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Using Lean Performance Metrics; Benchmarking the Aerospace Industry with the Automotive Industry

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Abstract

Lean manufacturing has been in development within the automotive industry, most notably at Toyota, for many years now. In recent years, also the aerospace industry has shown interest in the concept's potential, looking for better, faster and cheaper company performance.

Following research performed by Beelaerts van Blokland and others, this paper seeks to benchmark the aerospace and automotive industries based on their lean performance, using so-called lean performance metrics. The lean performance metrics are found to be a suitable measure of companies' performance with respect to the 3C's; continuation, conception and configuration. Using the metrics and the 3C-model, it is quantitatively shown that the aerospace industry as a whole is performing increasingly leaner. Because of the automotive industries' longer collective experience in the lean philosophy, the automotive industry is the better performer of the two. However, the aerospace industry is following suit. In addition, the use of the lean performance metrics, as well as the industry composed lean performance indices, given as the mean of the lean performance metrics, has been demonstrated and support for them being a valid way of valuating lean company performance is given.

Keywords: Lean Performance Metrics, Aerospace Industry, Automotive Industry, 3C-model.

Introduction

In 2007 the Toyota Motor Corporation surpassed the General Motors Corporation as the largest automotive manufacturer in the world, based on vehicle numbers. In 2004 it did so already in terms of profits. The reason for this is Toyota's lean production system, started just after World War Two, through which the company was able to continuously improve its performance (Womack, Jones and Roos, 2007). As of now, the lean production philosophy has been adopted by many companies throughout the world, in many different industries. However, the philosophy is most widespread in the automotive industry, the industry in which it first arose (Womack, Jones and Roos, 2007).

Womack and Jones (2003) describe the lean philosophy as "a way to do more and more with less and less – less human effort, less equipment, less time and less space – while coming closer and closer to providing customers with exactly what they want". This is achieved by eliminating the different forms of *waste* that can be present in a company. As stated by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007), "lean thinking places 'optimizing the total value' instead of 'minimizing the cost' as the main goal". Womack and Jones (2003) and Womack, Jones and Roos (2007) are good references for gaining more insights into the lean concept.

One industry to follow suit relatively late in the adoption of lean principles is the aerospace industry. In Flight International (1998), UK aerospace company BAE Systems expressed its view that the aerospace is ten to fifteen years behind the automotive industry in implementing the lean philosophy. Despite the criticism that lean is not transferable to other industries that is quite frequently heard (Crute, Ward, Brown and Graves, 2003), Flight

International (1999) states the aerospace industry is “in the grip of a revolution”, named ‘lean’, through which it aims to eliminate waste in order to achieve “faster development, better quality and lower cost”. This is agreed on by Cook (1999) and MIT’s Lean Aerospace Initiative (Murman et al., 2002).

Research about lean has mainly focused on process or product innovation. Through the superposition of the 3C-model devised by Beelaerts van Blokland (2006) on Porter’s (1985) value chain theoretical framework on a company’s organization, research on lean principles has been lifted to a higher aggregation; to an organizational level. The outcome of this value chain innovation process is a canted value chain that sees the 3C’s – *Continuation, Configuration, Conception* – as the primary activities of a lean organization. A lean enterprise is then one which is able to leverage these primary activities in order to increase its value flow throughout the whole value system.

From suppliers to the final customer, a company’s value chain is, as such, much more dependent on the whole value system which, from a lean perspective, becomes a lean value network system (Zegveld, 2006). The enhanced value flow in a company as a result of the adoption of lean principles and the 3C-model throughout its whole organization should then be appreciated by a tangible improvement of a company’s financial performance.

The aim of this paper is to provide insights into the use of lean metrics in benchmarking the aerospace industry with the automotive industry. Lean metrics, set up by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007), are believed to give a good measure of a company's overall leanness. By so doing, also the trends in lean performance in both industries are investigated. These metrics are Turnover per Capita (T/C), Profit per Capita (P/C) and Research and Development per Capita (R&D/C). Each of these measures a company’s ability to leverage respectively on its configuration, continuation and conception activities. As such two hypotheses are coined:

H1: The aerospace industry as a whole is performing less lean than the automotive industry.

And:

H2: The aerospace industry is getting more and more lean, following the automotive industry.

To test these hypotheses financial data of a sample of companies from both industries will be considered. The financial data used will be turnover, profit (EBIT), research and development (R&D) expenditures and finally the number of employees. Using these data, all of the above mentioned lean metrics can be determined quantitatively.

This paper will first feature the theoretical framework of the 3C-model. Next, the research methodology is explained and results of the lean performance benchmark analysis are presented. Finally conclusions and limitations will be discussed.

The 3C-Model and Value Chain Innovation

According to Beelaerts van Blokland, Plees, Voeten and Santema (2006), an innovation process within a value system is driven by three basic drivers; the three C's. These three C's, Continuation, Conception and Configuration, are forged into an analytical framework and can be used in the assessment of investment, development and production sharing between a company and its suppliers; *co-innovation*. Each of the three C's will be described below.

Beelaerts van Blokland, Plees, Voeten and Santema (2006) describe *continuation* as the possession of *customers*, or the presence of a *demand*, for a company. Customers, provide the company with the continuity, i.e. the possibility to continue the selling of its products and its business. Therefore, continuation is of the utmost importance to any company. In the light of innovations, continuity makes up the customers, which provide a company with the possibility to break even fast, as seen from the demand side of the business (Prahalad and Ramaswamy, 2001). Beelaerts van Blokland, Plees, Voeten and Santema (2006) state that for continuity, it is essential to know the customer and his needs.

Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007) define *conception* as "unique technology or smart and original processes, supported by intellectual property (IP) in cooperation with co-innovation parties, based upon the customer demand". Thus, it is related to the way in which a company and its co-innovation partners are able to translate customer needs and requirements into unique technologies or processes, through which they can outperform their competition. This is similar to the view by Von Hippel (2005) that the customer's needs and desires can be input to the development of new products and services. "The uniqueness of the product will be honored by the customers preferring one product" over that of the competition, thus evident as a higher market share (Beelaerts van Blokland, Plees, Voeten and Santema, 2006).

Finally, *configuration* is related to the organization of the value creating chain or system (Beelaerts van Blokland, de Gier, Santema and Zitter, 2006). According to Zsidisin and Smith (2004), risk, costs and development times can be reduced significantly through engaging in partnerships with suppliers early on in the innovation process. Thus, in the view of an innovation process, configuration provides an early breakeven from the supply point of view, through the achievement of lower costs, risks and development times. Lamming (1993) and Tidd et al. (2001) identified that partnerships are developed to reduce the supply base for the main contractor, to involve partners in the development of products, to increase cost transparency and learn together.

The ability of the focal company to multiply the innovation investments and its production share over the partners is expressed by the Innovation Investment Multiplier (IMP) and

Production Multiplier (PMP) respectively (Beelaerts van Blokland, 2006, Beelaerts van Blokland, Verhagen and Santema, 2008). These are defined as the total innovation investment or total production divided by the investment or production share of the innovator. The effects thereof result in a change in Market Share (ΔMS). Based on quantitative data from the automotive industry, the correlation between the PMP, ΔMS and IMP has been shown by Beelaerts van Blokland, Verhagen and Santema (2008). They have shown that co-innovation and co-investment on product level have a significant effect on the value-time curve.

Thus, together continuation, conception and configuration, become the primary activities that drive a company's value chain and value creation ability. Figure 1 illustrates the canted value chain as devised by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007). In line with the lean philosophy where a company has strong customer focus and moves towards the end of the whole value chain to meet the end customer demand, the canted value chain presents differences with the one defined by Porter (1985), which is primarily based on push and mass production.

These differences will be briefly explained. Inbound and outbound logistics are increasingly outsourced to specialized logistics companies, offering integrated services. These logistics services become a vital support activity for a company but are no longer considered as strategic value adding activities. On the other hand, procurement, which was considered as a support activity in the traditional framework, evolves from an operational function to an integral part of business strategy (Niezen and Weller, 2006). With a shift from many to just a few strategic suppliers (Kraljic, 1983), procurement evolves towards strategic supply management.

Also technology development becomes a key driver to a company's success as Research and Development activities are the ones that allow a company to develop new products to continuously satisfy the demanding customer. Thus, the 3C's well describe today's companies' primary activities; *continuation* encompassing marketing and sales and services, *conception* encompassing technology development and operations and *configuration* encompassing the strategic supply chain management function.

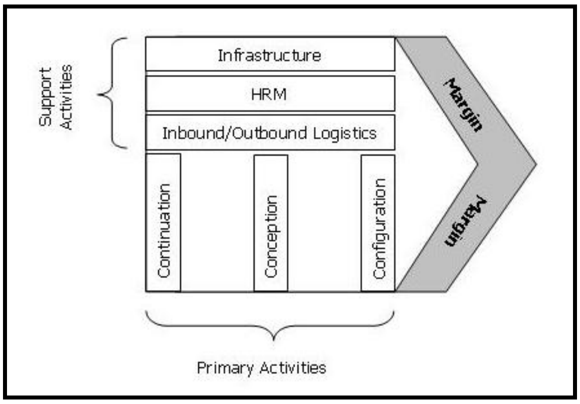

Figure 1 - The Lean Value Chain.

Lean Performance Metrics

Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007) have developed a number of so-called lean performance metrics that can be used to assess a company's leanness, particularly when combined with information about companies' value chains. These metrics are the profit per capita, the turnover per capita and the research and development expenses per capita and can easily be obtained from any (public) company's annual report. The per capita-base is used to correct for differences in company sizes and to get a measure of the company's efficiency through the use of its employees. Furthermore, profit, turnover and R&D expenses are not dependent on the accounting conventions adopted (Bryan, 2007).

According to Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007), continuation, is expressed through the profit per capita (P/C) metric, since it "gives an outlook on a company's ability for business continuity", since a high P/C "reflects that a company is able to add more customer value". In line with Maskell and Kennedy (2007), a focus on creating customer value will in time result in more value for the company. From a lean perspective this metric is then related to the level of focus on customer *pull* rather than on market push.

Next, a company's level of conception is captured by the R&D budget per capita (R&D/C), because this "is an indicator of the ability to leverage on the value system in order to generate innovation". Thus, the R&D/C can be seen as a measure of how well a company and its strategic partners are able to develop technologies and processes that adhere to their customers' needs. From a lean perspective this metric can therefore quantify the level of focus of a company and its supply network to deliver *customer value*.

Finally, a company's turnover per capita (T/C) is a measure of the leanness of the company's value chain configuration (Beelaerts van Blokland, Fiksiński, Amoa and Santema, 2007). By generating more turnover per employee, the company achieves a higher leverage over the value it processes to its customers. From a lean perspective this metric is then able to quantify the level of focus of a company on optimizing the value flow through its value chain.

In their research Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007) have proven that correlation amongst these metrics is significant and that they are able to quantify at organizational level the status of a company regarding its lean value chain. In the following section a methodology for using these lean performance metrics to assess performance at industry level will be presented. The interrelations between the three C's are given in figure 2.

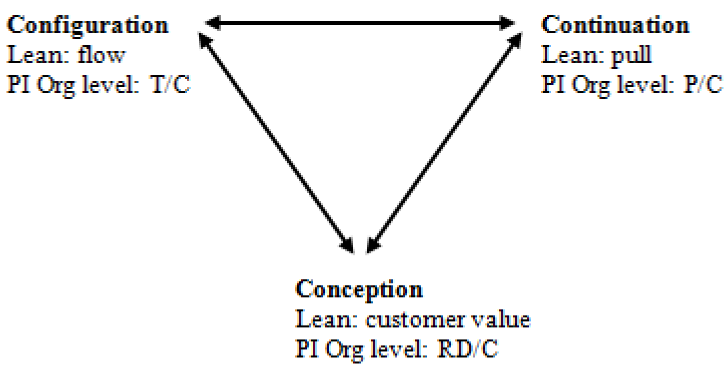

Figure 2 – The 3C-model and Metrics.

Methodology

To benchmark the aerospace industry to the automotive industry with respect to their historical lean performance the following methodology has been adopted. Firstly, a number of companies from both industries was identified to constitute the research sample. Secondly, relevant financial and company data from the two industry samples was collected from the companies' annual reports spanning a period of twelve years, from 1996 to 2007.

For each year and company the lean metrics (T/C, P/C and R&D/C) have been calculated. Subsequently, for each year, the mean for each lean metric was calculated for the aerospace and the automotive sample. In this manner a yearly *composite lean performance index* was obtained for both industries. The lean metrics used in this paper are already normalized based on the number of employees per company. The calculation of the industries' lean performance indices by arithmetical averaging of the lean performance metrics is thus deemed to suffice in well representing the industries' lean performance.

Statistical analysis of the collected data is performed by means of a linear regression model for each time series of the lean performance composite indices for the two industries. In order to assess the internal validity, the statistical significance of the identified linear trends has been tested through a two-tailed test at a level of significance of 0.05. Therefore, the trends showing a correlation coefficient (R) greater than the critical value (see table 1) were considered as statistically significant. The slopes of the trend lines given by the regression model were considered as indicators of lean performance. Thus, these have been used for performing the benchmark. Finally, the unit of measure adopted in the lean performance assessment is that of the United States Dollars (US$) per employee. Financial figures in the companies' annual reports not listed in US$ were converted using the US$ conversion rate at the end of each respective year.

Table 1: Industries’ Critical Value.				
Industry	**N**	**df = N-2**	**Significance Level**	**Critical Value**
Aerospace	23	21	0.05	0.413
Automotive	12	10	0.05	0.576

Particular attention has been given to drawing the samples representative of the two industries. As major global corporations have adopted lean policies, the two industry samples have been composed of leading global companies in the respective industrial sectors. Table 2 portrays the companies whose financial data was used to calculate the lean performance indices. The sample of the aerospace industry is composed of leading US, European and other international players in the sector. The sample of the automotive industry is composed of leading US, European and Asian motor vehicle manufacturers, added to the world’s leading tractor and agricultural vehicle manufacturer and the world’s leading earth moving vehicle manufacturer (John Deere and Caterpillar respectively). The authors believe that this diversification in the composition of the automotive sample balances the vast product portfolio offered by the aerospace related companies thus enhancing the external validity of this research.

<table>
<tr><th colspan="4">Table 2: The Study Sample.</th></tr>
<tr><th colspan="2">Aerospace Industry</th><th colspan="2">Automotive Industry</th></tr>
<tr><th>Company</th><th>Region</th><th>Company</th><th>Region</th></tr>
<tr><td>Alliant Techsystems</td><td rowspan="10">United States</td><td>Caterpillar</td><td rowspan="5">United States</td></tr>
<tr><td>BE Aerospace</td><td>Ford Motors</td></tr>
<tr><td>Boeing</td><td>General Motors</td></tr>
<tr><td>General Dynamics</td><td>John Deere</td></tr>
<tr><td>Goodrich</td><td>PACCAR</td></tr>
<tr><td>Honeywell</td><td>BMW</td><td rowspan="5">Europe</td></tr>
<tr><td>L-3 Communications</td><td>Porsche</td></tr>
<tr><td>Lockheed Martin</td><td>PSA (Peugeot-Citroen)</td></tr>
<tr><td>Northrop Grumman</td><td>Renault</td></tr>
<tr><td>Raytheon</td><td>Volkswagen</td></tr>
</table>

Rockwell Collins		Honda	Japan
Textron		Toyota	
United Technologies			
BAE Systems			
Dassault Aviation			
EADS			
Finmeccanica	Europe		
MTU Aero Engines			
Rolls Royce			
THALES			
Bombardier	Canada		
Embraer	Brazil		
Mitsubishi Heavy Industries	Japan		

Subsequently, statistical significance with regard to historical correlation of the relation between the lean performance metrics mentioned above has been investigated for both industries. The historical correlation of the lean performance indices has been tested as has been done by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007). Three graphs were plotted. The first portrays P/C versus T/C, the second portrays R&D/C versus T/C and the third portrays R&D/C versus P/C, all three at industry level.

In each of these graphs the time series of the relevant lean performance indices for the aerospace and the automotive industries were plotted. Subsequently a linear regression model was applied to each historical trend. Analogously to the statistical methodology described above, the outcome of the linear regression model has allowed to assess the statistical significance of the historical trend by performing a two-tailed test and also to benchmark the two industries by comparing the slopes of the linear trends.

As shown in table 3, the automotive lean performance time sample consists of one less element than the aerospace industry sample. This element corresponds to the data for the year 2007, which the authors have discarded because the trend lines for the automotive industry became extremely distorted. The reason for this distortion was Porsche. Porsche's numbers went up quite extremely due to its announcement of its acquisition of a large part of Volkswagen's shares. Therefore, these excessive results can be considered as a special occasion and are therefore discarded. This distortion of data points in graphs was a lot less present for all other graphs used in this paper, since these graphs were only dependent on one data series, whereas the graphs pertaining to the historical correlation of the lean performance indices are based on two data series.

Table 3: Historical Correlation Critical Values.

Industry	**N**	**df = N-2**	**Significance Level**	**Critical Value**
Aerospace	12	10	0.05	0.576
Automotive	11	9	0.05	0.602

Results

The analysis of the data shows the statistical significance of industry trends that have been obtained. Overall, the historical lean performance index trends show that the automotive industry has been ahead of the aerospace industry in the past and will be in the future. This was to be expected due to the simple fact that the automotive industry started to implement lean practices consistently in the 1980's, long before the aerospace industry. Furthermore, the aerospace industry has only in the last years started to become lean and faces greater challenges than the ones faced by the automotive industry in the path towards the lean enterprise. It is the overall legacy structure and dynamics of the aerospace industry that constitute barriers to change (Murman et al., 2002). Notwithstanding this, it may be appreciated that the trends towards lean are all positive and suggest that the industry is taking action in this respect. The lean performance indices will now be addressed one by one.

Turnover per Capita

The automotive and aerospace industry trends both show statistical significance and are found to be positive (see table 4). Supporting table 4, figure 3 shows the trends of both industries. The thick dots give the mean yearly values, whereas the thin dots indicate the minimal and maximal values and thus the spread over the range of companies in each industry. Thus, both industries are following a path towards becoming leaner with respect to their configuration activities. This may be concluded because T/C was taken as a lean metric for the company's configuration activities. It may also be appreciated, however, that the trend line of the automotive industry shows a slightly steeper trend with respect to the aerospace industry.

In the canted value chain devised by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007), from the lean perspective configuration is about how networked a company's value system is and how integrated the company is with its partners in order to leverage each other's resources to create value. On this behalf the automotive industry is performing better than the aerospace industry and also seems to be improving at a faster rate.

This may be explained by the fact that, firstly, the automotive industry has adopted lean long before the aerospace industry and, secondly, the product complexity of the aerospace industry makes it harder to develop and execute a lean supply chain (Murman et al., 2002). However, evidence of the improvement with respect to configuration in the aerospace industry is increasing, considering for instance that the major commercial aircraft programs are increasingly reliant on global supply chains of risk-sharing partners.

Table 4: Industries' Statistical Significance for T/C.

Industry	**r^2**	**r**	**Significant**	**Slope**
Aerospace	0.9626	0.9811	Yes	14489
Automotive	0.7288	0.8537	Yes	19651

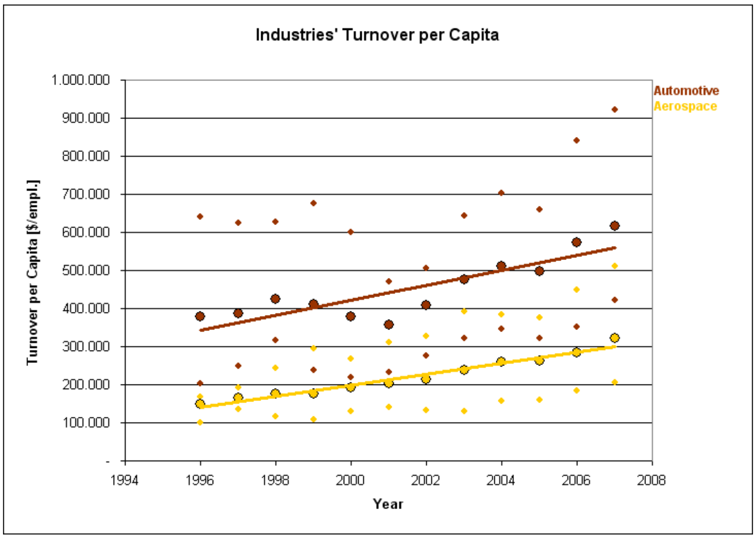

Figure 3 - The T/C for both Industries.

Profit per Capita

Both industries' trends show statistical significance and are found to be positive (see table 5). As such, both industries are following a path towards becoming leaner with respect to their continuation activities, see figure 4. It can also be seen that the trend line of the automotive industry shows a slightly greater rate of increase than the aerospace industry. Furthermore, the gap between the two industries was a lot smaller in 1996. In the subsequent years however the gap has increased suggesting better continuation performance of the automotive industry.

In the canted value chain, from the lean perspective continuation represents the ability of the focal firm to deliver according to customer pull rather than market push, creating greater value for the company. Also to this regard the automotive industry is performing better than the aerospace industry, which is showing slower improvement through time. Delivering according to customer demand is a challenge in general for the aerospace industry. The main barrier to change is given by the shift in cultural mindset from the past Cold War mindset of "Higher, Faster, Farther" to the present "Better, Faster, Cheaper" aimed at delivering products which best meet customer needs at an affordable price. This is supported by (Murman et al., 2002).

Table 5: Industries' Statistical Significance for P/C				
Industry	**r^2**	**r**	**Significant**	**Slope**
Aerospace	0.8108	0.9004	Yes	1454.7
Automotive	0.5548	0.7448	Yes	4089.5

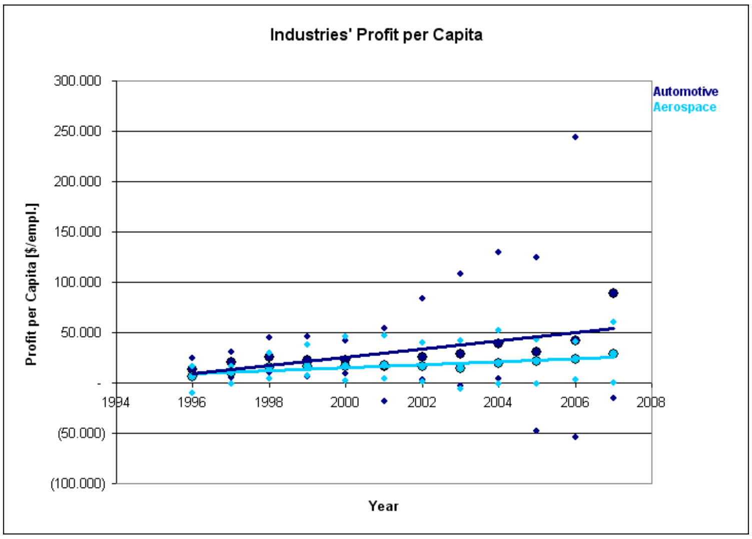

Figure 4 - The P/C for both Industries.

Research and Development per Capita

The automotive and aerospace industry trends both show statistical significance and are found to be positive (table 6, figure 5). As such, both industries are following a path towards becoming leaner with respect to their conception activities. Indeed, also in this case the automotive industry is the better performer, but differently from the other lean performance indices the rate of improvement with respect to R&D/C is approximately equal for both industries. Conception entails a company's ability to create customer value together with its co-innovating partners. On this behalf, while the automotive industry is again the better performer, it is evident how the aerospace industry is following suit. The recent co-development and co-investment policies adopted by the leading aircraft manufacturers in their product development are a clear example of the efforts that the aerospace industry as a whole is putting in to improve the quality and scale of its co-innovation partnerships.

Table 6: Industries' Statistical Significance for R&D/C.				
Industry	r^2	**r**	**Significant**	**Slope**
Aerospace	0.9265	0.9625	Yes	874.91
Automotive	0.5041	0.71	Yes	863.49

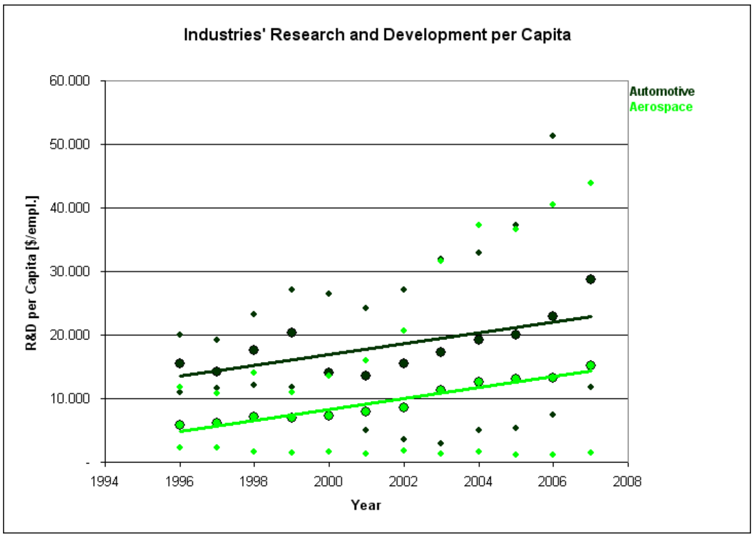

Figure 5 - The R&D/C for both Industries.

Historical Correlation of the Lean Performance Industrial Composite Indices

The statistical analysis of the historical correlation of the lean performance indices has resulted for all three cases in a relatively strong correlation with respect to the statistical significance interval chosen, together with a positive trend for both the aerospace and the automotive industries. From the graphs below, it may be seen how for all cases the automotive industry is the better performer. However, it is also seen how the aerospace industry is picking up quickly with regard to lean performance as is the case for T/C versus P/C and P/C versus R&D/C where the trends indicate a slightly faster rate of improvement for the aerospace industry compared to the automotive industry.

As mentioned, the superior lean performance of the automotive industry is mainly attributable to the fact that the automotive industry has commenced the path towards the lean enterprise long before the aerospace industry, while the latter industry is just starting the transformation towards becoming lean as its structure is shifting from the consolidated legacy structure to a more customer focused and value oriented one.

What stands out from the statistical significance test, as derived from the lean performance metrics T/C, P/C and R&D/C, is that correlation persists. This result constitutes further support for the validity of the lean metrics to quantify the lean value network system. It also proves the validity of these metrics for industry benchmarking purposes. This has been confirmed by having used the lean metrics to calculate lean performance composite indices at industry level in order to benchmark the aerospace industry to the automotive industry. The relevant statistical data, as well as the graphs (figures 6, 7 and 8), are presented below.

Table 7: Industries' Statistical Significance for Historical T/C versus P/C.

Industry	r^2	r	Significant	Slope
Aerospace	0.8168	0.9038	Yes	8.26
Automotive	0.8876	0.9421	Yes	7.36

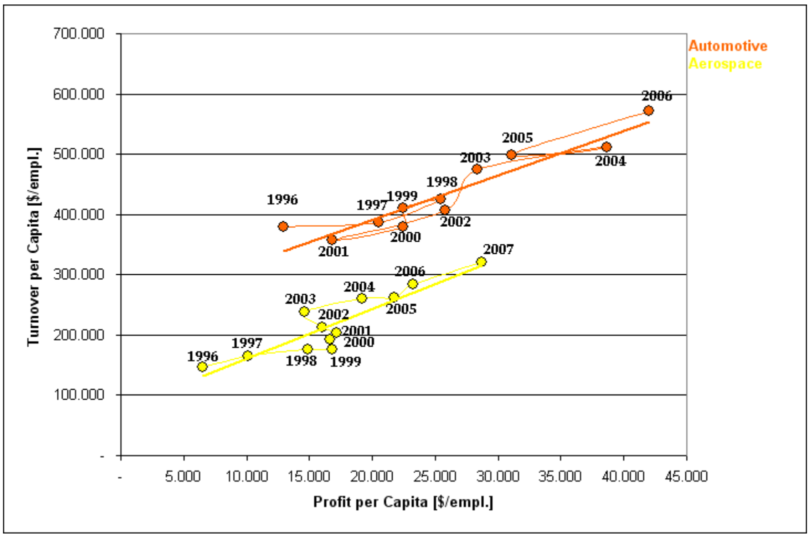

Figure 6 - Historical Correlations; T/C versus P/C.

Table 8: Industries' Statistical Significance for Historical T/C versus R&D/C.

Industry	r^2	r	Significant	Slope
Aerospace	0.9672	0.9835	Yes	15.98
Automotive	0.75	0.8660	Yes	19.52

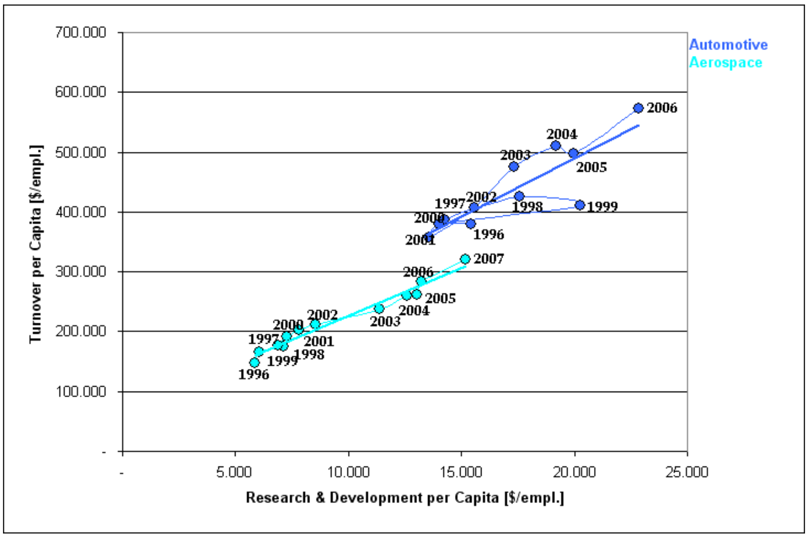

Figure 7 - Historical Correlations; T/C versus R&D/C.

Table 9: Industries' Statistical Significance for Historical P/C versus R&D/C.				
Industry	**r^2**	**r**	**Significant**	**Slope**
Aerospace	0.7198	0.8484	Yes	2.23
Automotive	0.5979	0.7732	Yes	1.51

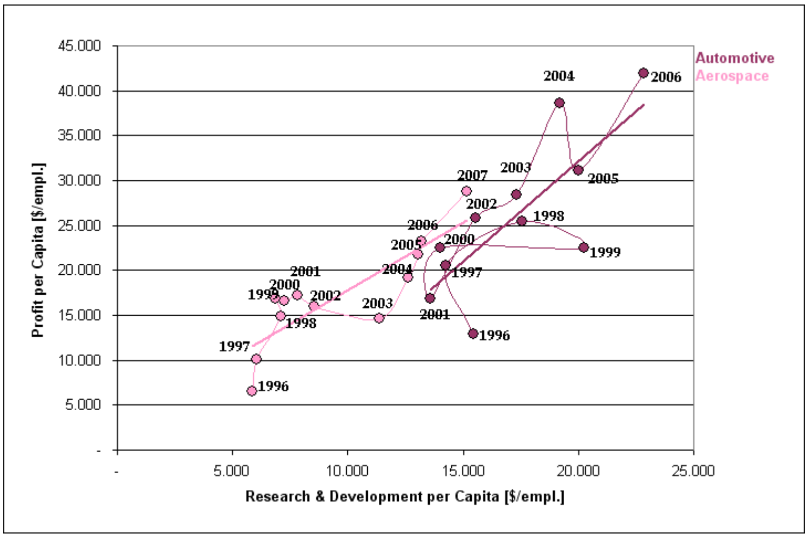

Figure 8 - Historical Correlations; P/C versus R&D/C.

Conclusion

This paper set out to investigate and compare the lean performance of the automotive and aerospace industries by using lean performance metrics, as they were devised in the paper by

Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007). Two hypotheses posed were formulated as:

H1: The aerospace industry as a whole is performing less lean than the automotive industry

and:

H2: The aerospace industry is getting more and more lean, following the automotive industry.

Having seen the time developments of the lean performance metrics, that were seen as measures for companies' performance with respect to the 3C's, for both industries, one can conclude that both hypotheses are found to be supported. It was found that indeed the automotive industry as a whole is performing leaner than the aerospace industry, but that the aerospace industry is following suit, displaying an upward trend in its lean performance metrics. By showing these quantitative results, this paper has delivered an important contribution in the research performed on the lean performance of the aerospace industry.

With both hypotheses supported, one can conclude that the aerospace industry is following the automotive industry when it comes to its level of leanness. In short, one could say that the aerospace industry is lagging behind. However, initial steps toward transformation in the aerospace industry have already been taken, although the full scale and scope of the changes required in the aerospace industry are even more dramatic than those in automobile, manufacturing and other industries (Murman et. al, 2002).

Furthermore, using the historical correlations of the lean performance metrics, taken on industry level, making up the industries' lean performance indices, it was shown that both industries are moving into a direction of a more and more lean way of doing business. The results indicate that this trend is quite steady for all three graphs and so it is shown that the three lean performance metrics P/C, T/C and R&D/C are dependent on one another, thereby lending increased support for their use as lean value indicators, since the overall leanness of a company should have a positive influence on all three of the lean performance metrics.

Although it is no real surprise that the aerospace industry is behind in its level of leanness, this paper has delivered quantitative proof for this idea. By having done so, the paper provides new insights into the lean performance metrics proposed by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007), as well as support for their use. Therefore, these metrics can be used in the future for more companies and industries.

Limitations and Recommendations for Further Research

This paper has used the lean performance metrics T/C, P/C and R&D/C. It was argued both in this paper, as by Beelaerts van Blokland, Fiksiński, Amoa and Santema (2007), that these metrics provide a good indication of a company's lean performance in the areas of the three C's; continuation, conception and configuration. For future research it would be interesting to show how the companies' and industries' performance with respect to these three C's is related to their overall value creating abilities. For this, use could be made of the market capitalization of a company, normalized on a per capita basis.

It is recommended that research in this area takes into account other factors of influence with respect to the market capitalization, since market capitalization is influenced by more factors than the ones that are expressed by the T/C, P/C and R&D/C.

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