

Chapter 8

EVALUATION OF LIFECYCLE EXPECTANCY OF PRODUCTS ACCORDING TO SUSTAINABILITY

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INTRODUCTION

Life cycle analysis is a inclusive assessment concept to evaluate and determine the volume of consumption of natural and other resources and the ecological effects integrated according to a good (or service) during the whole of the lifecycle time of the product. Evaluating lifecycle time has four stages as follows:

First step: declaring the aim, target and content of the study; second step: composing a life cycle stock; third step: life cycle effect evaluation; fourth step: perception of quality regulations (ISO 14040, 2006; Zhang et al 2015).

Life Cycle Inventory components include different actions, abilities and cooperation between the activities and the ecological area in the life cycle span of the product. The methods of Life Cycle Inventory include different kinds of activities and relations between the activity and ecological life. Reasonable and dependence connections correspond between the actions, input matters, footprints and good modification components (Suh and Huppel, 2005; Zhang et al., 2015). Life Cycle Quantity supports the influence data on the ecological area of a product life cycle, according to this impact; the concept is vital and essential for some implementations like eco-design of a good and the operation phase of design of a product lifecycle time. Generally, the implementations of different regulations achieved in various system structures (Zhang et al., 2015).

Sustainability of Life Cycle Expectancy Assessment (LCA) is an essential equipment to evaluate the ability of usage again of products and elements of products. This is “compounded life cycle focused method, extending Life Cycle Assessment, Life Cycle Expenditure and Social Dimension of Life Cycle” Evaluation. The assessment of Environmental usage performance is a way for evaluating source consuming and ecological effects integrated with the overall lifecycle span of a

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The shortening the serviceable life cycle of products/services was conceived to continue capitalism, competition system. This opinion directs the commercial evolution for association. This causes customers consume, donates money so this could have prevailed, continued lifeless. When the money distributes, citizen and business interests outstanding necessarily, partially in a short period, to fortunate life fashion (Keeble, 2013).

This study can provide general information and view of this topic and a new model approach considering the balance of sustainable production and consumption for the industry to identify the linkage between the sustainability and the financial performance of extensive social and, environmental impact assessments should also underpin new legislation on the procurement, the environmental impacts of wasteful consumption

REFERENCES

1. Abercrombie, S.(2000). George Nelson: The Design of Modern Design Paperback, The MIT Press-375 p, pp.220-260, ISBN-10: 0262511169.
2. Absatzwirtschaft. (2011). Online-Werbung: Kampagnen-Management für mehrere Kanäle. Retrieved June 12, 2011, from <http://www.absatzwirtschaft.de/content/online-marketing/news/kampagnen-management-fuer-mehrere-kanale;73459>
3. Adisa, A.(1999). Life cycle assessment and its application to process selection, design and optimization. Chemical Engineering Journal, 73 (1),pp. 1-21
4. Aladeojebi, T.-K.(2013). Planned Obsolescence. International Journal of Scientific & Engineering Research 4(6). ISSN 2229-5518. pp.1504-1508.
5. Allwood, J. M., Ashby, Michael F., Gutowski, T. G., Worrell, E. (2011). Material efficiency: a white paper, Resources Conservation & Recycling, 55, pp. 362-381.
6. Azapagic, A., Millington, A. and Collett, A.(2006). A methodology for integrating sustainability considerations into process. Chemical Engineering Research and Design 84 (6), pp.439-452.
7. Bakker, C., Wang, F., Huisman, J. and Hollander, M.(2014). Products that go round: exploring product life extension through design, Journal of Cleaner Production 69, pp.10-16.
8. Baran, P.A. and Sweezy P. M. (1966).” Monopoly Capital: an essay on the American economic and social order.” New York, Monthly Review Press,<http://monthlyreview.org/2004/10/01/monopoly-capitalism/>(10.05.2015).
9. Barreca,S.(1999).Technology life-Cycles and Technological Obsolescence. BCRI 6, <http://www.bcri.com/Downloads/Valuation%20Paper.PDF>, (10.05.2016).
10. Beder, S.(2000), Selling the Work Ethic, From Puritan Pulpit to Corporate PR, Zed Books, London, UK, pp.300-310.
11. Brook, L.(2009). Household waste prevention evidence review: attitudes and behaviours to bulky waste and reuse (L3 m3-6 (T)). A report to the Department for Environment, Food and Rural Affairs. Defra project WR1204. London, A report for Defra’s Waste and Resources Evidence Programme, http://randd.defra.gov.uk/Document.aspx?Document=WR1204_8361_OTH.pdf.
12. Brook, L.(2011b). Public understanding of product lifetimes and durability, reuse of bulky items: a report to the Department for Environment, Food and Rural Affairs. London: Defra; 2011b.
13. Byggeth, S., Broman, G. and Robert, K. (2007). “A Method for Sustainable Product Development Based on a Modular System of Guiding Questions,” Journal of Cleaner Production 15,

- pp. 1–11.
14. Catulli, M. (2011). What uncertainty? Further insight into why consumers might be distrustful of product service systems. *Journal of Manufacturing Technology* 23 (6), pp. 780-793.
 15. Cialdini, R. B. (1998). *Commitment and consistency. Influence, The Psychology of Persuasion*. New York: Harper, p.57.
 16. Cialdini, R. B. (2007). *Social, Influence, The Psychology of Persuasion*. New York: Harper, p.115.
 17. Chan, C.-S.C., Yu, K.-M., Yung, K.-L.(2010). Green product development by using life cycle assessment (LCA), theory of inventive of problems solving (TRIZ). In: 2010 International Conference on Manufacturing Automation (ICMA) 13-15 Dec, pp. 24-29.
 18. Chang, D., Lee, C.K.M. and Chen C.-H.(2014). Review of life cycle assessment towards sustainable product development, *Journal of Cleaner Production* 83, pp. 48-60.
 19. Chapman, J. (2009). *Emotionally Durable Design: Objects, Experiences, and Empathy*, third edition. Ava Publishing SA, Earthscan, London.
 20. Chung, C.-J. and Wee, H.-M.(2008). Green-component life-cycle value on design and reverse manufacturing in semi-closed supply chain. *International Journal of Production Economics* 113, pp. 528-545.
 21. Cooper, T and Christer, K. (2010). Marketing durability, in Cooper, T. (ed.) *Longer Lasting Products: Alternatives to the Throwaway Society*, Gower, Farnham, pp. 273-296.
 22. Culaba, A.B. and Purvis, M.R.I.(1999). A methodology for the life cycle and sustainability analysis of manufacturing processes. *Journal of Cleaner Production* 7 (6), pp.435-445.
 23. Curran, A, Williams, I and Heaven, S.(2007). Management of household bulky waste in England. *Resources, Conservation and Recycling* 51, pp.78–92.
 24. Cooper, T.(2004). Inadequate life: evidence of consumer attitudes to product obsolescence. *Journal of Consumer Policy* 27, pp.421–49.
 25. Cooper, T. (2005). Slower consumption: reflections on product life spans and the Throwaway Society. *Journal of Industrial Ecology*, 9, pp. 51–67.
 26. Cox, J., Griffith, S., Giorgi, S. and King, G.(2013), Consumer understanding of product life-times, *Resources, Conservation and Recycling*, 79. pp. 21– 29.
 27. Dannoritzer, C.(2010), *Lightbulb Conspiracy Documentary*, Norway, <http://freedomlightbulb.blogspot.com.tr/2012/05/lightbulb-conspiracy-documentary-by.html>, 10.05.2014.
 28. Dao, V., Langella, I. and Carbo, J. (2011). From green to sustainability :Information Technology and integrated sustainability framework, *Journal of Strategic Information Systems* 20 , pp.63-79.
 29. Deci, E. L., & Ryan, R. M. (1995). Human autonomy: The basis for true self-esteem. In M. H. Kernis (Ed.), *Efficacy, agency, and self-esteem* (pp. 31-49). New York: Plenum Press.
 30. Den Hollander, M. and Bakker, C.(2012). A business model framework for product life extension. In: *Proceedings of Sustainable Innovation 2012, Resource Efficiency, Innovation and Lifestyles*, 29-30 October 2012. Alanus University, Bonn, pp. 110-118.
 31. Gluch, P. and Baumann, H.(2004). The life cycle costing (LCC) approach: a conceptual discussion of its usefulness for environmental decision-making. *Building and Environment* 39, 571-580.
 32. Grantham, J.(2012). *Living on a Finite Planet (Where No-one Likes to Hear Bad News)* published in *The Future in Practice: The State of Sustainability Leadership*. Paper for University of Cambridge Programme for Sustainability Leadership.
 33. Gramatyka, P., Nowosielski R., and Sakiewicz P.(2007). Recycling of waste electrical and electronic equipment, *Journal of Achievements in Materials and Manufacturing Engineering*, 20(1-2), pp. 535-538.
 34. Grossmann, I.E.(2004). Challenges in the new millennium: product discovery and design, enterprise and supply chain optimization, global life cycle assessment. *Computers & Chemical Engineering* 29, pp. 29-39.
 35. Glenn Adamson, G.(2003), Preface by David Gordon, *Industrial Strength Design*, How Brooks

- Stevens Shaped Your World, 300 pp. <http://www.idsa.org/content/brooks-stevens-fidsa>.
36. Guiltinan, J. (2009). Creative Destruction and Destructive Creations: Environmental Ethics and Planned Obsolescence, *Journal of Business Ethics* 89, Springer. DOI 10.1007/s10551-008-9907, pp. 19-28.
 37. Hatcher, G.D., Ijomah, W.L. and Windmill, J.F.C. (2011), "Design for remanufacture: a literature review and future research needs", *Journal of Cleaner Production*, Vol. 19 Nos 17/18, pp. 2004-2104.
 38. Hanssen, O.J.(1999). Sustainable product systems experiences based on case projects in sustainable product development. *Journal of Cleaner Production*, 7, pp. 27-41.
 39. Heimbuch, J.(2012). Lifebook Design Combines All Your Gadgets Into One Modular Laptop. *Treehugger*. Available from: <http://www.treehugger.com/gadgets/lifebook-design-combines-all-our-gadgets-into-one-modular-laptop>. Html, 10.06.2015.
 40. Horowitz, D. (1994). Vance Packard and American Social Criticism. The University of North Carolina Press. 1st ed., p.400 , pp.300-310.
 41. Huisman, J., van der Maesen, M., Eijsbouts, R.J.J., Wang, F., Baldé, C.P., and Wielenga, C.A. (2012). The Dutch WEEE Flows. United Nations University, Bonn, Germany. ISP - SCYCLE.
 42. Initiative., U. S. (2009). One Global Understanding of Re-Use— Common Definitions
 43. ISO 14040, (2006). Environmental Management Life Cycle Assessment Principles and Framework. International Organization for Standardization, Geneva, Switzerland.
 44. Joseph, F. (2009). Design for Environment: A Guide to Sustainable Product Development, second edition. McGraw Hill, New York.
 45. Kaebernick, H., Kara, S., and Sun, M.(2003). Sustainable product development and manufacturing by considering environmental requirements. *Robot. Cim.-Int. Manuf.* 19, 461-468.
 46. Kloepffer, W.(2003). Life-cycle based methods for sustainable product development. *International Journal of Life Cycle Assessment*. Springer, 8 (3), pp. 157-159.
 47. Kloepffer, W. (2008). Life cycle sustainability assessment of products. *International Journal Life Cycle Assessment*, 13 (2), pp. 89-95.
 48. Keeble, D.(2013), Thesis of Bachelor, Apple rejoins EPEAT Environmental ratings System (Arthur, C.(2012), http://www.academia.edu/6820547/Keeble_Daniel, 15.04.2014.
 49. Kersey, B.(2012), iPhone port tipped to lock out unlicensed accessories, <http://www.slashgear.com/new-iphone-port-tipped-to-lock-out-unlicensed-accessories-21235103>, 10.05.2014.
 50. Kovach, S. (2013), How Samsung is out-innovating Apple.
 51. <http://edition.cnn.com/2013/02/18/tech/gaming-gadgets/samsung-apple-innovation/>, 10.05.2014.
 52. Labuschagne, C., and Brent, A.C.(2005). Sustainable project life cycle management: the need to integrate life cycles in the manufacturing sector. *International Journal of Project Management* 23, pp.159-168.
 53. Lee, M. (1997) . Fast Fashion. *The Ecologist*, 37(2), pp. 60.
 54. Lee, M. J. (1993). *Consumer Culture Reborn: The Cultural Politics of Consumption*, London, Routledge.
 55. Leonard, A. (2010). *The Story of Stuff*, Free Press A Division of Simon & Schuster, Inc. chapter 4-5, pp.126-188.
 56. Li, F.Y., Li, J.F., Duan, G.H., and Li, J.Z.(2006). Green design-oriented product AHP life cycle environmental impact assessment model. In: *International Technology and Innovation Conference*, pp. 1020-1025.
 57. London, B.(1932). "Ending the Depression Through Planned Obsolescence". Wisconsin University, [http://www.murksneindanke.de/blog/download/London_\(1932\)_Ending_the_depression_through_planned_obsolescence.pdf](http://www.murksneindanke.de/blog/download/London_(1932)_Ending_the_depression_through_planned_obsolescence.pdf) , 10.04.2014.
 58. Lua, B., Lia, B., Wang, L., Yang, J., Liua, J. and Wangb, X.V.(2014). Reusability based on Life Cycle Sustainability Assessment: case study on WEEE, *Procedia CIRP* 15, 21st CIRP Conference on Life Cycle Engineering.
 59. Lu, D. and Realf, M.J.(2012). Point-based standard optimization with life cycle assessment for

- product design. *Computers & Chemical Engineering* 34 (9), pp.1356-1364.
60. Max-Neef (1992). Development and human needs. In P. Ekins, and M. Max-Neef, (Ed), *Real-life economics: Understanding wealth creation*. Routledge, New York, NY
 61. Maxwell, D., and van der Vorst, R.(2003). Developing sustainable products and services. *Journal of Cleaner Production* 11. pp. 883-895.
 62. Maycroft, N. (2009). "Consumption, planned obsolescence and waste." Lincoln: University of Lincoln. 5, pp.24.
 63. Mazhar, M.I., Kara, S. and Kaebernick, H.(2007). Remaining life estimation of used components in customer products: life cycle data analysis by Weibull and artificial neural networks. *Journal of Operations Management*, 25, 1184-1193.
 64. Mont, O., Dalhammar, C. and Jacobsson, N.(2006). A new business model for baby prams based on leasing and product remanufacturing. *Journal of Cleaner Production* 14, pp.1509-1518.
 65. Murphy, S.(2011), Android, iPhone User Stereotypes Revealed, <https://www.yahoo.com/news/android-iphone-user-stereotypes-revealed-181805502.html>, 10.05.2014.
 66. Ness, B., Urbel-Piirsalu, E., Anderberg, S. and Olsson, L.(2007). Categorising tools for sustainability assessment. *Ecological Economics*. 60 (3), pp. 498-508.
 67. Norris, G. (2001) . Integrating life cycle cost analysis in LCA. *International Journal of Life Cycle Assessment*, 6 (2),pp.118-120.
 68. Nussbaum, M. (1998). *The Good as Discipline, the Good as Freedom*. In *Ethics of Consumption*, Crocker, D. and T. Linden (Ed), Rowman and Littlefield, NY.
 69. O'Brian, M., Doig, A., and Clift, R.(1996). Social and environmental life cycle assessment (SELCA). *International Journal of Life Cycle Assessment*, 1 (4). pp. 231-237.
 70. Ocampo-Duque, W., Juraske, R., Kumar, V., Nadal, M., Domingo, J.L., and Schuhmacher, M.(2012). A concurrent neuro-fuzzy inference system for screening the ecological risk in rivers. *Environmental Science and Pollution Research* 19 (4), pp. 983-999.
 71. Packard, V. (1960). "The Waste Makers- Progress through Planned Obsolescence" <http://soilandhealth.org/wpcontent/uploads/0303critic/030320wastemakers/wastemakers.pdf>, pp.45-57, 10.05.2014.
 72. Park, J.-H. and Seo, K.-K. (2003a). A knowledge-based approximate life cycle assessment system for evaluating environmental impacts of product design alternatives in a collaborative design environment. *Advanced Engineering Informatics*, 20(2), pp.147-154.
 73. Park, J.H. and Seo, K.K. (2003b). Knowledge-based approximate life cycle assessment system in the collaborative design environment. In: 3rd International Symposium on Environmentally Conscious Design and Inverse Manufacturing, 8-11 Dec, pp. 499-503.
 74. Park, M. (2010). Defying obsolescence. In: Cooper T, editor. *Longer lasting products: alternatives to the throwaway society*. Farnham, England-Gower.
 75. Park, J.H., Seo, K.K., and Wallace, D. (2001). Approximate life cycle assessment of classified products using artificial neural network and statistical analysis in conceptual product design. In: *Proceedings EcoDesign: Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing*.
 76. Planned obsolescence, *The Economist*, <http://www.economist.com/node/13354332-Planned-obsolescence> Mar 23rd 2009 | Online extra, 10.05.2015.
 77. *Planned Obsolescence Documentary*-Obsolescence, Industry, Economy, Phoebus Cartel, Bernard London, <https://archive.org/details/PlannedObsolescenceDocumentary>, (10.05.2014).
 78. Prakash, S., Liu, R., Schischke, K. and Stobbe, L.(2012). Timely Replacement of a Notebook Under Consideration of Environmental Aspects. Report for the Federal Environment Agency, Germany. Report no. (UBA-FB) 001666/E.
 79. <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4317.pdf>,15.10.015
 80. Rauscher, R.C. and Momtaz, S. (2014). "Sustainable Communities: A Framework for Planning: Case Study of an Australian Outer Sydney Growth Area ", the Macquarie Dictionary.

81. Rebitzer, G., and Hunkeler, D.(2003). Life cycle costing in LCA: ambitions, opportunities, and limitations. *International Journal of Life Cycle Assessment* , 8 (5), pp. 253-256.
82. Rosenau-Tornow, D., Buchholz, P., Riemann, A. and Wagner, M. (2009). Assessing the long-term supply risks for mineral raw materials e a combined evaluation of past and future trends. *Resource Policy* 34, pp.161-175.
83. Sakiewicz, P., Nowosielski, R., Pilarczyk, W. and Cezarz, K.(2012). Selected Engineering Problems, Institute of Engineering Processes Automation and Integrated Manufacturing Systems, pp.185-188.
84. Schmidt, J. H., P. Holm, A. Merrild and P. Christensen (2007). "Life cycle assessment of the waste hierarchy - A Danish case study on waste paper." *Waste Management* 27(11). pp. 1519-1530.
85. Schau, E.M, Lehmann, A., Traverso, M.(2010). Towards Life Cycle Sustainability Assessment, *Sustainability*, 2, pp.3309-3322, doi:10.3390/su2103309.
86. Schmidt, W.P.(2003). Life cycle costing as part of design for environment *International Journal of Life Cycle Assessment* , 8 (3),pp. 167-174.
87. Seo, K.-K., Min, S.-H., Yoo, H.-W. (2005). Artificial neural network based life cycle assessment model for product concepts using product classification method. In: *Computational Science and its Applications-ICCA 2005*. Springer Berlin, Heidelberg.
88. Slade, G. (2006). "Made to Break: Technology and Obsolescence in America- Cell Phones and E-Waste. Cell Phones and E-Waste, Harvard University Press Paper Back Edition, Cambridge, Massachusetts, pp.264.
89. Simon, M., Bee, G., Moore, P, Pu, J.S. and Xie, C.W.(2001). Modeling of the life cycle of products with data acquisition features. *Computers In Industry*, 45(2), pp.111-122.
90. Smith, D. (2012). " Apple iPhone 5S Rumors: 5 Features And Specs We're Expecting To See Upon Its Release Date ". *International Business Time*, <http://www.ibtimes.com/apple-iphone-5s-rumors-5-features-specs-were-expecting-see-upon-its-release-date-1341017>. 10.05.2015.
91. Sousa, I., and Wallace, D. (2006). Product classification to support approximate life-cycle assessment of design concepts. *Technological Forecasting and Social Change*, 73 (3), 228-249.
92. Stamford, C.(2012), Gartner Says Worldwide Media Tablets Sales to Reach 119 Million Units in 2012, <http://www.gartner.com/newsroom/id/1980115>. 10.05.2014.
93. Stevels, A. (1997). Optimization of the end-of-life system. *Ecodesign: A Promising Approach*. Brezet, J. C. and Hemel, C. V. Paris, UNEP Working Group on Sustainable Product Development.
94. Stevens, B.(1960). " Planned Obsolescence" ,
95. <http://storyofstuff.org/wp-content/uploads/movies/scripts/Story%20of%20Stuff.pdf>,20.04.2014.
96. Suh, S. and Huppel, G. (2005). Methods for life cycle inventory of a product. *Journal of Cleaner Production* ,13 (7), 687-697.
97. Sucena, M.P, Prado, S.S., Alves, R.C.G., and Moura, D.F.C., (2013). Neuro-fuzzy-integral model evaluation of dependability of critical components. In: *International Conference on Industrial Engineering and Operations Management*, July 10-12, Spain.
98. Tan, R.R., Culaba, A.B. and Purvis, M.R.I. (2002). Application of possibility theory in the life-cycle inventory assessment of biofuels *International Journal of Energy Research*. 26 (8),pp.737-745.
99. The Internet Encyclopedia of Philosophy (IEP), Sen's Capability Approach, *The Internet Encyclopedia of Philosophy* (IEP) (ISSN 2161-0002) <https://www.iep.utm.edu/sen-cap/>
100. Udo de Haes, H.,Heijungs,R., Suh,S. and Huppel, G.(2004). Three strategies to overcome the limitations of LCA. *Journal of Industrial Ecology*. 8(3), pp.19-32.
101. Veshagh, A. and Obagun, A.(2007). Survey of sustainable life cycle design and management. In: *Advances in Life Cycle Engineering for Sustainable Manufacturing Businesses*. Springer, London, pp. 237-242.
102. Vilaa,C., Abellán-Nebota, J.V., Albiñanaa, J.C. and Hernándezb, G(2015).An Approach to

- Sustainable Product Lifecycle Management(Green PLM), *Procedia Engineering*,132, pp. 585 – 592.
103. Waldman, M.(1997). “Eliminating the Market for Secondhand Goods: An Alternative Explanation for Leasing.” *Journal of Law and Economics* 40, pp. 61–92.
 104. Waldman, M.(1996). “Planned Obsolescence and R&D Decision” , *The RAND Journal of Economics*, vol. 27, no. 3, pp. 583–595.
 105. Wang, L.M., Li, F.Y., Li, J.F., Wang, X.W.(2010). Sensitivity and uncertainty analysis of life-cycle assessment based on multivariate regression analysis. *ICRM-Green Manufacturing*, pp. 184-191.
 106. Waste Watch. Electrical and electronic equipment recycling information sheet (2012) (online) <http://wasteonline.brix.fatbeehive.com/resources/InformationSheets/ElectricalElectronic.htm> , 10.05.2015.
 107. Watson, M.(2008). A review of literature and research on public attitudes, perceptions and behaviour relating to remanufactured, repaired and reused products. A report for the Centre for Remanufacturing and Reuse, Sheffield, pp. 1-26,
 108. <http://www.remanufacturing.org.uk/pdf/story/1p143.pdf>.10.05.2015.
 109. Williams, E. and Sasaki, Y.(2003). Energy analysis of end-of-life options for personal computers: resell, upgrade, recycle. *IEEE International Symposium on Electronics and the Environment*, Piscataway, New Jersey, IEEE.
 110. World Commission on Environment and Development (1987). *Our Common Future*. Oxford University Press, United Kingdom. <http://www.un-documents.net/our-common-future.pdf>, 10.05.2015
 111. Wrisberg, N., Udo de Haes, H.A., Triebswetter, U., Eder, P. and Clift, R.(2002) . *Analytical Tools for a Environmental Design and Management in a Systems Perspective. Eco-efficiency in Industry and Science*. Kluwer Academic Publishers, Dordrecht- vol 10 pp. 200-220, Springer.
 112. WRAP (2011) . *Realising the reuse value of household WEEE*. Banbury: Waste and Resources Action.<http://www.wrap.org.uk/sites/files/wrap/WRAP%20WEEE%20HWRC%20summary%20report.pdf>, 10.05.2015.
 113. Zhang,Y., Luo, X., Buis, J.J. and Sutherland, J.W.(2015). LCA-oriented semantic representation for the product life cycle, *Journal of Cleaner Production* 86 (2015), pp.146-162.
 114. Zhang, W. and Fan, Y. (2006). *Information Technology for Balanced Manufacturing Systems*. in *IFIP International Federation for Information Processing*, Vol. 220 , ed. Shen, W., (Boston; Springer), pp. 183-192.