Evaluation of Sustainable Competitiveness through Innovation

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Abstract

Clients’ continuous expectation increase and the need to be ahead of competitors, cause a huge pressure in companies and aggressiveness into markets. Due to this fact, companies’ need to be in permanent change to gain competitiveness. One way to achieve this aim is through innovation. But the question is How? Where to innovate? Innovation at any cost? What kind of impacts should be expected? Is it possible to evaluate companies’ innovation skills and stablish a relation with outcomes? This paper provides a model that contributes to competitive advantage creation through innovation integrating concerns about sustainability, based on the triple bottom line principles. Therefore, the model promote innovation preserving a balance between economic, social and environmental results. The model is based on 7 competitiveness drivers, which include all key factors of a company, and allow the evaluation of companies’ resources to be innovative, taking into account requirements structured in 8 proficiency levels. Additionally, the model allow the evaluation of the companies’ competitive advantage, considering innovation indicators, related to each competitiveness driver. This evaluation promotes another perspective of companies’ innovation capability, as well as the identification of opportunities to improvements, concerning the areas where companies have lower scores regarding innovation resources and results. This model, in this perspective is an added value tool, once it allows a more focused approach about innovation priorities, taking into account that innovation cannot be just considered “product innovation” and the fact that there are a lot of other aspects in an organization that have influence on it.

*Keywords:* Strategic planning, Competitiveness, Sustainability, Innovation, Evaluation

1. Introduction

The constant need to be ahead, aiming to achieve competitive advantage, is the fundamental reason that drives companies to be innovative. With this purpose it is crucial to develop capabilities to foresee new business opportunities and to create market trends, which requires strategic vision, taking into account their resources’ limitations and potentialities (McManus et al, 2007). This attitude demand the ability to explore alternative strategies and the talent to lead/ manage resources to new projects (Hamel & Valikangas, 2003). In such a context, it is vital to define appropriate strategies to face this challenges and to do so, companies should integrate innovation models into their strategic planning processes, allowing the evaluation of their current competitiveness and the appropriate definition of their business goals, operational targets and actions needed to achieve their objectives in a sustainable way.

1. Problem Statement

Nowadays companies are more exposed to market changes and more vulnerable to customers’ demand and competitors’ aggressiveness. This fact increase companies’ pressure to survive and to avoid bankruptcy or insolvency. According to (Gittleson, 2012) *“The average lifespan of a company listed in the S&P 500 index of leading US companies has decreased by more than 50 years in the last century, from 67 years in the 1920s to just 15 years today, according to Professor Richard Foster from Yale University, by 2020, more than three-quarters of the S&P 500 will be companies that we have not heard of yet.* Also Fortune 500 has a similar view about this issue, ([Perry](https://www.aei.org/scholar/mark-j-perry/), 2014) says that *“almost 88% of the companies from 1955 till 2014 have either gone bankrupt, merged, or still exist but have fallen from the top Fortune 500 companies.”* Considering ([Collins](https://www.amazon.com/Jim-Collins/e/B001H6GSHK/ref=dp_byline_cont_book_1), 2009) *“Every institution, no matter how great, is vulnerable to decline. There is no law of nature that the most powerful will inevitably remain at the top. Anyone can fall and most eventually do”*.

Indeed there are a relevant number of cases that are evidences of this reality, namely big companies from different economic sectors that never imagine could fall into bankruptcy, like WorldCom (2001), Enron (2001), Arthur Andersen (2002), Parmalat (2003), Refco (2005), Delta Air Lines (2005), Lehman Brothers (2008), General Motors (2009), [Blockbuster](http://www.bloomberg.com/news/2011-04-26/blockbuster-wins-final-bankruptcy-court-approval-to-sell-assets-to-dish.html) (2010), [Kodak](http://money.cnn.com/2012/01/19/news/companies/kodak_bankruptcy/index.htm) (2012), among others.

To reduce the risk of bankruptcy companies need to be prepared to face changes and to gain competitive advantage. Clayton (1997) stated that *“If you do what worked in the past, you will wake up one day and find that you’ve been passed by”*, and explained how innovation can be an advantage. Also in (Lendel & Varmus, 2011) perspective *“the companies try to ensure their competitiveness through innovation. To be in the company conducted effective work with innovation is necessary to adopt and implement an innovation strategy”*.

Following this line of thoughts, Drucker (1985) offered a systematic approach to the creative process by the introduction of the discipline of innovation and ([Dibrell et al, 2011b](http://www.sciencedirect.com/science/article/pii/S0148296313003573#bb0090)) introduce the concept of innovativeness, which means that firms’ emphasis their strategy on innovation.

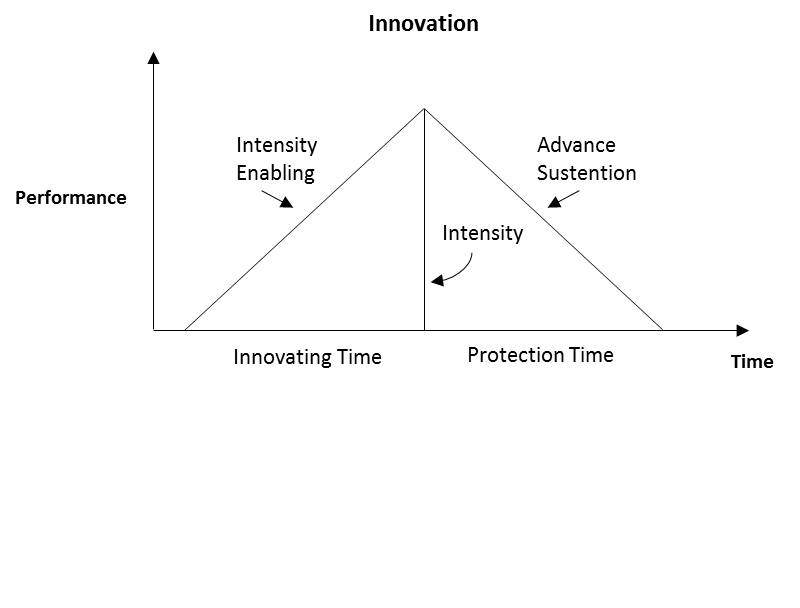
On other hand, new concepts like sustainability arise and may be of interest to be considered in the design of alternative models. In fact, sustainability can be based on the triple Bottom Line (3BL) principle (Norman & Macdonald, 2004), and according to this researcher *“The idea behind the 3BL paradigm is that a corporation's ultimate success or health can and should be measured not just by the traditional financial bottom line, but also by its social/ethical and environmental performance”*. Following (Hubbard, 2009) *“The TBL adds social and environmental measures of performance to the economic measures typically used in most organization”*. It seems to make sense to use this principle to evaluate companies’ performance (results).

Considering the above, the aim of this research was to design a model to support companies on their strategic evaluation process, taking into account their current competitiveness based on their capability to be innovative and their capacity to increase their performance, measured through economic, social and environmental results (sustainability).

1. Research Methodology

Therefore the research methodology applied was a deductive approach, once this method assume empirical approaches to validate hypothesis and assumptions. Beyond the literature review, which allowed the analysis of several strategic planning approaches and tools (e.g. PESTLE[[3]](#footnote-3), Balanced Scorecard, LARG[[4]](#footnote-4), among others), the most worldwide recognized evaluation models and international standards (e.g. EFQM[[5]](#footnote-5), Shingo Prize, GRI and DJSI[[6]](#footnote-6), IS0 9000 (series)[[7]](#footnote-7), 14001[[8]](#footnote-8), 22400[[9]](#footnote-9), ISO 26000[[10]](#footnote-10), ISO 45001[[11]](#footnote-11), ITIL[[12]](#footnote-12)); there were involved 18 experts to obtain feedback and validations about the model’s components and

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| --- | --- |
| indicators, through questionnaires and workshops.  There was a concern to select experts according to appropriate profiles to assure their suitability to reach the research objectives. Therefore, four selection criteria were established, namely: Overall business experience and vision; Years of professional experience; Current role and professional career; and Specific skills related to the research filed. The pool of experts considered had an average age of 51 years old (minimum of 38 and maximum of 66 years) and more than 485 accumulated years of experience (minimum of 15 and maximum of 41 years), covering all critical business dimensions and relevant components pre-defined at the research scope, due to their careers in management, quality, monitoring, innovation, sustainability, manufacturing and logistics and in technology.   1. The Sustainable Competitiveness Evaluation model – innovation based   The present research enabled the design of a | sustainable competitiveness evaluation model, based on innovation dimension. The model assume that companies should evaluate two components to be able to define more reliable strategic goals and targets to reinforce and achieve continuously competitive advantage, through innovation, in concrete:   * Their resources or ability to manage them, in order to be systematically innovative (focused on the company’s innovation efficiency); and * If they are an innovative company (focused on the company’s innovation impact or results, which means their innovation effectiveness).   According to the above, and taking into account the “Innovation S – Curve” or the innovation lifecycle framework of (Dismukes et al, 2012) it is possible to establish a relation between innovation resources management and innovation performance (Figure 1). |



**Figure 1** – Innovation Triangle

The Innovation Triangle assume two parameters that define innovation dimension, which depend on time and have impact on performance (innovation indicators allow to express innovation results in terms of economic, social and environmental values), namely:

* Intensity Enabling – which measures the resources ability to be intensively innovative, which means that a higher performance level stated is achieved faster. Thus, Innovating Time is shorter when this parameter has high values.
* Advance Sustention – which measures the resources ability to maintain longer this innovation advantage. Thus, better this parameter the longer is the Protection Time.

Considering this assumptions, we conclude that if a company has a short innovation time and a long protection time and is achieving high innovation results (performance), then the company can be considered has having sustainable competitiveness. If compared with a competitor, acting in the same economic sector, and if its evaluation results reveal a better score than its competitor, then the company have a competitiveness advantage in terms of innovation.

Anyway, the question that should be answered now is: How can innovation resources management be measured, as well as what kind of innovation indicators should be used?

Considering the analysis of several evaluation models and strategic approaches, we define seven competitiveness drivers (Table 1), which are the foundations of the Sustainable Competitiveness Evaluation model based on innovation.

**Table 1** – The 7 competitiveness Drivers of the sustainable competitiveness evaluation model based on innovation, considering a comparison analysis with other models and approaches

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Criteria of EFQM model** | **Principles of Shingo Prize model** | **Competitiveness Drivers** | **Balanced Scorecard Perspectives** | **PESTLE** |
| Leadership | Culture Enablers  Leadership & Ethics  Enterprise Culture  Enterprise Thinking  Consistent Lean Policy Deployment | **Corporate Behavior** | Learning and Growth | Political  Legal |
| Strategy  Customer Results  Society Results | Quality  Delivery  Cost  Competitive Impact | **Business Proposition** | Customer | Economic |
| Business Results | Business Results  Financial Impact | **Financial Stability** | Financial |
| People  Partnerships & Resources  People Results | People Deployment | **Organization Wellbeing** | Learning and Growth | Social |
| Processes, Products & Services  Partnerships & Resources | Continuous Process Improvement  Lean Ideas  Value Stream & Support Processes | **Operational Leanness** | Internal Business Processes | Technical  Environmental |
| **Technological Alignment** |
| **Facilities Suitability** |

Once the definition of the seven competitiveness drivers and after more detailed analysis, reflections and workshops with experts, 14 competitiveness elements were established, as well as 24 evaluation criteria (sources of enhancement) – Table 2.

**Table 2** – Competitiveness elements, sources of enhancement and leverage factors by each competitiveness driver of the Sustainable Competitiveness Evaluation Model based on innovation















Thus, the model allow the evaluation of a company’s innovation competitiveness by analyzing the level of compliance and evidences of the ability to comply with each of the requirements that express each leverage factor for each evaluation criteria (Table 2).

Even so, we still evaluating resources. In fact we just are capable to evaluate the company’s ability to innovate (how the company manage their means to reduce innovation time and to enlarge innovation protection time). So, to complete de evaluation model, the innovation performance measures should also be defined. With this purpose, among a wide range of indicators applicable, we selected 18 indicators to be part of the model (Table 3), which should be measured annually.

**Table 3** – Innovation indicators of the Sustainable Competitiveness Evaluation Model based on innovation

**Corporate Behavior (4)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Impact Indicator** | **Evaluation Purpose**  (what is the company’s …) | **Calculation**  (metrics) | **Sustainability dimensions** | | | **R/I** |
| **Econo mic** | **Social** | **Environ mental** |
| Environmental index | Commitment to global warming and climate change reduction | (Total of gas emission x total of water consumption x total of energy consumption x total solid waste produced)/ GVA |  |  | X | I |
| Patents and trademark index | Innovation effectiveness | 0,8 x nº of patents approved + 0,2 x nº of trademarks  registered | X |  |  | I |
| Average innovation cycle time | Innovation efficiency | ∑n i time since idea till launch of the new product or servicei/ nº of new products or services launched | X |  |  | I |
| Number of scientific publications | Relevancy to innovative and scientific knowledge (innovation recognition) | Nº of scientific articles published in recognized scientific journals (ex.: ISI) | X | X |  | I |

**Business Proposition (2)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sales of new products (and services) on total of sales | Capacity to convert innovation into business | (Sales of new products and new services/ total of sales) x 100 | X | X | X | I |
| Sales of green products (and services) on total of sales | Ability to convert environmental commitment into business and introduce green solutions into the value chain | (Sales of green products and green services/ total of sales) x 100 | X |  | X | I |

**Financial Stability (2)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| EBITDA profit margin (profitability) | Ability to generate profit, through higher prices based on quality advantage, perception or branding; or through lower product costs due to production efficiency or economies of scale | (EBITDA/ Gross revenue) x 100 | X |  |  | I |
| RoPDE (Return on product development expense) | Innovation effectiveness (ability to generate earnings by new products or services) | (Gross Margin – PDE)/ PDE x 100 | X | X | X | I |

**Organizational Wellbeing (3)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| High qualified employee rate | Commitment to excel, continuous improvement, research and innovation | (Nº of employees with doctoral or master degree/ total nº of employees) x 100 |  | X |  | I |
| Training costs per employee | Commitment to continuous training and development of employees’ skills to promote improvements and innovation | Total training cost/ total nº of employees |  | X |  | R/I |
| Carbon footprint per employee | Capacity to reduce carbon emission | Total carbon emission/ total nº of employees |  |  | X | I |

**Operational Leanness (3)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| OEE (Overall Equipment Effectiveness) | Operational productivity | Availability x Performance x Quality | X |  |  | I |
| % of recycled material used as raw material input | Commitment to green supply chain | (Nº of recycled units of raw material/ total units of raw material used) x 100 |  |  | X | I |
| Non conformity rate | Operational reliability | (Nº of defect units/ total units produced) x 100 | X |  |  | R/I |

**Technological Alignment (2)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ICT investment rate | Commitment to ICT up-grading and overall performance increase | (ICT investment amount/ (total investment amount – direct innovation investment)) x 100 | X |  |  | I |
| Number of systems integrated with other company systems | Ability to integrate ICT systems in its value chain | (% ICT suppliers integration + % ICT customers integration)/ 2 | X | X | X | R/I |

**Facilities Suitability (2)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ergonomic and health costs rate | Commitment to employee health and capability to avoid occupational diseases | ((compensation for injury, mutilation or deformity + absenteeism costs due to diseases)/ total personnel costs) x100 | X | X |  | R/I |
| Space productivity | Facilities efficiency | Gross revenue/ facility’s square foot | X |  | X | I |

1. Conclusions

The validation process handled with the experts of this research allowed to conclude that the sustainable competitiveness evaluation model - based on innovation, seems to be a value added approach. In fact, they had a unanimous opinion about the importance of the model and all assumed that it could be a helpful tool for managers to identify in what fields of innovation the company need to improve, as well as to support the definition of actions that should be implemented to drive the company to higher levels of sustained competitive advantage. In spite of the expert’s opinion, the suitability of the model should be validated through its application on a real business context, through the development of cases studies.

Regarding the model’s improvement, other issues could be taken into account for further research and to answer to additional aspects, namely product-related sustainability factors, such as for example at Business Proposition sales of green products should be also “social”? at Financial Stability could be another aspect producing more intelligent or more simple products? at Organization Wellbeing the ability for problem solving and to people change themselves should be incorporated? Carbon footprint per employee should be called at Operational Leanness, too? Technological Alignment should also check the consequences of new product (medium term, long term)? Facility Suitability should also contain the investment for suitable facilities for an effective innovation process, or this is covered by Financial Stability?

It is possible to conclude that, although the developed model achieved which at this stage can be assumed as a benefit for companies as a tool to support the process of increasing their competitive advantage, there still room for improvements.

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1. References

Arash Shahin, Hosein Rezaei Dolatabadi, Milad Kouchekian (2012). Proposing an Integrated Model of BSC and EFQM and Analyzing its Influence on Organizational Strategies and Performance - The Case of Isfahan Municipality Complex. *International Journal of Academic Research in Economics and Management Sciences, Vol. 1, No. 3.*

Berghman, L., Matthyssens, P., Streukens, S., & Vandenbempt, K. (2013). Deliberate Learning Mechanisms for Stimulating Strategic Innovation Capacity. Long Range Planning, 46(1-2), 39–71. *Elsevier Ltd. Retrieved from* [http://linkinghub.elsevier.com/retrieve/pii/ S002463011200074X.](http://linkinghub.elsevier.com/retrieve/pii/%20S002463011200074X.)

Chesbrough, H. (2006). Open Business Models:How to Thrive in the New Innovation Landscape. *Harvard Business School Press.*

Chesbrough, H. (2013). Open business models: How to thrive in the new innovation landscape. *Harvard Business Press.*

Christensen, C. M. (2013). The innovator's dilemma: when new technologies cause great firms to fail. *Harvard Business Review Press.*

Clayton M. Christensen (2009). Exploring The Limits Of The Technology S-Curve. Part I: Component Technologies. *Production and Operations Management, Wiley Online Library.*

Clayton, C. (1997). The innovator’s dilemma: When new technologies cause great firms to fail. *Harvard Business School Print*.

Collins, J. C. (2009). How the mighty fall: And why some companies never give in. *(1th ed.) Random House.*

Dibrell, C., Craig, J., & Hansen, E. (2011). Natural environment, market orientation, and firm innovativeness: An organizational life cycle perspective. *Journal of Small Business Management*, *49(3), 467-489.*

Dibrell, C., Craig, J. B., & Neubaum, D. O. (2014). Linking the formal strategic planning process, planning flexibility, and innovativeness to firm performance. *Journal of Business Research, 67(9), 2000-2007.*

Dismukes, J. P., Bers, J. A., & Sekhar, J. A. (2012). Toward a holistic six-period radical innovation life cycle model. *International Journal of Innovation and Technology Management, 9(01), 1250001.*

Drucker, P. F. (1985). Innovation and entrepreneurship practices and principles. *AMACON*.

Drucker, P. (2014). Innovation and entrepreneurship. *Routledge.*

Flak, O., & Grzegorz, G. (2015). Verification of the relationships between the elements of an integrated model of competitiveness of the company. Procedia - *Social and Behavioral Sciences, 207, 608–631. Elsevier B.V. Retrieved from* <http://dx.doi.org/10.1016/j.sbspro.2015.10.132.>

Frank Boons, Florian Ludeke-Freund (2013). Business Models for Sustainable Innovation: State-of-the-art and Steps Towards a Research Agenda. *Journal of Cleaner Production, Volume 45, pages 9-19.*

Gittleson, K. (2012). Can a company live forever. *BBC News*.

Hamel, G., & Valikangas, L. (2003). The quest for resilience. *Harvard business review*, *81*(9*), 52-65.*

Helena Carvalho, Susana G. Azevedo, V. Cruz–Machado (2013). An Innovative Agile and Resilient Index for the Automotive Supply Chain. *International Journal of Agile Systems and Management - Inderscience Publishers, Vol. 6, Nº. 3.*

Helena Carvalho, V. Cruz–Machado (2013). Modeling Resilience in Supply Chain. *Doctoral Dissertation, UNL/ FCT.*

Hubbard, G. (2009). Measuring organizational performance: beyond the triple bottom line. *Business Strategy and the Environment*, *18*(3), *177-191.*

J Mairesse, P Mohnen (2002). Accounting for Innovation and Measuring Innovativeness: an Illustrative framework and an Application. *American Economic Review, 92, 226-231.*

[Jay Barney](http://jom.sagepub.com/search?author1=Jay+Barney&sortspec=date&submit=Submit) (1991).Firm Resources and Sustained Competitive Advantage. *Journal of Management, Vol. 17, Nº1, pages 99-120.*

John Cantwell (2003).Innovation and Competitiveness. *Handbook of Innovation, Chapter 21, Oxford University Press.*

Jussi Lehtinen, Tuomas Ahola (2010). Is Performance Measurement Suitable for an Extended Enterprise?. *International Journal of Operations & Production Management, Volume 30, Issue 2, pages 181-204.*

Keld Laursen, Ammon Salter (2006). Open for Innovation: The Role of Openness in Explaining Innovation Performance Among U.K. Manufacturing Firms. *Strategic Management Journal, 27: 131-150.*

Lendel, V., & Varmus, M. (2011). Creation and implementation of the innovation strategy in the enterprise. *Economics and management, 16, 819-825.*

McManus, S., Seville, E., Brunsdon, D., & Vargo, J. (2007). Resilience management: a framework for assessing and improving the resilience of organisations. *Resilient organisations research report.*

Michael E. Porter (1983). Industrial organization and the evolution of concepts for strategic planning: The new learning. *Managerial and Decision Economics,* [*Vol. 4, Issue 3,*](http://onlinelibrary.wiley.com/doi/10.1002/mde.v4:3/issuetoc) *pages 172–180.*

[Michael E. Porter](http://scholar.google.pt/citations?user=g9WIbh0AAAAJ&hl=en&oi=sra) (2008). [Competitive advantage: Creating and sustaining superior performance](http://www.google.com/books?hl=en&lr=&id=H9ReAijCK8cC&oi=fnd&pg=PR15&dq=competitive+advantage&ots=p7aBPJ9-4D&sig=tmFmFQitYcazjZU9BFLabLRmdi0). *Google Books.*

Monica Sharma, Rambabu Kodali (2008). Development of a framework for manufacturing excellence. *Measuring Business Excellence, Vol. 12 Iss: 4, pp.50 – 66.*

Norman, W., & MacDonald, C. (2004). Getting to the bottom of “triple bottom line”. *Business Ethics Quarterly*, *14*(02), 243-262.

Paola Cocca, Marco Alberti (2010). A Framework to Assess Performance Measurement Systems in SMEs. *International Journal of Productivity and Performance Management, Volume 59, Issue 2, pages 186-200*

Per-Arne Wikström (2010). Sustainability and organizational activities – three approaches. *Strategic Approaches to Sustainability Policy and Management,* [*Vol. 18, Issue 2,*](http://onlinelibrary.wiley.com/doi/10.1002/sd.v18:2/issuetoc) *pages 99–107.*

Perry J. Mark (2014). Fortune 500 firms in 1955 vs. 2014. [www.aei.org/publication/fortune-500-firms-in-1955-vs-2014-89-are-gone-and-were-all-better-off-because-of-that-dynamic-creative-destruction/](file:///\\192.168.1.150\share\Data-Base\5-IJoSI\!!!IJoSI出刊進度追蹤\%23203%20v5-2\www.aei.org\publication\fortune-500-firms-in-1955-vs-2014-89-are-gone-and-were-all-better-off-because-of-that-dynamic-creative-destruction\)

Rainer Feurer and Kazem Chaharbaghi (1994)*.* Defining Competitivenes: A holistic approach. *Management Decision, Vol. 32 Iss: 2, pp.49 – 58.*

Rosanna Garcia, Roger Calantone (2002). A Critical look at Technplogical Innovation Typology and Innovativeness Terminology: a literature Review. *Journal of Product Innovation Management, Volume 19, Issue 2, pages 110-132.*

Sauka, A. (2015). Measuring the competitiveness of Latvian companies, 14, *140–158.*

[Stuart L. Hart](http://amp.aom.org/search?author1=Stuart+L.+Hart&sortspec=date&submit=Submit), [Mark B. Milstein](http://amp.aom.org/search?author1=Mark+B.+Milstein&sortspec=date&submit=Submit) (2003). Creating sustainable value*. Academy of Management Perspectives - Vol. 17 no. 2 56-67.*

Suzanne Rosselet (2011)*.* Leveraging Competitiveness To Wage War Against Short-Termism - Building The House Of Sustainable Competitiveness. *World Competitiveness Center.*

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3. PESTLE – Political, Economic, Social, Technological, Legal and Environmental analysis; [↑](#footnote-ref-3)
4. LARG – Lean, Agile, Resilient and Green [↑](#footnote-ref-4)
5. EFQM – European Foundation for Quality Management excel award [↑](#footnote-ref-5)
6. GRI – Global Dow Jones Sustainability Index [↑](#footnote-ref-6)
7. ISO 9000(series) – Quality management [↑](#footnote-ref-7)
8. ISO 14001 – Environment management [↑](#footnote-ref-8)
9. ISO 22400 - Automation systems and integration -- Key performance *indicators* (KPIs) for *manufacturing* operations management [↑](#footnote-ref-9)
10. ISO 26000 – Social responsibility [↑](#footnote-ref-10)
11. ISO 45001 - Occupational health and safety [↑](#footnote-ref-11)
12. ITIL - *Information Technology Infrastructure Library* [↑](#footnote-ref-12)