design for mass customization. *Computer-Aided Design*, 36(8), p. 745-757.

Jørgensen, A., A. Le-Boqc, L. Nazakina and M. Hauschild, 2008. Methodologies for social life cycle assessment. *International Journal of Life Cycle Assessment*, 13(2), p. 96-103.

Labrousse M., A. Bernard, 2008. FBS-PPRE, an Enterprise Based Knowledge Life Cycle Model, *Methods and Tools for Effective Knowledge Life-Cycle-Management*, p. 285-305.

Labuschagne C., A. C. Brent and R. P. G. van Erck, 2004. Assessing the sustainability performances of industries, *Journal of Cleaner Production*, 13(4), p. 373-385.

Laine, 2005. Meanings of the term 'sustainable development' in Finnish corporate disclosures. *Accounting Forum*, 29(4), p. 395-413.

MacCarthy, B., 2003. Fundamental modes of operation for mass customization. *International Journal of Production Economics*, 85(3), p. 289-304.

Medini, K., C. Da Cunha and A. Bernard, 2011. Towards an Integrated Mass Customization and Sustainability Assessment Framework. *The 2011 World Conference on Mass Customization, Personalization, and Co-Creation*, San Francisco, USA.

Mangena S. and A. Brent, 2006. Application of a Life Cycle Impact Assessment framework to evaluate and compare environmental performances with economic values of supplied coal products. *Journal of Cleaner Production*, 14(12-13), p. 1071-184.

Rebitzer, G., T. Ekvall, R. Frischknecht, D. Hunkeler, G. Norris, T. Rydberg, W-P. Schmidt, S. Suh, B. P. Weidema and D. W. Pennington, 2004. Life cycle assessment part 1: framework, goal and scope definition, inventory analysis, and applications. *Environment international*, 30(5), p. 701-720.

Supply Chain Council, 2010. *Supply Chain Operations Reference Model, Version 10.0 Business strategies for sustainable development*, Supply Chain Council, USA.

Todorov, V. and D. Marinova, 2011. Modelling sustainability. *Mathematics and Computers in Simulation*, 81(7), p. 1397-1408.

Welborn, C., 2009. Customization Index : Evaluating the Flexibility of Operations in a Mass Customization Environment. *The IUP Journal of Operations Management*, 8 (2), p. 6-13.

Yang, S.L. and T. F. Li, 2002. Agility evaluation of mass customization product manufacturing. *Journal of Materials Processing Technology*, 129(1-3), p. 640-644.