ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI) MASTER EN INGENIERÍA INDUSTRIAL

Analysis and modelling of the automotive body and chassis suppliers' footprint strategies

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Madrid

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Me gustaría expresar mi más profundo agradecimiento a todas aquellas personas que se han involucrado en la consecución de mi trabajo, y en especial, al brillante equipo de A.T. Kearney en Madrid, y a D. Nicolás Sanz Ernest, quien se ha convertido para mí un ejemplo a nivel profesional y personal.

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Analysis and modelling of the automotive body and chassis suppliers' footprint strategies

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Abstract:

The main goal of the document is to present the trends and circumstances that the automotive industry is currently experiencing, and with focus on the supplier sector, understand the importance of competitiveness and identify and quantify the critical success factors that would provide a component manufacturer, in this case, in hot stamping, with a ruthless manufacturing footprint.

The automotive industry is a main pillar for the global economy, accounting for 3% of the world's GDP and heavily contributing to job creation, industrial development and fostering of R&D. Within the sector, component manufacturers are gradually becoming a key element towards value addition, as vehicle production is becoming increasingly complex and integration of suppliers within OEM's value chain is critical.

OEMs, component manufactures and the sector as a whole, have been enjoy a period of relatively strong growth and profitability since the recession in the 2008-2009 period. Nevertheless, the industry is starting to face a series of challenges which will definitely condition their future returns, especially meaningful regarding cost-pressure, weight and regulations.

This intensification of cost-pressure and weight focus forces OEMs and suppliers to manufacture increasingly light-weight vehicles, that are cost-effective and comply with environmental and safety regulations. For this purpose, body in white and chassis components become critical, as they represent almost 40% of a car's weight, and it is expected that 15% of the investment towards achieving fuel efficiency goals will rely on them.

In order to tackle the need to produce light components, the industry has come up with new technologies and materials to replace traditional mild steel which allow for a significant weight reduction. These innovative materials encompass Ultra High Strength Steel (UHSS) and hot

stamped steel, and aluminium and composites. These last two technologies, although offering the highest weight reduction, are still under development and their high manufacturing costs hinder their general expansion.

Given the relevance and competitiveness of the sector, this document focuses on one of these innovative technologies, hot-stamping, and generates value by identifying and quantifying the critical success factors that would provide a hot stamping manufacturer's plant with a sustained competitive advantage. As a result of global growth, suppliers have had to expand its operations, and in order to tackle future industry challenges, manufacturers must search to become ruthless competitors by means of an optimized footprint.

If this document just held on to a descriptive level, the utility of it would be limited. Therefore, the influence of the identified levers and their impact on overall manufacturing costs are quantified through a cost model. The model identifies the main cost drivers and highlights potential performance improvement initiatives, which are then contextualized through a case study.

In order to carry out this task, the following analysis will be developed:

- Characterization of the automotive and supplier industry
- Role of body in white and chassis
- Competitive landscape in the body in white and chassis stamping sector
- Identification of success factors for the competitiveness of a hot stamping plant
- Modelling of competitiveness through a case study

Characterization of the automotive and supplier industry

The automotive industry constitutes a main driver of macroeconomic expansion and stability, and forces technological advancement in both developed and developing countries. Its strong growth in past years has allowed the industry to robustly contribute to job creation, government revenue and industrial and research development.

Production since the recession has grown with a 8,3% CAGR, especially pulled by the growth in the Greater China market and the recovery of Europe and North America. Profitability since 2009 have been relatively higher for component manufacturers, especially those focused on tires and power train, and enhancing product innovation.

Despite the growth experienced in previous years, the sector will encounter a series of challenges which will condition future profitability. OEMs and suppliers will encounter an intensification of complexity, cost-pressure and weight focus, they will experience a shift of the centre of gravity towards emerging markets and an increase in the digital demands, and they will face a change in the industry landscape, as component manufacturers will be required to add increasing value to the final product.

Role of body in white and chassis

The challenges regarding cost pressure and weight faced by OEMs and component manufacturers forces the industry to produce increasingly lighter cars, which are cost effective and meet environmental and safety regulation. Towards achieving this goal, a car's body in white (BIW) and chassis play a critical role as they account for almost 40% of the vehicle's weight, and are expected to require 15% of the investment needed to accomplish the fuel efficiency targets.

In order to tackle the need to produce light components, the industry has come up with new technologies and materials to replace traditional mild steel which allow for a significant weight reduction. These innovative materials encompass Ultra High Strength Steel (UHSS) and hot stamped steel, and aluminium and composites. These last two technologies, although offering the highest weight reduction, are still under development and their high manufacturing costs hinder their general expansion.

UHSS and hot-stamped steels allow offer significantly higher yield strengths with a 20% weight reduction, while increasing manufacturing costs by 15%. Aluminium, which needs to be alloyed to be used in structural components, besides reducing 40% weight, offers high recyclability and emission reduction. Composites offer even further weight reduction, 50% and reduced manufacturing complexity. Nevertheless, these technologies respectively increase manufacturing costs by 30% and 470%.

Competitive landscape in the body in white and chassis stamping sector

The body in white and chassis market is dominated by a few players who have achieved leadership through global coverage and breath of capabilities. Within the stamping sector, Cosma (company of Magna International), Gestamp Automoción, Benteler Automotive and Tower International are the largest competitors. They present revenues ranging from 2.000 to 8.000 million dollars, and have an operational efficiency averaging 10% EBITDA margin.

Although there are many local players present with focus only on a certain region, and some OEMs internally develop stamping activities, the industry is turning towards higher consolidation, as body and chassis account for 40% of all the current M&A activity in the industry.

Identification of success factors for the competitiveness of a hot stamping plant

As it has been highlighted, the stamping of body in white and chassis, and more precisely, hot stamping, is highly competitive, which makes the identification of competitiveness success factor very important.. The automotive industry has become a greatly global industry in the past decades and hence, automotive suppliers have had to expand their operations and try to optimize their manufacturing footprint.

Therefore, one of the ways an automotive supplier could become a ruthless competitor and build up a strategy that wouldn't be able to be imitated by its competitors is by developing a ruthless footprint.

The four identified critical success factors to achieve footprint competitiveness encompass:

- The technological know-how of the hot-stamping processes, products, materials...

  Research is carried out in order to define material properties, processes, machinery and future developments, as well as the wide range of products possibly manufactured with hot stamping and the increasing demand faced by the technology.

- A strategic location that would allow benefiting from Just in Time (JIT) production with the customer, appropriate raw material sourcing and reduced logistic and shipping costs

  Proximity to OEM plant is proved to positively affect both hard features like JIT and shipping costs and soft features like image and cultural impact. Besides, potential raw material price difference are partially explained by the location and its influence on cost drivers

- An adequate work-force, which shows a successful balance of personnel cost, skills, productivity and education.

  Detailed analysis performed evidences how worker characteristics vary along different countries and can explain cost and performance differences

- High operational efficiency based on lean techniques and good Overall Equipment Effectiveness (OEE) and Total Productive Maintenance (TPM) performances

  Presentation of the vast benefits enhanced through the implementation of OEE and TPM strategies together with benchmarks on hot stamping and other comparable technologies

Modelling of competitiveness through a case study

If this document just held on to a descriptive level, the utility of it would be limited. By means of designing a model to quantify the impact of the identified competitiveness success factors, it allows to build a further perspective, a real case scenario.

The case study defines a supplier of hot stamping components, which must manufacture the B-pillar production for a vehicle from one of its plants. In order to find out which location offers the biggest cost competitiveness, the model illustrates detailed cost breakdowns and studies the main cost drivers in each plant in light of the identified success factors.

The model and its application to a case study are very useful in order to highlight improvement initiatives, and their potential impact on cost and performance. It proposes a series of initiatives which prove to achieve an 11pp OEE increase and a 50% reduction in maintenance costs, regarding the fields of plant capacity and organization improvement; establishment of standard work, 5S and visual management; reduction of unplanned machine and tool maintenance; and efficiency and consistency of changeovers through SMED.

Furthermore, the application to a case study allows to contextualize manufacturing performances within a financial evaluation and to come across with concepts such as operational profit, required cost of capital and average annual ROCE, which in the auto-component industry are standardized to be >12%, 8,1% and >15% respectively. Finally, the employment of a model allows to carryout sensitivity analysis and to evaluate the impact of other potential soft skills such as coordination, culture impact or image.

Conclusions

The first analytical topics of the document grant an understanding of the current situation and challenges faced by OEMs and suppliers, and highlight the big relevance that body and chassis components will have towards achieving cost and weight reduction goals. Furthermore, it serves as an introduction on the characteristics of the BIW and chassis components and technologies, and remarks the importance of competitiveness.

Nevertheless, the biggest value addition of this document mainly relays on the identification and quantification of the success factors that make a hot stamping plant achieve a ruthless footprint. Through this analysis, the most important levers towards becoming competitive are defined and evaluated.

On the one hand, the situation of outside and uncontrolled conditions such as country labour characteristics, shipping costs and raw material cost drivers are described in depth. Such detailed description intents to be positively valued by manufacturers before leveraging and deciding on their footprint decision.

On the other hand, in depth research of the technology, with focus on materials, processes and products, and their alternatives, and definition of rules towards achieving excellent operational and maintenance performances are defined. By means of these levers, clear and detailed initiatives are proposed to improve performance and become more cost competitive.

Moreover, the application of these identified success factors in a case study allows contextualizing them within a real manufacturing scenario. The definition of a cost model helps to illustrate the impact on overall cost of the identified levers and their influence towards competitiveness improvement. The quantification of the impact of the success factors allows, furthermore, to apply financial evaluations and sensitivity analysis.

Análisis y modelado de las estrategias industriales de los fabricantes de carrocería y chasis en el sector de la automoción

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Resumen:

El objetivo principal del documento es presentar las tendencias y características actuales de la industria de la automoción, y con foco en los fabricantes de componentes, entender la importancia de la competitividad e identificar y cuantificar los factores críticos de éxito que les permitirían obtener una huella industrial competitiva, en este caso, en el sector de estampación en caliente.

La industria de la automoción es un pilar clave para la economía global, pues representa un 3% de PIB mundial, y contribuye enormemente a la creación de puestos de trabajo, desarrollo industrial y fomento del I+D. Dentro del sector, los fabricantes de componentes se están convirtiendo gradualmente en un elemento clave en la elaboración de valor añadido, dado que la producción de vehículos se está haciendo progresivamente más compleja y su integración en la cadena de valor es crítica.

OEMs, fabricantes de componentes y el sector en general han disfrutado de un periodo de crecimiento y rentabilidad relativamente alto desde la recesión en 2008 y 2009. No obstante, la industria está empezando a enfrentarse a una serie de retos que seguramente condicionen sus ingresos, siendo de especial relevancia los retos en materia de reducción de costes, peso y regulaciones.

El afán por la reducción de costes y peso obliga a los OEMs y resto de fabricantes a prodcir coches cada vez más ligeros, económicos y que cumplan con las regulaciones medioambientales y de seguridad. Por este motivo, la carrocería y el chasis se vuelven elementos clave, pues representan casi un 40% del peso de un vehículo, y se estima que albergarán el 15% de la inversión necesaria para cumplir con los objetivos de eficiencia energética.

Con el objetivo de fabricar componentes ligeros, la industria ha desarrollado una serie de tecnologías y materiales para remplazar el tradicional acero dulce. Entre ellos, destacan los aceros de ultra alta resistencia (UHSS) y de estampación en caliente, y el aluminio y los composites. El uso de estas dos últimas tecnologías, a pesar de ofrecer las mayores reducciones de peso, no ha sido ampliamente extendido, dado que aun suponen un coste de fabricación muy alto.

Dada la competitividad y relevancia del sector, este documento se centra en una de estas tecnologías de innovación, la estampación en caliente, y trata de generar valor mediante la identificación y cuantificación de los factores críticos de éxito que ofrecerían una ventaja competitiva sostenida. Como respuesta al crecimiento global de la industria, los fabricantes de componentes han expandido sus operaciones, y la optimización de su huella industrial es clave de cara a convertirse en competidores feroces.

Si este documento se quedase en el plano descriptivo, su utilidad sería limitada. Por ello, la influencia de las palancas identificadas y su impacto sobre el coste total de fabricación se han cuantificado a través de un modelo de costes. El modelo identifica los principales factores de costes y destaca una serie de iniciativas potenciales para la mejora del rendimiento, que son contextualizadas en el marco de un caso práctico.

Para llevar a cabo esta tarea, se desarrollan los siguientes análisis:

- Caracterización del sector de la automoción y los fabricantes de componentes
- Papel de los componentes de carrocería y chasis
- Entorno competitivo en carrocería y chasis
- Identificación y evaluación de los factores críticos de éxito para la competitividad de una planta de estampación en caliente
- Modelado de la competitividad mediante un caso práctico

Caracterización del sector de la automoción y los fabricantes de componentes

El sector de la automoción constituye una palanca básica para el progreso económico y la estabilidad, y fomenta el desarrollo tecnológico en países desarrollados y en vías de desarrollo. El gran crecimiento en los últimos años ha ayudado a la industria en la creación de puestos de trabajo, recaudación de impuestos y desarrollo industrial.

La producción desde la recesión ha crecido con una tasa compuesta anual de 8,3%, especialmente favorecida por el crecimiento del mercado chino y la recuperación de los mercados europeos y americanos. La rentabilidad desde 2009 ha sido relativamente más alta para los fabricantes de componentes, especialmente aquellos enfocados en neumáticos y sistemas de propulsión, y aquellos centrados en innovación de producto.

A pesar del crecimiento experimentado en años previos, el sector afrontará una serie de retos que condicionarán futuras rentabilidades. Las OEMs y resto de fabricantes se enfrentarán a una intensificación de la complejidad y la reducción de peso y costes, un movimiento continuado del centro de gravedad hacia mercados emergentes, un incremento de la demanda digital y un cambio en el panorama de la industrial, requiriendo una mayor porción de valor añadido por parte de los fabricantes de componentes.

Papel de los componentes de carrocería y chasis

Los retos en materia de reducción de coste y peso que afronta la industria guían hacia la fabricación de componentes más económicos, ligeros y conformes con las regulaciones medioambientales y de seguridad. Con el fin de lograr este objetivo, los componentes de carrocería y chasis juegan un papel clave pues representan casi el 40% del peso del vehículo y se espera que acaparen un 15% de la inversión necesaria para alcanzar las metas de eficiencia de combustible.

Con el objetivo de fabricar componentes ligeros, la industria ha desarrollado una serie de tecnologías y materiales para remplazar el tradicional acero dulce. Entre ellos, destacan los aceros de ultra alta resistencia (UHSS) y de estampación en caliente, y el aluminio y los composites. El uso de estas dos últimas tecnologías, a pesar de ofrecer las mayores reducciones de peso, no ha sido ampliamente extendido, dado que aun suponen un coste de fabricación muy alto.

Los UHSS y aceros de estampación en caliente ofrecen límites elásticos significativamente más altos con una reducción en peso del 20%, y un incremento de los costes de facturación del 15%. El aluminio por su parte, que necesita ser aleado para su uso en elementos estructurales, ofrece una reducción de peso del 40%, además de una alta reciclabilidad y reducción de las emisiones. Los composites ofrecen una reducción de peso aún mayor, 50%, y una reducción de la complejidad de fabricación. No obstante, están tecnologías suponen un incremento de coste del 30% y 47% respectivamente.

Entorno competitivo en carrocería y chasis

El mercado de la carrocería y chasis está dominado por pocos actores que han logrado el liderazgo a través de una cobertura global y una amplia línea de productos. Dentro del sector de estampación, destacan Cosma (empresa de Magna International), Gestamp Automoción, Benteler Automotive y Tower International. Presentan unos ingresos en el rango entre 2.000 y 8.000 millones de dólares, y tienes unas rentabilidades operativas del 10% de margen de EBITDA de media.

A pesar de la existencia de muchos pequeños competidores locales con foco en una región específica, y la internalización de la actividad por parte de algunas OEMs, el sector está tendiendo hacia la consolidación, y los sectores de carrocería y chasis representan un 40% de toda la actividad de fusiones y adquisiciones en la industria de la automoción actualmente.

Identificación y evaluación de los factores críticos de éxito para la competitividad de una planta de estampación en caliente

Como ya se ha manifestado, el sector de carrocería y chasis, y más concretamente, de estampación en caliente, es altamente competitivo, por lo que la identificación de los factores críticos de éxito para la competitividad se vuelve un aspecto clave. El sector de la automoción se ha convertido en una industria global en las últimas décadas, lo que ha llevado a los fabricantes a expandir sus operaciones y tratar de optimizar su huella industrial.

Por ello, una de las vías para lograr convertirse en un competidor feroz y llevar a cabo una estrategia difícilmente imitable por competidores es mediante el desarrollo de una huella industrial feroz.

Los cuatro factores críticos de éxito identificados para la obtención de una huella industrial competitiva incluyen:

- Alto conocimiento tecnológico sobre el proceso de estampación en caliente, productos, materiales…

  Se ha llevado a cabo una profunda investigación de cara a la definición propiedades de los materiales, procesos, maquinaría y alternativas potenciales, además de la amplia gama de posibles productos estampados en caliente y la demanda creciente que afronta la tecnología

- Una ubicación estratégica que permita beneficiarse de producción JIT con el cliente, un suministro de materias primas apropiado y un coste logístico reducido

  La proximidad a la planta de ensamblaje del OEM afecta positivamente tanto a funciones ‘hard’ como JIT y costes logísticos, como funciones ‘soft’ como imagen y choque cultural. Además, diferencias potenciales en el precio de materias primas se pueden explicar parcialmente con la ubicación y su influencia en los factores de coste

- Una mano de obra adecuada, que muestre un balance correcto entre coste de personal, capacidades, productividades y educación

  Se ha desarrollado un análisis detallado sobre la variación de las características de los trabajadores del sector entre países, y su impacto en las diferencias de coste y rendimiento

- Alta eficiencia operativa basada en técnicas lean y buenos rendimientos en términos de OEE y TPM

  Se presentan los grandes beneficios de una estrategia de OEE y TMP y más particularmente, comparativas de estampación en caliente con tecnologías alternativas

Modelado de la competitividad mediante un caso práctico

Si este documento se quedase en el plano descriptivo, su utilidad sería limitada. A través del diseño de un modelo para cuantificar el impacto de los factores de competitividad identificados, se logra construir otra perspectiva desde un caso práctico real.

El caso define un fabricante de componentes de estampación en caliente, que debe fabricar la producción de pilares B para un OEM desde una de sus plantas. Para averiguar cuál de sus ubicaciones ofrece la mayor competitividad de costes, el modelo ofrece un desglose de costes detallado, y estudia los principales palancas de coste de cada planta a la luz de los factores de de éxito identificados.

El modelo y su aplicación a un caso práctico son de gran utilidad de cara a subrayar iniciativas de mejora, y su impacto en coste y rendimiento. Propone una serie de medidas que logran una mejora del OEE de 11pp y una reducción del 50% de los costes de mantenimiento, en materia de capacidad y organización de la planta; establecimiento de estandarización del trabajo, 5S y gestión visual; reducción del mantenimiento no planificado de maquinas y herramientas; y eficiencia y consistencia transiciones mediante SMED.

Asimismo, la aplicación de un caso práctico permite evaluar el rendimiento en fabricación desde un punto de vista de financiación, e incluir conceptos como margen operativo, coste de capital y retorno de la inversión anual medio. Por último, su uso también permite llevar a cabo análisis de sensibilidades y evaluar el impacto de otras capacidades de tipos soft como coordinación, impacto cultural e imagen.

Conclusiones

Los primeros aspectos más analíticos del documento otorgan un entendimiento de la situación actual y los retos que afrontan OEMs y fabricantes de componentes, y subraya la relevancia que los componentes de carrocería y chasis juegan de cara a conseguir los objetivos de reducción de costes y peso. Asimismo, sirve como una introducción de las características de estos componentes, y recalca la importancia de la competitividad.

No obstante, el mayor valor añadido del documento recae sobre la identificación y cuantificación de los factores críticos de éxito que permiten a una planta de estampación en caliente obtener una huella industrial feroz. Mediante este análisis, se definen las palancas más importantes para hacerse competitivo.

Por un lado, se describen en detalle factores ajenos y no controlados por los fabricantes como las características de la mano de obra, costes logísticos y de materias primas…Una descripción tan detallada pretende ser de utilidad para fabricantes de cara a decisiones sobre su huella industrial.

Por otro lado, se realiza un profundo examen de la tecnología, con enfoque en materiales, procesos y productos y sus alternativas, y una definición de las reglas que ofrecen una excelencia operativa y de mantenimiento. Por medio de estas palancas, se identifican claras iniciativas para la mejora del rendimiento y la competitividad de costes.

Además, la aplicación de estos factores de éxito identificados en un caso práctico permite la contextualización en un escenario de fabricación real. La definición del modelo de costes ayuda a ilustrar el impacto de estas palancas sobre el coste total, y su influencia de cara a la mejora de la competitividad. La cuantificación de estas medidas, asimismo, permite la aplicación de evaluaciones de tipo financiero y análisis de sensibilidad.

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List of abbreviations

Abbreviation	**Concept**
BIW	Body in White
BRIC	Brazil, Russia, India and China
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CFRP	Carbon-Fiber Reinforced Polymer
GDP	Gross Domestic Product
HSS	High Strength Steel
HSS	Hot Stamping
JIT	Just in Time
M&A	Mergers and Acquisitions
NPV	Net Present Value
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
pp	porcentage points
R&D	Research and Development
ROCE	Return on Capital Expenditure
SMED	Single Minute Exchange of Die
SOP	Start of Production
TPM	Total Productive Maintenance
TRIAD	USA, Europe and Japan markets

1. Characteristics of the automotive industry

1.1 Contribution of the automotive industry to society

The automotive industry is a basic pillar of the global economy, and constitutes a main driver of macroeconomic growth and stability and forces technological advancement in both developed and developing countries, spanning many adjacent industries. The core automotive industry (vehicle and parts makers) supports a wide range of business segments, both upstream and downstream, leading to a multiplier effect for growth and economic development.

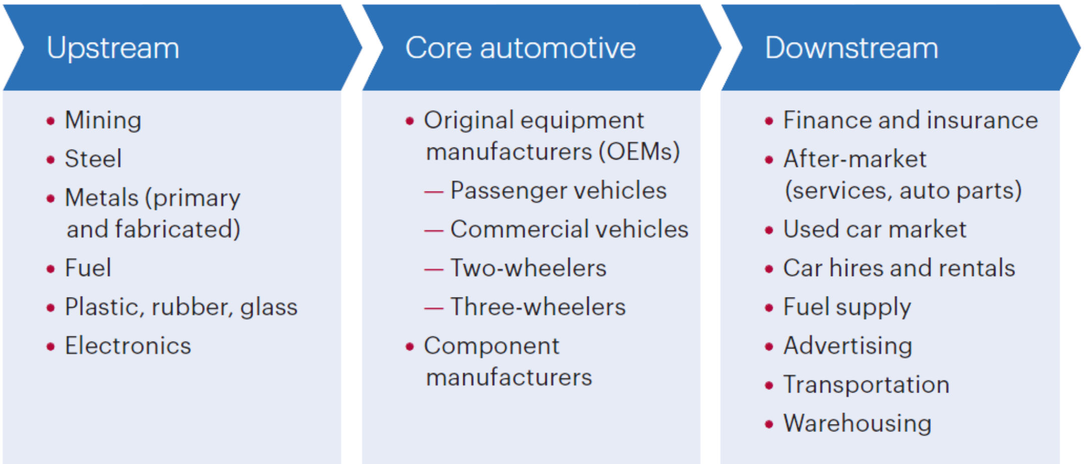

Figure 1. Contribution of the automotive industry - A.T. Kearney

The automotive industry plays a key role in the global economy, accounting for 3 percent of all GDP output. Furthermore, the sector heavily contributes towards job creation and skill development, as its numerous forward and backward links bring both direct and indirect employment. In Europe alone, the automotive industry accounts for roughly 12 million jobs; in the US, more than 8 million; and in Japan, more than 5 million.

Amongst other great contributions of the sector towards society you find generation of government revenue, creation of industrial development and foster of R&D and innovation. (1)

The automotive sector contributes significantly to tax revenues through vehicle sales, usage-related levies, personal income taxes, and business taxes. Production of vehicles, parts, and services deliver sales, value-added, and local taxes and import duties. For instance, in Japan, auto-related taxes totalled $7.72 billion in 2012, approximately 10% of all tax revenues, according to the Japan Automobile Manufacturers Association.

Across the world, automotive segment boosts regional development. Industrial clusters form as original equipment manufacturers' (OEMs) plants are surrounded by component manufacturing facilities, including component suppliers, aftermarket shops, and logistic providers. These clusters lead to new municipalities with solid road infrastructures, railway and freight connectivity, and new housing developments.

Moreover, the industry remains at the forefront of cutting-edge manufacturing technology. The customer demands for lower costs and improved performance and safety push the OEMs and other Tier 1 suppliers towards an intense R&D investment. The auto segment represents the third biggest R&D investment industry, after pharmaceuticals and technology, annually accounting for 108 billion dollars.

1.2 Automotive production trends

The worldwide automotive industry has been enjoying a period of relatively strong growth and profitability, and since the recession in the 2008 – 2009 period, where only 48.4 million passenger cars were produced, growth has risen up to 72.3 million. This production has mainly taken place in Europe, China, USA and Japan, who together represent and 86% of the total production. (2)

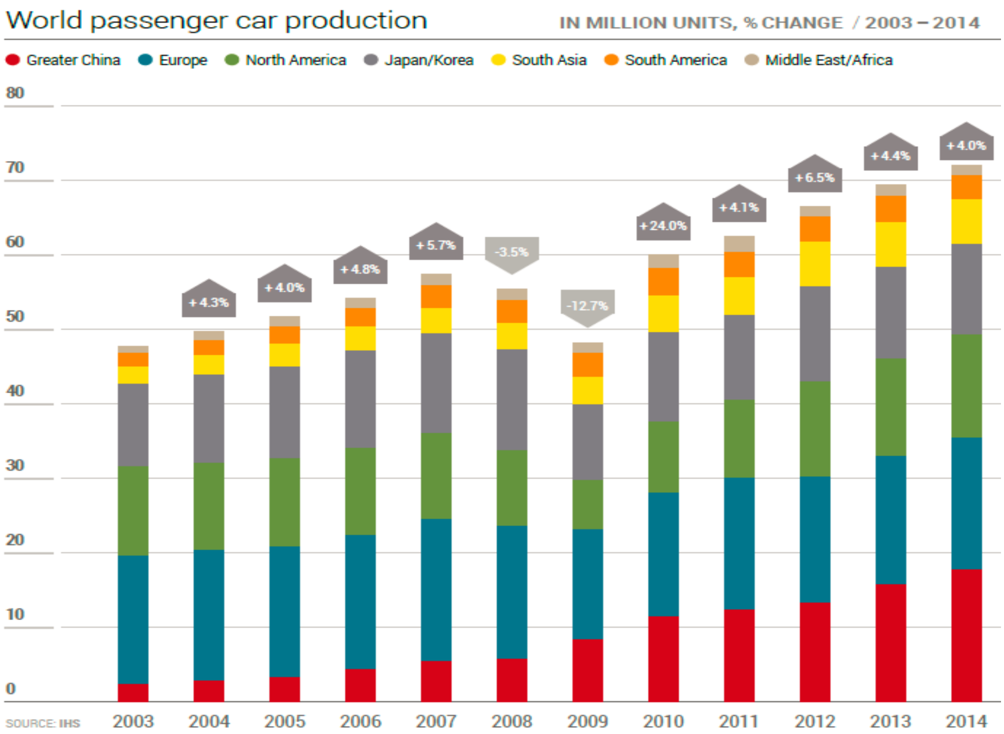

Figure 2. World passenger car production - European Automobile Manufacturers Association

Besides the relative growth of the industry, the unevenness of global markets has become a challenge. While the US market has recovered and Europe is emerging from a six year slump, sales in China - the biggest vehicle market – is slowing in recent years and sales in Russia and South America have plunged.

Although it is very important for OEMs and suppliers to evaluate past production trends and understand how the auto market has performed in the different regions, it is critical to identify where the future production will take place. Within the future production, it is of special relevance the production of new cars/ models, known as Start of Production – SOP , as this means car models with relatively important modifications will come to the market, implying the possibility of OEMs starting production in different locations, and new/different Tier 1 suppliers could start supplying components.

An adequate period of time in which to evaluate the new production can be from 2018 to 2022, as car production cycles average between 5 to 10 years, and all of the SOP prior to 2018 has probably been already awarded.

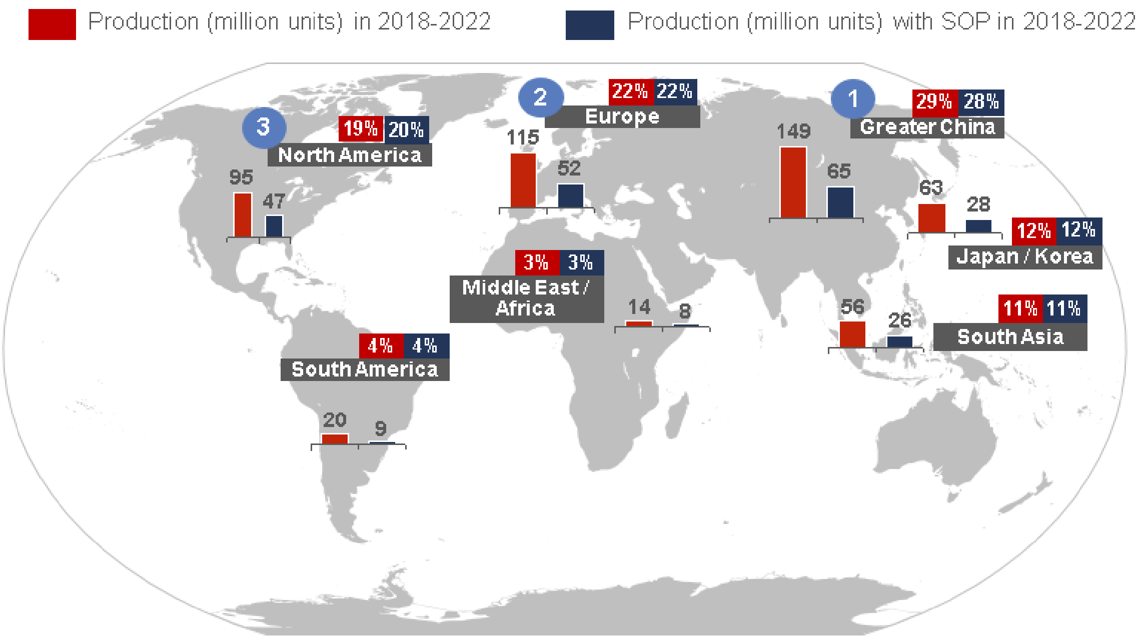

Figure 3. Global future light vehicle production based on IHS automotive

As reflected in the map above, the SOP production worldwide in the 2018-2022 will be of 235 million cars, of which 28% accounts for production in the Greater China market, 22% in Europe and 20% in North America. If focus is placed on Europe, 115 million cars will be produced during this period, 45% of which will be part of new production.

The European countries with highest production will be Germany, Spain, France and UK, which together represent 63% of Europe's SOP production. Spain, which is the second biggest European market, accounts for the production of 15 million cars in the 2018-2022 period, of which 6.6 million will be production of new models.

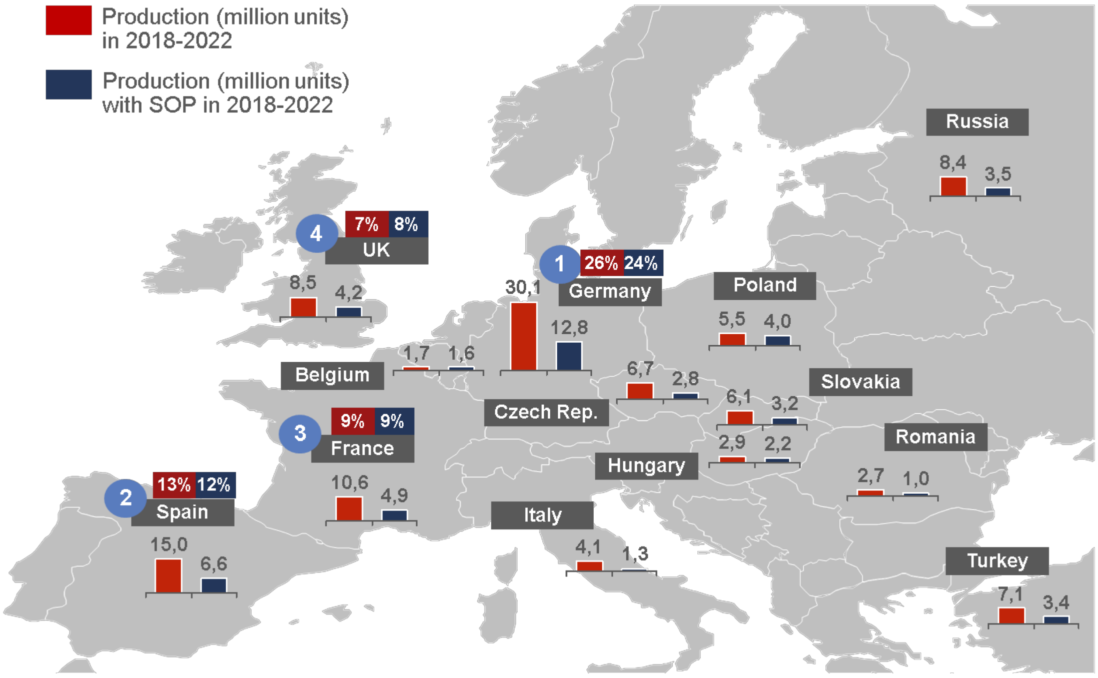

Figure 4. European light vehicle production based on IHS automotive

1.3 Challenges faced by the automotive industry

The short-term future for the global automotive industry seems uncertain and volatile given the geographical production unevenness. The global light vehicle production is expected to continue its growth in the close future, although at a slower pace of 3% according to A.T. Kearney:

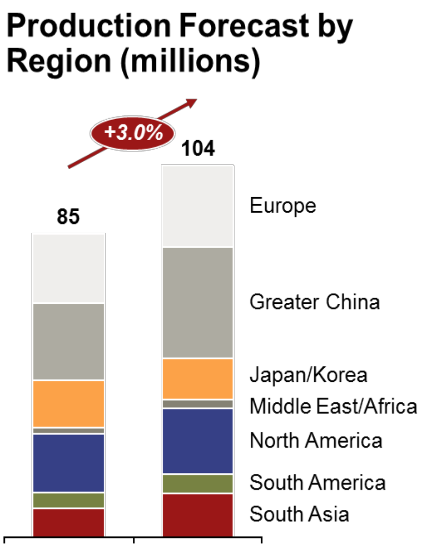

Figure 5. Automotive production forecast for 2020 – A.T. Kearney

- Europe will be stable at a low production growth level
- Japan could have a declining production
- North America will see only a moderate growth after having rallied in previous years
- Brazil, Russia and India have potential to grow after a difficult performance during 2013 and 2014, but there is also a risk for further stagnation
- China remains the only one major driver, and its secondary market is an important factor to take into account

Besides the volume growth, the automotive industry will face other challenges in the short – medium term (2020). The main challenges that the sector will encounter are the increase of industry complexity and cost pressure, diverging markets, digital demands and a shifting industry landscape:

Cost pressure:

- Complexity: The rising number of derivatives serving different vehicle segments and markets based on a single platform generates complexity and pushes costs up.

- Regulation: The increase in regulations with respect to environmental and safety standards will raise both costs and complexity. By 2015, 95% of a car must be recyclable. The carbon dioxide emission target, amongst others, will push OEMs to invest more in e-mobility, meaning electrical/hybrid powertrains and lightweight and aerodynamic drag-reducing technologies. Nevertheless, in 2020, conventional internal combustion engines will still account for more than 90% of cars. (3)

- Weight: OEMs and suppliers are forced to reduce the weight of the cars and components in order to meet regulations and gain consumption efficiencies. Important decisions concerning technology and material mix must be taken. The right trade-off has to be found balancing the rising cost of alternative materials such as Ultra High Strength Steel, aluminium or composites, and its weight reduction capabilities.

Diverging markets:

- Growth shift: The automotive industry's economic centre of gravity will continue to shift, as sales, volumes and market share keep moving toward emerging markets. Emerging markets' share of global sales is expected to rise up to 60% by 2020. Nevertheless, the location of current production and supply is not sufficiently aligned to the expected sales evolution. Furthermore, there may also be a portfolio mismatch as smaller vehicle classes are growing more strongly than others, especially in fast growing emerging markets.

- After-sales Chinese market: Attention must be placed on the after-sales Chinese market, which is expected to grow 20% per year. (3)

Digital demands:

- Connectivity: As a result of costumer desire for connectivity, the number of networked cars will rise 30 percent a year for the next several years; by 2020, one in five cars will be connected to the Internet. Industry's future profits and differentiation will take place through delivering services for the car and technological feature for comfortable and eventually autonomous driving.

- Digital retail: Digital channels are already the primary information source for customers. This situation could lead to the potential threat of competition from online retailers and puts pressure on the existing dealership structure.

Change in Industry landscape:

- Suppliers' value addition: In order to manage the rising production volumes, automakers will have to build a local supplier base, design an enhanced value chain and reinforce supplier capacities. The imperative to reach environmental targets makes the value suppliers add more important, especially, in finding powertrain solutions.

- Intensification in OEM battle: Given the production overcapacity that exists in markets as important as Europe and China, OEMs will need to revise production footprints and manage production expansion with higher flexibility over the short and medium term to be able to respond to market shifts.

KPMG's Global Automotive Executive Survey 2015 interviewed 200 senior executives from the world's leading automotive companies and the results reflect the remarks and challenges mentioned above.

The survey shows that market growth in emerging markets, downsizing and optimizing the powertrain, increasing the use of platforms and the standardization of modules, and the rationalization of European production were amongst the biggest concerns of automakers and suppliers. (4)

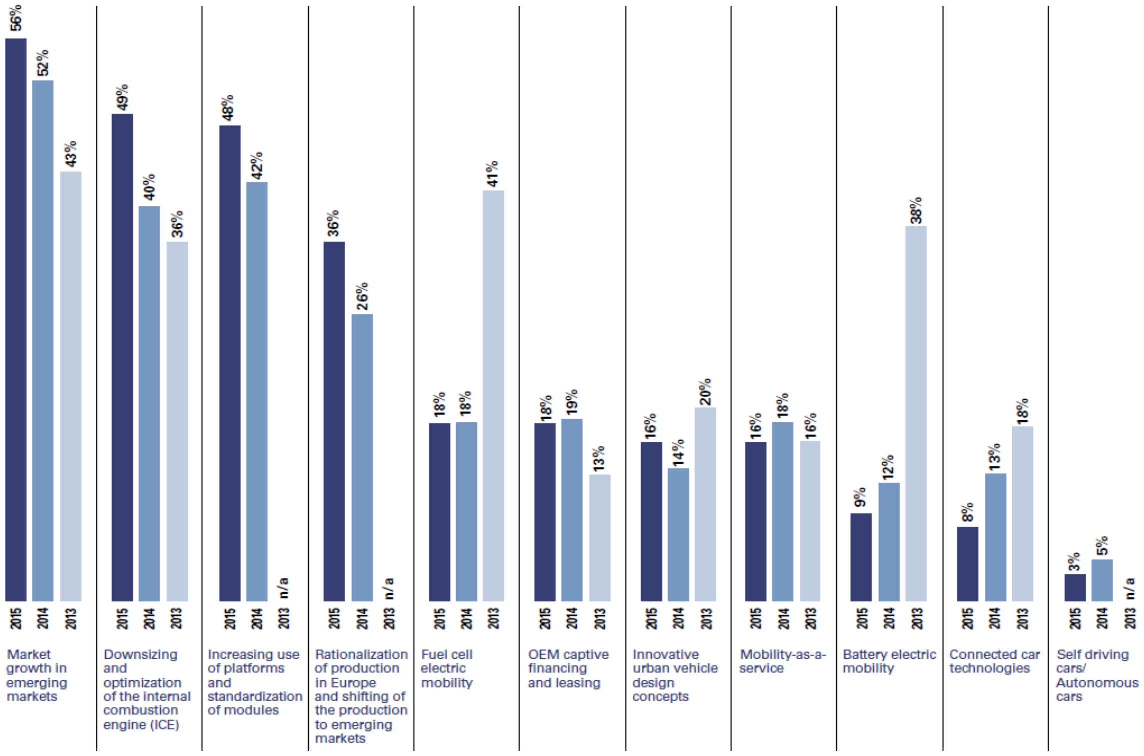

Figure 6. Survey results on major concerns in the automotive industry - KPMG

2. Automotive suppliers' performance

2.1 Current trends

The growth in the car production and sales previously described during the last years has evidently had a positive impact on the automotive supplier market, where suppliers have increased their revenues by 50% since the recession and have achieved a global EBIT margin of approximately 7.5% . (4)

Despite the fact that the growth has slowed since 2012, automotive suppliers have on average, outperformed their OEM customers in terms of profitability. Some of the success factors that have been applied by suppliers are a strong effort to maintain technological differentiation, focus on segments with above average rates and margin potentials, anti-cyclical efficiency improvements (overheads, plant locations…), production and engineering footprint outside TRIAD markets (USA, Japan and Europe) and the globalization of processes and structures.

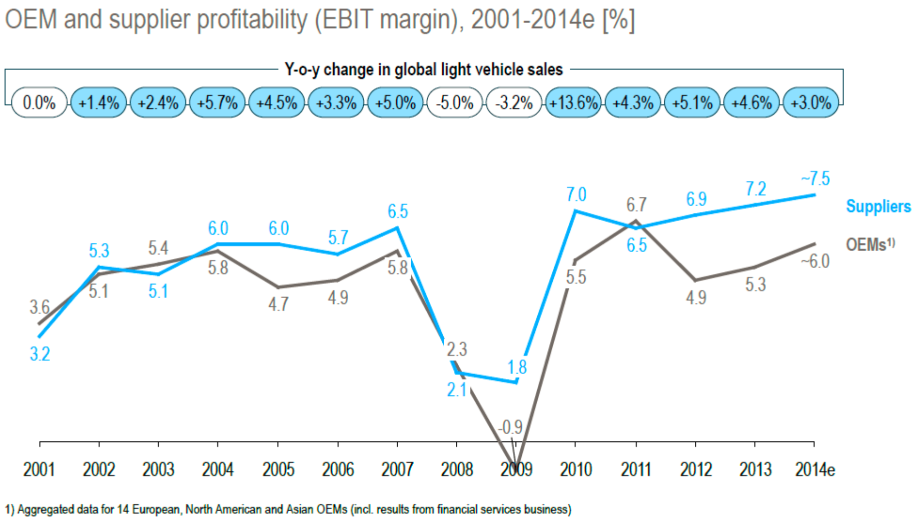

Figure 7.OEE and supplier profitability - Roland Berger / Lazard

Suppliers have maintained or improved their margins based on better utilized capacities, higher leverage of fixed costs and a favourable product mix development. Furthermore, many of them have substantially improved their liquidity and financing situation and find themselves in a more stable position than in 2007. Nevertheless, this positive development came with significantly higher complexity of the business for automotive suppliers – global reach, product proliferation, diverging technology roadmaps…

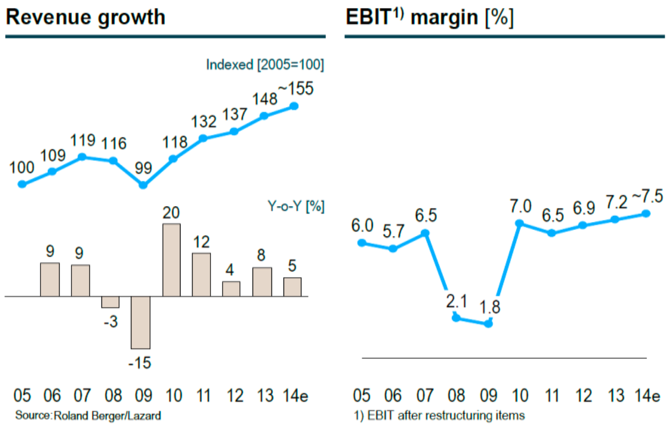

Figure 8. Average revenue growth and EBIT margin of automotive suppliers - Roland Berger / Lazard

Besides, for the first time since 2011, automotive supplier Mergers & Acquisition activity increased. Price Water House Coopers (PWC) estimated about 211 major deals for 2014, a 13% increase over 2013 (5). This has mainly happened because suppliers have aligned with OEMs global platform strategies, because improving vehicle assembly forecasts in Europe are providing additional confidence for large global suppliers and mid-sized European suppliers and due to the need for new and complementary technologies to address future automotive trends. These trends encompass from "light-weighting," powertrain enhancements and "autonomous driving" to the "connected car".

North American and European suppliers are the biggest consolidators in 2014, respectively representing 47% and 30% of total top global consolidation, and the majority of all automotive supplier acquisitions globally are targeting powertrain and chassis suppliers.

It is also noteworthy the increased involvement of Private Equity in the resurgence of automotive supplier consolidation with almost a quarter of all deals in 2014 involving Private Equity firms.

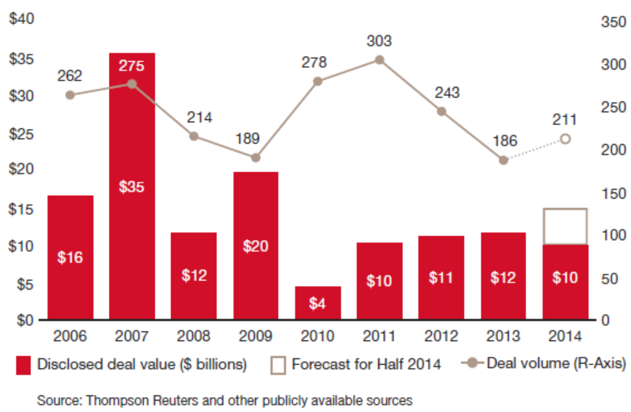

Figure 9.Component suppliers M&A activity - PWC / Thomson Reuters

2.2 Performance based on region, company size, product focus and business model

As already commented in the previous section, suppliers have been operating at historically high-level margins in the last years. Despite this trend, certain clusters of suppliers have maintained or even improved their above average profitability over a long period of time whilst others have shown a deteriorating performance. This situation can partially be explained by evaluating the influence of the region of operation, the size of the supplier, its product focus and the business model followed. (4)

2.2.1 Region

- NAFTA suppliers have significantly improved their performance since the auto crisis as they still benefit from their business restructuring
- Performance of Europe- based suppliers partly impacted by weak home market in 2013 showed a positive trend in 2014, benefiting from leading technology and favourable customer mix
- Chinese suppliers are still very strong but with gradually decreasing margin levels due to intensified competition
- Japanese suppliers on average remain at a weaker profitability level given their dependence on their home market and OEMs

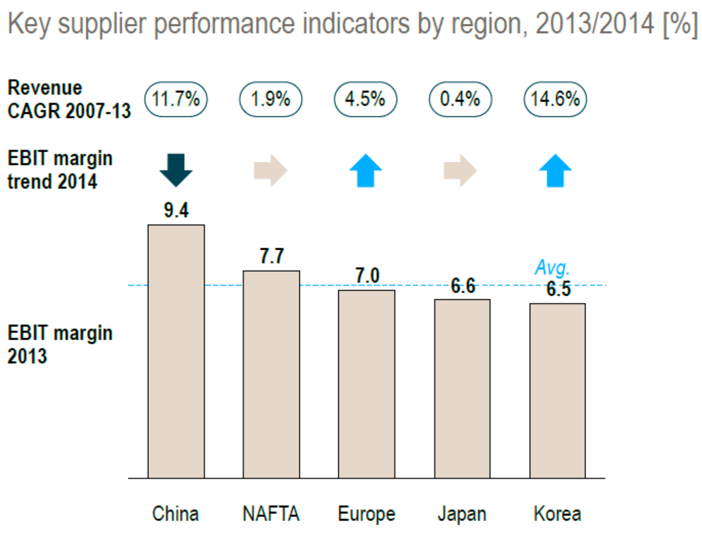

Figure 10. Supplier performance by region -Roland Berger / Lazard

2.2.2 Company size

- Suppliers with over 10 billion Euros revenues maintained their strong profitability level of above 7% EBIT in 2014, benefiting from globalization and scaling of costs
- Lower midsized suppliers (0.5 to 2.5 billion Euros revenues) remained above average
- Upper midsized suppliers (2.5 to 10 billion Euros revenues) remained below average
- Small suppliers (below 0.5 billion Euros revenues) had the lowest profitability

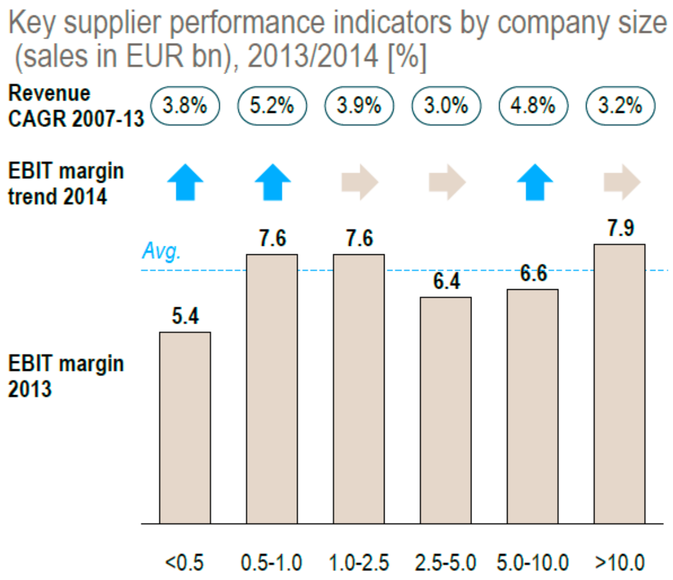

Figure 11.Supplier performance by company size -Roland Berger / Lazard

2.2.3 Product Focus

- Tire-focused suppliers maintained their strong margins as they benefit from their after market
- Powertrain margins were reduced by the intensified competition on its growing business
- Exterior suppliers improved in recent years due to the growth of lightweight focus, while chassis developed slightly below average, focusing on safety. These segments will be deeply analysed in next sections
- Interior-focused suppliers saw margins decline and had the lowest profitability level overall as they are struggling with high commoditization pressure

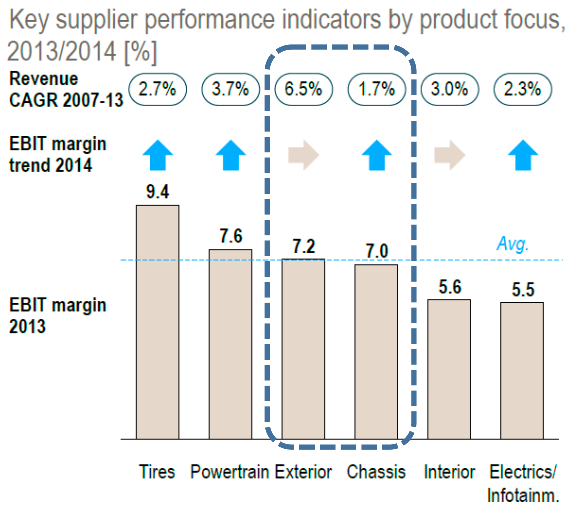

Figure 12. Supplier performance by product focus-Roland Berger / Lazard

2.2.4 Business model

- Product innovators had stable above-average margins as their products have higher differentiation potential and higher willingness from OEMs
- There are high entry barriers through intellectual property in many innovation-driven segments
- Competitive structure was more consolidated in innovation-driven segments, hence obtaining stable below average margins
- Higher fragmentation in many process-driven segments has driven price competition

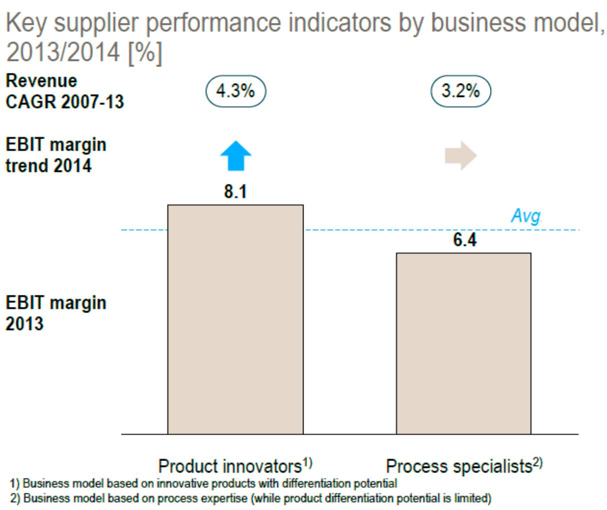

Figure 13. Supplier performance by business model -Roland Berger / Lazard

2.3 Challenges faced by automotive suppliers

Slow growth is also expected in the automotive supplier industry in the future, and the record profitability of the past years is expected to come to an end soon. Furthermore, automotive suppliers will face a series of short and long-term challenges, which they will have to overcome in order to maintain their positive performance. These challenges mainly come as a result of car buyers' behaviour, OEM's strategy, competition within the industry, supply base trends, technology and legislations and financing. (4)

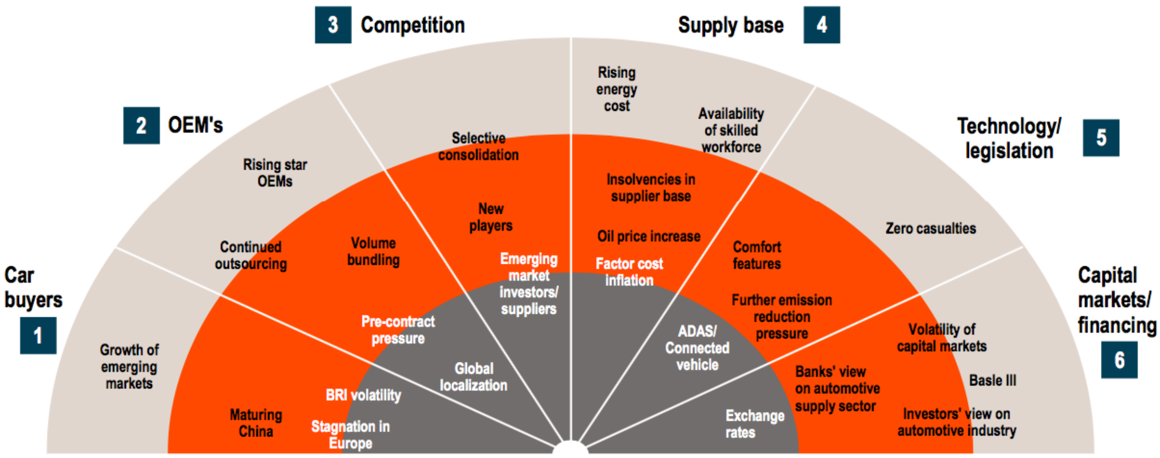

Figure 14. Supplier CEO radar screen – Roland Berger / Lazard

<u>Car buyers:</u>

As previously described as a challenge within the automotive industry, the diverging markets will have a clear impact on suppliers' production, footprint and employment. They will have to estimate the impact of the reduction of relevance of TRIAD markets, the volatility of BRIC markets and the maturity of the Chinese market.

<u>OEMs:</u>

The OEMs are increasingly globalizing their footprint, and consequently suppliers are required to follow. Furthermore, OEMs are tending towards further outsourcing strategies, and suppliers must cope with pre-contract pressure.

<u>Competition</u>

Emerging markets suppliers are looking to strengthen their technology capabilities and overseas presence. Market access and player consolidation will be driven by M&A, with China being a dominant stakeholder (at least one Chinese investor has typically been involved in each relevant

M&A auction process in the last years). Moreover, the downstream expansion of raw material providers will increase the competition in the industry.

Supply base:

Amongst the biggest challenges that suppliers will need to face within their supply resources are the rising energy cost and the volatility of oil price, and the availability of a talented an adequate workforce, topic which will be discussed in detail later.

Technology and legislation

Regulatory requirements focused on safety and emission reduction will pressure suppliers to offer lighter and cleaner products with improved performance. Furthermore, in particular supplier components, this need to improve efficiency and request for technology evolution, driver assistance and connectivity, will allow non-traditional players to enter the market.

Financing:

The growth, consolidation and M&A of suppliers will be largely dependant on the volatility of the capital markets and exchange rates, and the investors' view of the automotive sector, especially banks.

Although the global vehicle component market is expected to grow, these structural changes in the industry will redistribute revenues across products and locations. This situation yields higher opportunities and risks and could bring huge benefits if product, customer and mix decisions taken are the most appropriate.

3. Body and chassis within the automotive industry

3.1 Product definition and relevance towards achieving the industry's goals

The automotive chassis is the base of a vehicle and it is considered one of its key structures. It is now extensively referred to with the term rolling chassis, which encompasses all major units necessary to propel the vehicle and direct and control its motion: frame, transmission system, suspension system, steering system, brakes, engine…Nevertheless, for the purpose of this study, the term chassis will denote solely the skeletal frame on which the other mechanical parts are mounted.

The body of a vehicle, referred to as body in white (BIW), is its essential structure and it is usually made from stamped metal parts, which are subsequently welded together. Metal body components are classified into two groups: exterior parts, which encompass bonnets, roofs, doors and wings, and structural parts that include floors, pillars, rails and wheel arches.

As previously explained, some of the major challenges that the industry is facing are cost pressure and weight reduction. Regulation is forcing OEMs to develop increasingly lighter cars and hence, they must be able to manufacture cars that comply with regulations at a reasonable price. OEMs therefore hand down these requirements to their suppliers.

Within achieving this task, OEMs and suppliers must put a particular emphasis in body and chassis, as according to the World Steel Association, the body of a car currently accounts for 36% of its weight (6). Furthermore, the aim to reduce weight will highly impact the cost of BIW and chassis, as 15% of the increase in cost as a result of improving fuel economy will come from these components. (7)

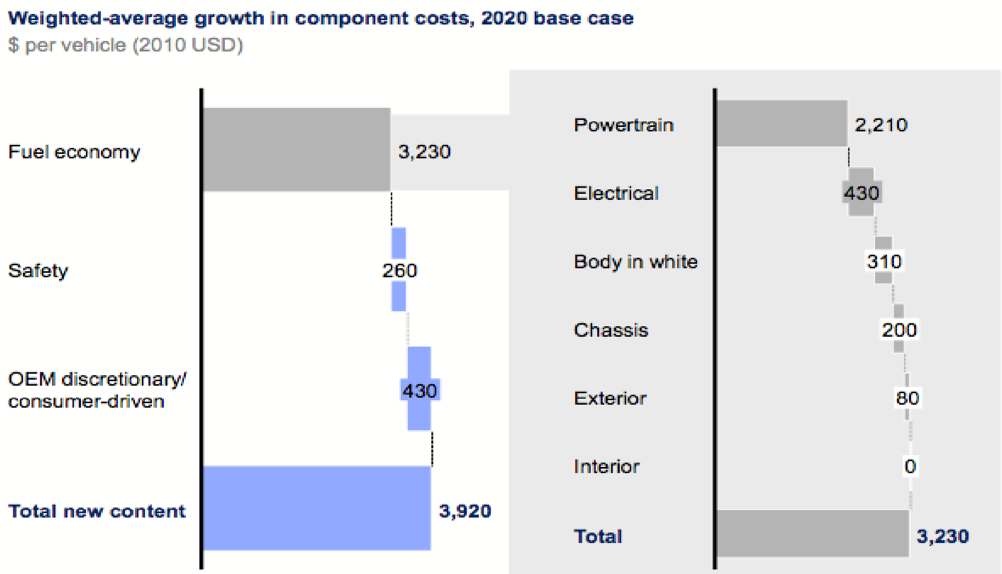

Figure 15. Growth in component costs - McKinsey & Company

3.2 Body and chassis requirements and attributes

The main functions of the chassis frame are to support the other mechanical elements and bodywork of the vehicle and to withstand static and dynamic loads with deflection and distortion. The main forces that chassis must withstand are the weight of the body, passengers and cargo load, longitudinal tensile forces determined by acceleration and braking, transverse lateral forces caused while steering, torque transmitted from the engine and impacts. (8)

Body components, besides structural requirements, must offer a minimum resistance to air and minimum vibrations during the running of the vehicle.

The choice of materials and design for the different car elements is one of the most important factors in automotive projects. In order to take decisions, they must be evaluated according to certain criteria, which may be the outcome of performance results, environmental regulation, safety concerns or customer requirements. The most important criteria that should be met in the body and chassis structure design are lightweight, cost effectiveness and safety considerations.

- Lightweight: It has become the most important criterion for the automotive industry given the emphasis placed on the reduction of emissions and fuel efficiency improvement. Experiments have proven that a 10% weight reduction can lead to around 5% improvement in fuel usage (9). In order to achieve this weight reduction, all car manufacturers and suppliers are investing significantly in lightweight materials. Automakers can obtain weight reduction through three main ways:
  - Replacing heavier materials by lower density materials: replacing steel with high strength steel, aluminium, magnesium, composites or foam. The figure below shows the mass reductions expectations for different materials within the BIW and chassis components.
  - Optimizing the design of load-carrying elements and exterior attachments so as to reduce their weight without any loss in rigidity or functionality.
  - Optimizing the production process, such as reducing spot welding and replacing new joining techniques.

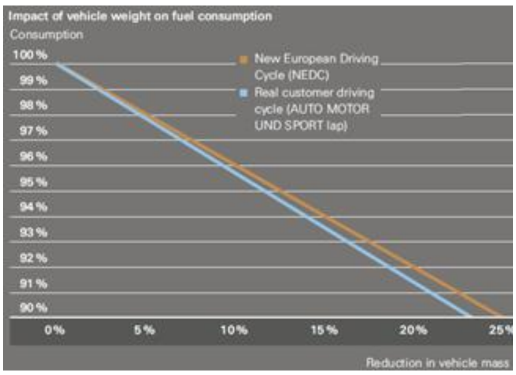

Figure 17.Impact of vehicle weight on fuel consumptions - ZF Friedrichshafen

Materials and Mass Reduction Expectations

Material	Material Replaced	Mass Reduction %
Magnesium	Steel, Cast Iron	60 – 75%
Carbon Fiber Composites	Steel	50 – 60
Aluminum Matrix Composites	Steel, Cast Iron	40 – 60
Aluminum	Steel, Cast Iron	40 – 60
Titanium	Alloy Steel	40 – 55
Glass Fiber Composites	Steel	25 – 35
Advanced High Strength Steels	Mild Steel, Carbon Steel	15 – 25
High Strength Steel	Mild Steel	10 – 15

Figure 16. Materials and mass reduction expectations - Gestamp

- Cost effectiveness: It is one of the most important consumer driven factors in automotive industry and determines whether the materials and designs may be selected for a vehicle component. Cost includes three components: actual cost of raw materials, manufacturing value added, and the cost to design and test the product.
  Alternatives to conventional steel such as high strength steel, aluminium or composite materials are more expensive; hence, decisions to select light metals must be justified on the basis of improved functionality. This topic will be discussed further onwards.

- Safety: One of the most important safety concepts to consider in the automotive industry, and especially, in the body and chassis structure area, is crashworthiness. It is defined as the potential of absorption of energy through controlled failure modes and mechanisms that provides a gradual decay in the load profile. Therefore, chassis and body structures must be stiff, and present excellent energy absorption and a good resistance to fatigue failure.

3.3 Types of chassis and body structure

In order to fulfil these criteria and load requirement, nowadays, two different types of chassis may be found in the market: Independent chassis and monocoque or unibody chassis.

- Independent chassis: they are the earliest kind of chassis and only few car models are manufactured with it. Amongst this category, the most significant varieties are ladder chassis and backbone chassis.

Figure 18. Ladder Chassis - Toyota Tundra

o Ladder chassis: Until the early 60's, nearly all cars used the ladder chassis as standard. As its name implies, ladder chassis resembles a shape of a ladder having two longitudinal rails linked by several lateral and cross members. It is a heavy structure with excellent resistance, simple design and behaves well upon impact. Due to these characteristics, most SUVs, pick-ups, trucks and buses currently still employ it. Some variations to this design include the perimeter and X-frame chassis.

Figure 19. Backbone chassis - Mazda MX5

o Backbone chassis: Alternatively, this chassis has a rectangular tube like backbone that is used to join the front and rear axle together. This easy to make and cost effective alternative is powerful enough to support sports cars and other car models such as the Volkswagen Beatle.

Figure 20. Monocoque chassis - BMW M5

- Monocoque chassis: It is a one-piece structure that defines the overall shape of a vehicle. This type of automotive chassis is manufactured by welding the floor pan and other pieces together. In such a fully integrated body structure, the whole vehicle is a load-carrying unit that handles all the loads experienced by it. Monocoque chassis are heavy due to all the metal needed but provide excellent stiffness and impact strength results. Since monocoque chassis is cost effective and suitable for robotized production, nowadays 99% of the production cars use this type of chassis.

The body structure encompasses many components, both exterior and structural, and includes bonnets, roofs, fins, doors and floors, pillars, rails, wheel arches, front-end modules, bumpers and crash beams.

Figure 21. Components of body structure

3.4 Materials

Around 60% of every vehicle is made of steel, mostly in the body and chassis frames, where on average, 70-80% is steel (10). Aluminium is the second most popular material, and although it is mainly used in powertrain, its use for chassis and body structure is rising. The aim to reduce car weight has led to the investigation and application of composites and fibre components. According to McKinsey & Company, high strength steel increases the part cost 15%, aluminium a 30%, and carbon fibre a 470%, with respect to conventional steel. (11)

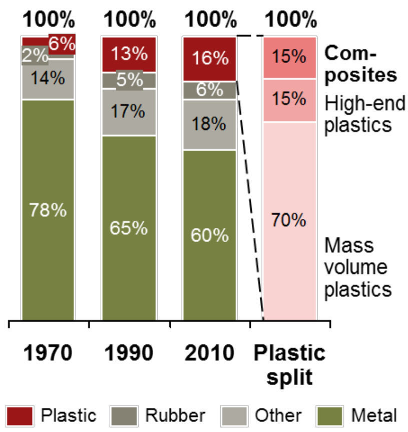

Figure 22. Evolution of material split in automotive industry - A.T. Kearney

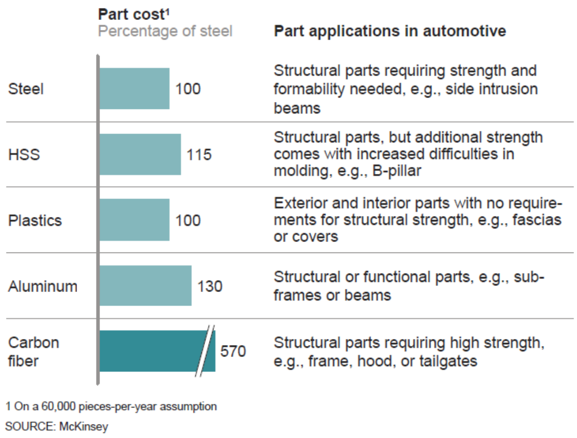

Figure 23. Material price comparison in the automotive industry – Mckinsey & Company

The performance and properties of these materials will now be analyzed.

3.4.1 Steel and High Strength Steels

Steel is the most popular material given its good mechanical properties, its low economic costs and the high availability of both the raw material and the machinery to process it.

Properties

The critical mechanical properties that make steel an excellent material are its stiffness, which allow other components to work as they are designed to, good yield strength and ultimate strength, particularly when alloyed, excellent energy absorption and a good resistance to fatigue failure.

Although offering such performance, the biggest issue with the use of steel is its density: almost 3 times the density of aluminium. This is an increasingly important concern given the focus on weight reduction, fuel efficiency and addition of safety equipment in the automotive industry.

In order to tackle this concern, both OEMs and suppliers have been focusing on the use of high strength steels and ultra-high strength steels in order to reduce weight while maintaining performance. According to the American Institute of Steel and Iron, high strength steels are steels with tensile strengths between 270 and 700 MPa, and ultra-high strength steels those with tensile strengths beyond 700 MPa. For a given thickness, a high strength steel plate is stiffer than a conventional steel plate, and hence, for a given stiffness, the thickness needed would be smaller, therefore, lighter, achieving the weight reduction objective.

On average in the automotive industry, HSS offer a 20% weight reduction with an increase in cost around 15%). (11)

Alloys of High Strength Steel

According to the hardening mechanism employed to increase strength, high strength steel, which is extensively used in chassis and body structures, can be classified as:

- Bake hardening steel: A 40 MPa increase in tensile strength can be achieved through a low temperature treatment.
- Microalloyed steel: Obtained through the grain size reduction and the precipitation of it. Sometimes, elements such as Titanium, Niobium or Chromium are added to provide extra hardness.
- Phosphorus alloyed steel: Steel with a ferritic matrix which contains elements such as Phosphorus and provide high strength levels and can be easily conformed.

Ultra high strength steels are defined by a great stiffness, large energy abortion and resistance to deformation. Different types and alloys can be distinguished:

- Martensitic steel: Steel with a martensitic microstructure, obtained from austenite through an annealing treatment. The yield strength can be increased up to 1400 MPa.
- Boron steel: Steel with a high degree of hardness achieved through a heating process and the addition of Boron, Chromium and Manganese.

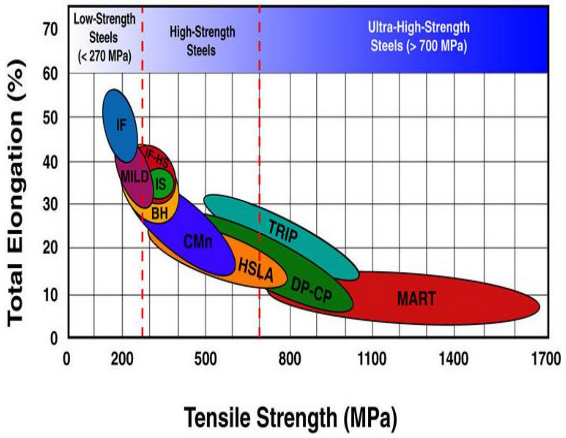

Figure 25. Tensile strength for different steel alloys

Figure 24. Audi A5 Sportback steel chassis

Stamping

Besides the steel alloy produced, it is important to analyse the stamping technique used in the conformation of the metal. The most distinguished techniques in the automotive sector are cold stamping and hot stamping.

- Cold stamping: Involves the transformation of a sheet of metal at room temperature inside a forming die under pressure. In order to achieve complex forms, parts must be pressed or stamped and cut in several steps, under different press technologies. This technique includes roll forming, where a coil strip is subjected to a bending operation by passing the strip through sets of rollers resulting in continuous deformation, and hydro-forming, which uses a high pressure hydraulic fluid to press room temperature tubes into a die. Ultra-high strength steels may be conformed using cold stamping. (12)

- Hot stamping: Press Hardening is an innovative process by which advanced ultra-high strength steel is formed into complex shapes more efficiently than with traditional cold stamping. The process involves the heating of the steel blanks until they are malleable, followed by formation and then rapid cooling in specially designed dies, creating in the process a transformed and hardened material. Because of this ability to efficiently combine strength and complexity, press hardened parts accomplish in one relatively light-weight piece what would typically require thicker, heavier parts welded together in more than one process under cold stamping (12). Hot stamping will be discussed in depth in a future section.

According to A.T. Kearney, the value distribution of steel in a vehicle in the future will clearly tend toward hot stamped steel and Ultra High Strength steel in detriment of mild and high steel strength. Hot stamped steel and Ultra High Strength Steel will respectively represent a 12.8 % and 18% of a vehicle's value in 2025.

Press mechanisms

Within stamping, a key factor to study together with the stamping technique is the type of press and press mechanism chosen. Four different press mechanisms can be identified:

- Progressive press: Uses single dies with built-in multiple forming stages and the parts are automatically transferred through the press while being attached to the coil. Separation occurs in the last step and is able to run at high speeds (20-40 strokes / minute). (13)

- Tandem press: Represents a series of three or more individual presses arranged in a line. The first press is fed with steel blanks or coils from where the stamped part is moved to the subsequent presses (manually or automatically by a robot). They run at comparably low speed (5-10 strokes / minute).

- Transfer press: Generally constructed as a single press that contains all stations necessary to form a complete part. The press makes multiple hits at each stroke and the parts are automatically transferred between the stamping steps. Runs at 10-25 strokes / minute.

- Normal press: Usually manually loaded with blanks, and stamped parts are manually unloaded, hence, operating at low speeds.

3.4.2 Aluminium

Aluminium is increasingly being used in the automotive industry, as with a lower density than steel, it can reduce the weight of the vehicle body up to a 40% (11). This offers improvements in fuel efficiency, braking handling and acceleration.

Although raw aluminium has too low yield strength for structural use, its strength can significantly increase when alloyed, making it suitable for chassis applications. Moreover, aluminium is highly recyclable, as 90% of automotive aluminium scrap materials are recycled annually, and according to The Aluminum Association, the extensive use of aluminium compared to steel would achieve up to a 20 percent reduction in total life cycle energy consumption and up to a 17 percent reduction in CO2 emissions.

These properties have consolidated the growth of aluminium within past years, which averages to be 394 lb (-180 kg) per car, accounting for a 13% growth in the 2012-2015 period. (14)

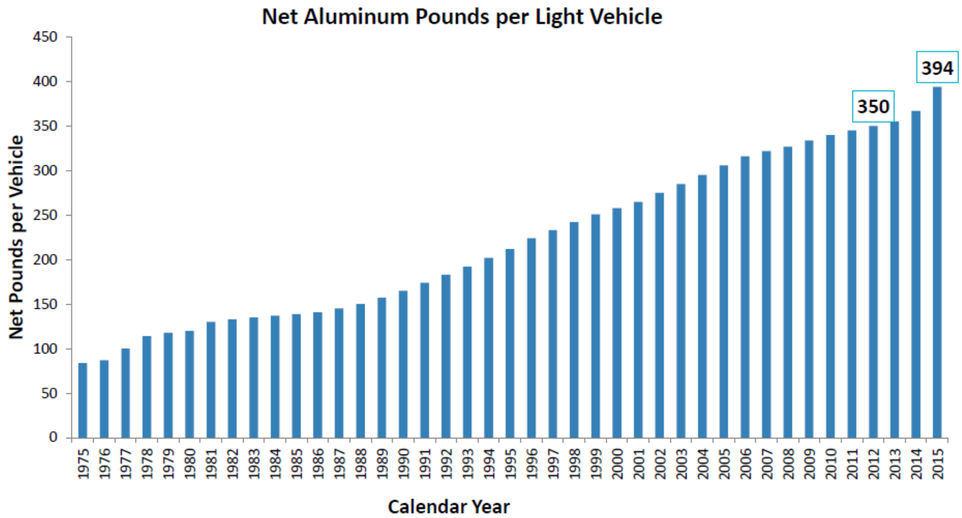

Figure 26. Evolution of average aluminium weight in average car – Ducker Worldwide

Additionally, aluminium usage has also been pushed by the wide range of processes available to covert the raw material into products. It can be:

- Supplied as plate or sheet and subsequently formed to shape
- Produced in a super-plastic form that can be vacuum-formed to shape at low temperatures
- Produced as film
- Forged and extruded
- Cast into intricate shapes by several different methods, suitable for all volumes of production
- Be reinforced with ceramics to produce materials with greater resistance to wear and high temperatures

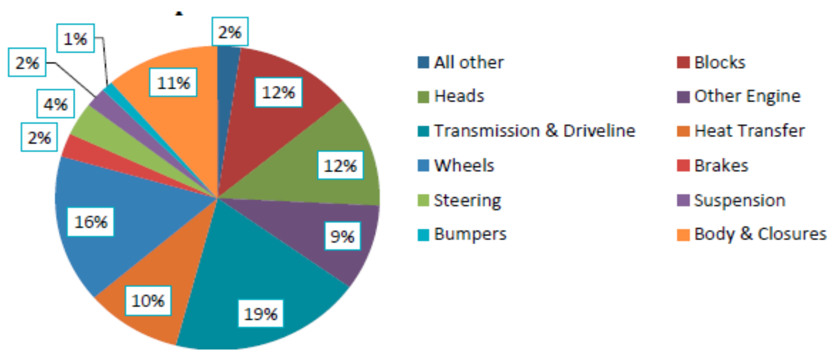

Figure 27. Distribution of aluminium weight in an average car – Ducker Worldwide

Although it is primarily used in automotive powertrain, (almost 100% of pistons, about 75% of cylinder heads, 85% of intake manifolds and transmission) , it is increasingly being introduced in body and chassis, representing on average an 30% of the aluminium use, and even brands like Range Rover mount their whole chassis with aluminium. (15)

Figure 28. Range Rover Sport aluminium chassis

Another factor that definitely favours the adoption of aluminium as the chosen material is the abundant supply of the raw material, as there are mining and process facilities in many countries worldwide. This fact ensures that sufficient supplies of aluminium will be available to meet the increased demand and that a country's potential political instability is unlikely to affect supply.

Besides the attractiveness of Aluminium as an alternative material, the most significant impediment to its growth is its price, as its use rises the cost approximately a 30%. (11)

3.4.3 Composites

In many industries like aviation wind energy and automotive, composites are becoming increasingly important offering significant weight reduction potential compared to conventional materials like steel.

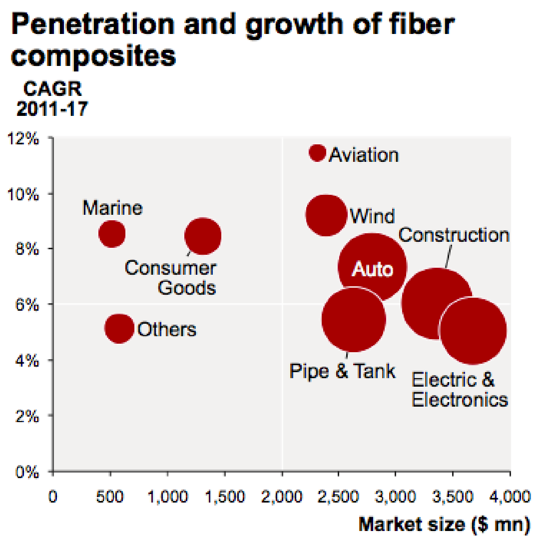

Figure 29. Penetration and growth of fibre composites - A.T. Kearney

In particular, some of the most popular composites are carbon fibre polymers, especially used when looking for high strength-to-weight ratio and rigidity. They consist of two parts: a matrix and reinforcement. The reinforcement is carbon fibre, which provides the strength and rigidity. Unlike isotropic materials like steel and aluminium, CFRP has directional strength properties. The matrix is usually a polymer resin, such as epoxy, to bind the reinforcements together.

Besides offering a 30-40% weight reduction at equal strength, composites may have lower manufacturing complexity, (as a single composite moulding can take the place of up to 15-20 individual components) and reduced tool cost (composite tooling cost is only 40% of steel stamping tooling cost). (16)

Furthermore, their mechanical properties allow greater design flexibility, smoothness and geometry detail, and have superior chemical and dent resistance than aluminium and steel panels as well as better sound insulation properties. These benefits push the industry towards a more intense use of plastics and composites at the expense of metals such as steel and aluminium.

For these reasons, the fibre composites market is very attractive in terms of size and future growth. Although development has especially taken place in the aviation, wind and marine markets, it has also become relevant in the automotive sector, with an expected CAGR growth of around 8% in the 2011-2017 period.

Figure 30. Hyundai Intrado carbon fiber chassis

This growth in the automotive industry has also had a significant impact within the chassis and body in white sector, where composites are becoming especially relevant. The earliest and main development of carbon fibre chassis has taken place in the sports and end user car sectors, where weight is a key performance factor. Nevertheless, certain brands have focused on this material and Hyundai for example, has developed a carbon frame for the automotive body of the Intrado concept car. Carbon fibre chassis are always monocoque designs with stronger and weaker areas similar to using different alloys in metal.

Nevertheless, the adoption of composites in the automotive industry still faces several challenges. According to a survey carried out by A.T. Kearney amongst OEMs, the main impediment for the growth of composites against other alternative lightweight materials already mentioned is its cost. Other obstacles faced by composites are the need of high capital investments as current equipment is not compatible, supply chain volatility due to the lack of significant suppliers and the need to comply with safety and recyclability regulations, which demands recycling of 95% of material in 2015.

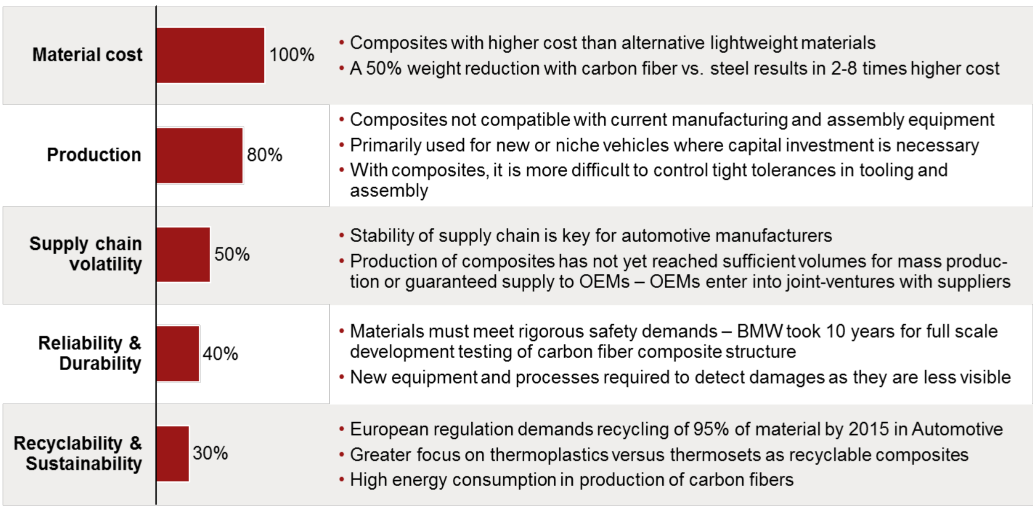

Figure 31. Carbon fibre survey to OEMs – A.T. Kearney

4. Competitive landscape in the body and chassis supply industry

Before diving into the body and chassis supply sector, it is important to understand the role of suppliers in the automotive industry.

4.1 Value chain in the automotive industry

Over the years OEMs have transitioned from being vertically integrated companies to become highly efficient integrators of components in car platforms they define and own. The global nature of the automotive industry means that it is important for car manufacturers to be able to on board their suppliers as quickly as possible, independently of the country in which they may be based around the world.

The automotive industry has a 'tiered' supply chain structure. Upstream from the car manufacturers or OEMs are Tier 1, 2 and 3 suppliers, whose role is described below.

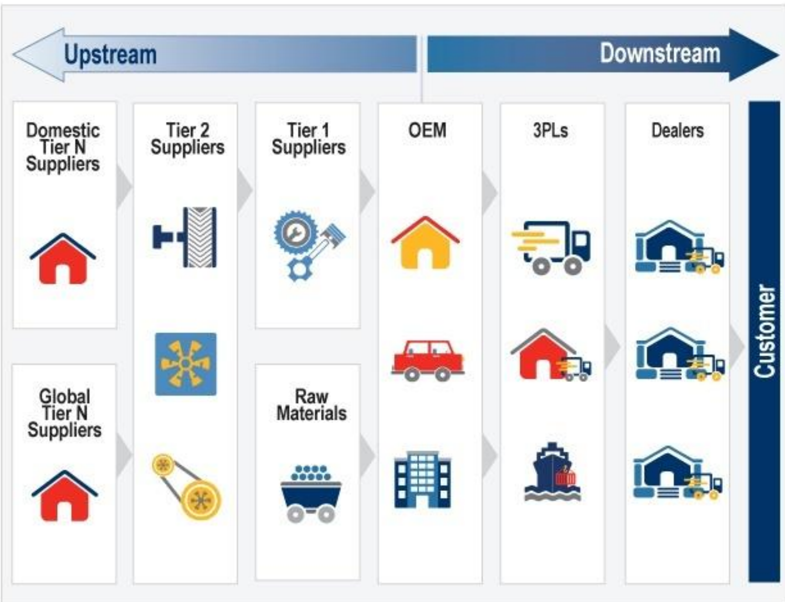

Figure 32. Automotive value chain

- Automakers – OEMS: Once analysed consumers' needs and desires, automakers design models which are tailored to consumers' demands. The design process normally takes five years. Automakers have manufacturing units where they develop core competences: engines are manufactured, and parts supplied by first tier suppliers and second tier suppliers are assembled. Automakers are the key to the supply chain of the automotive industry. Many automakers also cover other operations such as stamping.

- First Tier Suppliers: They assembly components into complete units such as dashboards, brakes-axle-suspension, cockpits…and manage second tier suppliers. Tier1 suppliers are highly important to the car manufacturers so they will typically have a plant close to the car manufacturers to support Just-In-Time type production processes. Tier 1 suppliers are being required to perform and integrate more steps of the automotive manufacturing process, to do them better, and to accomplish them in close synchronization with the global business plans of OEMs.

- Second Tier Suppliers: They design vehicle systems or bodies for first tier suppliers and OEMs. They work on designs provided by the first tier suppliers or OEMs. They also provide engineering resources for detailed designs. Some of their services may include welding, fabrication, shearing, bending…They could be based anywhere in the world and many companies in this particular sector have established a manufacturing presence in low cost countries around the world.

- Third Tier Suppliers: They provide basic products like rubber, glass, steel, plastic and aluminium to the second tier suppliers.

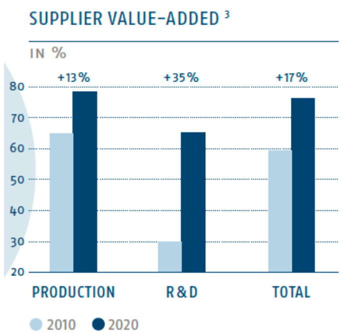

Figure 33. Increase in supplier value-added - Benteler

According to Benteler annual report 2014, the projected growth in value-added among automotive suppliers up to 2020 is 17% taking 2010 as a baseline. There will be a 13% increase in supplier value added in production and 35% in Research and Development. This is against the background of automotive manufacturers that are increasingly concentrating on marketing and sales and are outsourcing these areas. (17)

4.2 Characterization of market competition in body and chassis

The chassis and body stamping market is a challenging market dominated by few players who have achieved leadership through global coverage and breath of capabilities. Nevertheless, there are many small local players present which focus only on a certain region. Besides, almost all suppliers plan on expanding their global footprints.

Moreover, numerous OEMs, including Ford, GM, & Toyota maintain their own stamping operations.

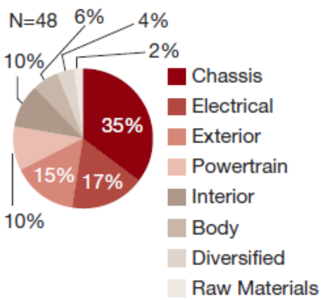

Figure 34. Share of deals in automotive suppliers per sector - PWC

Currently there is some consolidation in the industry and the trend is that this consolidation will go further. Mergers and Acquisition activity is intense in the sector:

- Chassis represents one of the largest shares of M&A activity, representing 35% of deals
- Body suppliers are becoming more popular targets growing to 6% of all automotive supplier deals globally. (5)

Amongst the largest competitors are Magna, Tower, Gestamp and Benteler, whose business is described below.

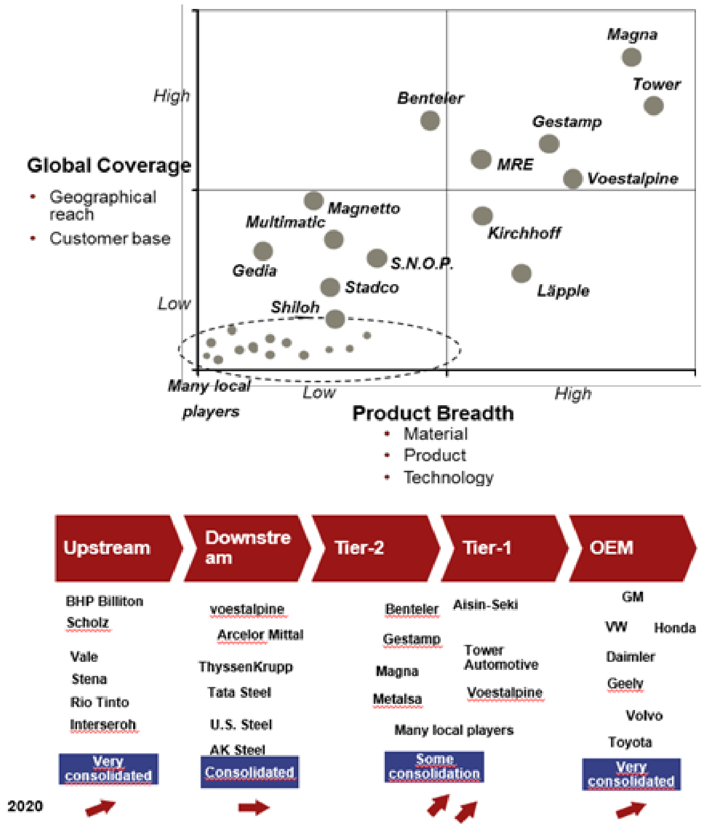

Figure 35. Chassis and BIW market competition overview - A.T. Kearney

4.3 Business, financial and R&D overview of top players in the industry

- Magna International:

Magna is a global automotive supplier headquartered in Canada, with over 131,000 employees and 287 manufacturing operations and 81 product development, engineering and sales centres in 29 countries. It is the largest automobile parts manufacturer in North America by sales of original equipment parts as its product offer encompasses body and chassis, powertrain, electronics, exteriors, seating, closures, roof systems, interiors and vision systems. Its operating groups include Magna Steyr, Magna Powertrain, Magna Exteriors, Magna Seating, Magna Closures, Magna Mirrors, Magna Electronics and Cosma International. Magna Interiors was sold to Grupo Antolín in 2015.

As the graph below highlights, Magna has shown a strong growth, both in revenues and EBITDA margin during the last years, as a result of their increase in North American and Asian production sales. By the end of 2014, their financials reflected over 35,000 M€ and a 9% EBITDA margin. Given its size, Magna shows far bigger revenues than the other big BIW competitors, maintaining an overall margin in line with the big competitors of this specific sector.

Cosma International is a wholly-owned operating unit of Magna International providing a comprehensive range of body, chassis and engineering solutions to OEMs. In 2014, Magna's body and chassis segment generated 8,079 million US dollars, a 22% of its whole business (36,641 million US dollars).

Regarding R&D, the company's corporate constitution requires a minimum of 7% of its pre-tax profits for any fiscal year to be allocated to research and development the following year. The most important activities under development in the body and chassis fields include a partnership with Ford in developing a multi-material lightweight vehicle concept and a Class A magnesium sheet roof panel.

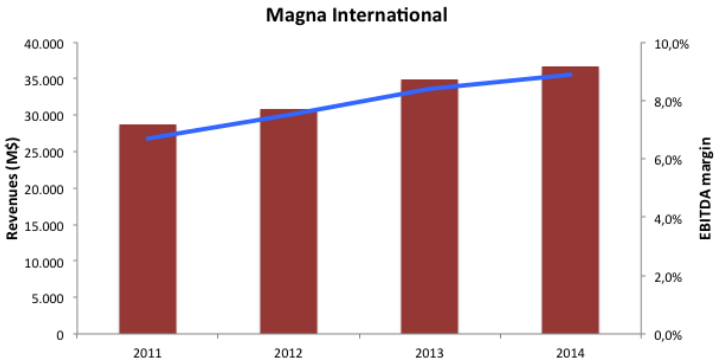

Figure 37. Magna International's revenues and EBITDA margin

- Gestamp Automocion:

Gestamp Automocion, S.A. is a public limited company, fully owned by the RIberas family. It employs around 32,000 workers, across 21 countries, distributed in 86 manufacturing facilities and 11 R&D centres.

It is an international automotive supplier which designs, develops and manufactures metal components and assemblies for the automotive market, primarily focusing on light passenger vehicles. The company's activities are focused around three product lines: metal vehicle body components, chassis components and mechanisms.

Gestamp Automocion, as illustrated below, generated sales of 6,256 million euros in 2014 and 5,853 in 2013, with an EBITDA margin of 10,5% and 10,4% respectively. More than 50% of the sales came from Western Europe. In 2014, the Company's sales grew by 6.9%, mainly caused by improved sales figures in China, North America, and Europe. In particular, increased sales in Spain and the UK helped drive the company's positive results in Europe. These increases were slightly offset by weakness in the Russian and Mercosur markets, and the depreciation of certain currencies versus the euro.

According to UniCredit analysis in 2011, Gestamp was leader of body-in-white supply in Europe - 31% market share and South America- 22% market share and number 2 in the chassis market in Europe (behind Benteler) and South America (behind Magna), with a 24% and 25%market share respectively (18). In the last years, the company has performed very important strategic acquisitions: Edscha (2010) and ThyssenKrupp's metal forming division (2011). The acquisition of Edscha has allowed Gestamp to achieve an over 50% share for door hinges and door checks in the European market. (20)

Regarding R&D, Gestamp has 11 research and development centres, approximately employing 1000 workers. The two key areas of focus for the Company's R&D department include reducing the weight of metal car components and improving the strength and safety of its steel components.

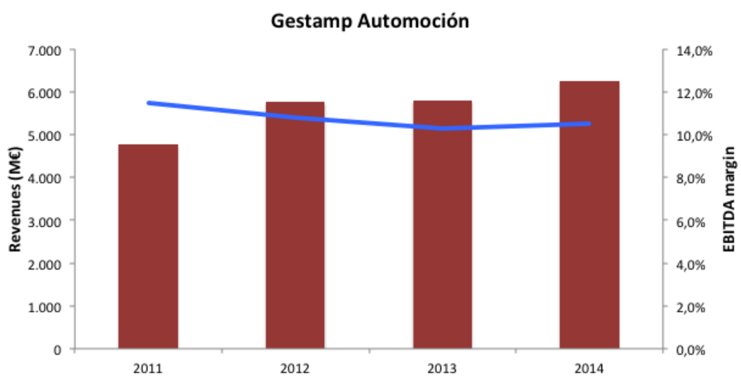

Figure 38. Gestamp Automoción's revenues and EBITDA margin

- Benteler Automotive:

Benteler Automotive is an independent business division of Benteler International AG, a strategic management holding headquartered in Austria, which also has Steel/Tube and Distribution divisions. The group employs around 27,500 workers, spread across 38 countries, including 79 production facilities and 20 engineering offices.

The holding presents relatively stable revenues since 2011, above 7,000 M€, with EBITDA margins below the industry average, between 4 and 6%. The situation was particularly weak during 2013, driven by a significant fall in revenues in the Steel/Tube and Distribution divisions and a series of restructuring and reorganization costs.

Regarding Benteler Automotive, it mainly operates in the chassis, modules, structures, engine and exhaust systems product groups. It generated sales of 5,865 million euros in 2014 and 5,903 million euros in 2013, which respectively stood for a 76% and 80% of all the holding's revenue. Operations in the Automotive Division were therefore flat in the near past, as the positive input of a good economy in the global automotive industry was offset by the significant decline in Brazil and the economy in Russia, and a series of site closures during 2014.

Regarding R&D, the company has over 1,200 employees working in research and development in 32 locations over 18 countries and spent 93 million Euros in 2014. The company is cooperating with OEMs and other suppliers on several projects to reduce the weight of various systems and components through hybrid materials. These projects are funded by the European Union and the state of North Rhine-Westphalia. Examples of projects include a hybrid bumper made from aluminium and Ultra-Strong Steel, and a structure made from aluminium and fibre-reinforced synthetics.

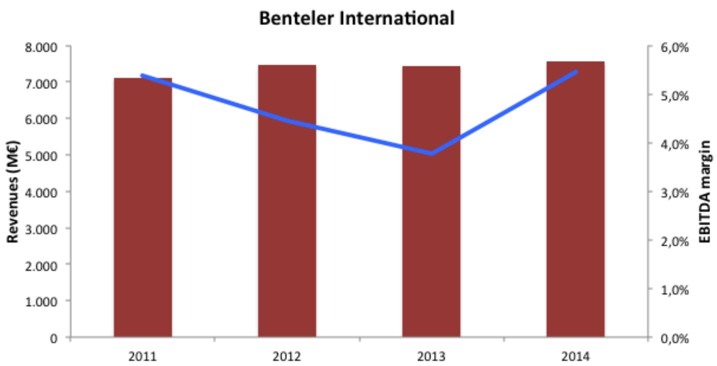

Figure 39. Benteler International's revenues and EBITDA margin

- Tower International:

Tower is a leading integrated global manufacturer of engineered structural metal components and assemblies headquartered in Michigan. The company offers automotive customers a broad product portfolio, supplying body-structure stampings, frame and other chassis structures, as well as complex welded assemblies, for small and large cars, crossovers, pickups and SUVs.

The company employs 7,800 workers and has 9 manufacturing locations in US, 11 in Europe, 6 in China and 3 in Brazil. Regarding R&D, it has a total of seven technical centres located in the following countries: United States, Brazil, Germany, Italy, China, India, and Japan.

Tower is the significantly smaller than the other BIW suppliers previously mentioned, presenting revenues more than three times smaller than Gestamp and Benteler, and exhibiting high operating profit margins.

It has generated sales of 2,068 million dollars in 2014 and 1,967 in 2013, with EBITDA margins stable just below 10%. Total revenues increased during 2014 by 5.2%, reflecting primarily higher volume in the Americas segment (USD 79.5 million) and in the International segment (USD 48.3 million), yet slightly offset by unfavourable product mix. Revenues were positively impacted by the strengthening of the Euro against the U.S. dollar in the International segment, but were negatively impacted by the depreciation of Brazilian Real and the Chinese RMB.

In 2016 despite its operating profitability, Tower International has announced plans to investigate the potential sale of Tower Europe.

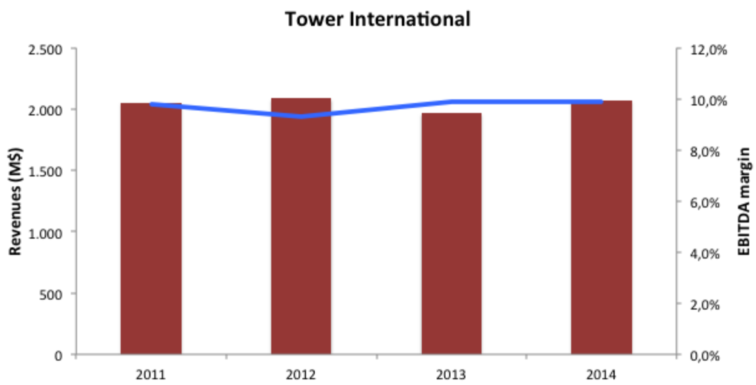

Figure 40. Tower International's revenues and EBITDA margin

5. Success factors for the competitiveness of a hot stamping plant

As previously analysed, the automotive industry has become a greatly global industry in the past decades, and hence, automotive suppliers have had to expand their operations as a result. The optimization of their manufacturing footprint has become a critical aspect of their strategies in order to adapt to the dynamics of the industries, strongly driven by diverging markets and cost pressure.

After over viewing and characterizing the automotive industry, with a main focus on the body and chassis supply sector, the next exercise will consist in analysing the most important factors that allow a hot stamping supplier to increase the competitiveness of its plants and become a successful supplier.

According to Oliver Wyman, in the past, relatively simple cost considerations were needed when selecting locations for new plants and having a good technology position was enough to generate business. Nevertheless, today, the requirements that suppliers face encompass a far wider range of aspects, which have to be acknowledged in order to provide the basis for competitive positioning. Amongst all the elements that suppliers take into account when evaluating footprint decision, the rationals on which a higher focus is placed are personnel cost, market access and customer proximity. (19)

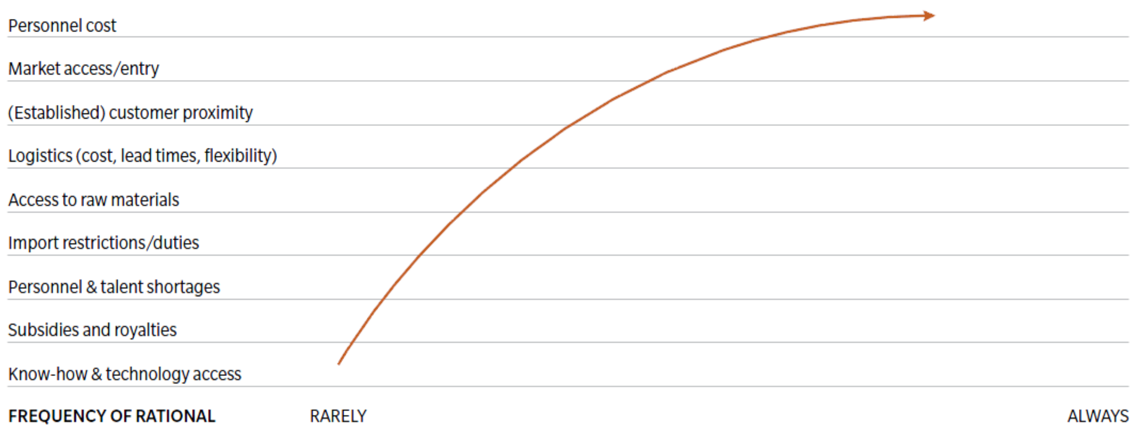

Figure 41. Rational in footprint decisions at automotive suppliers - Oliver Wyman

With the aim of evaluating the most important success factors for the competitiveness of a hot stamping plant, emphasis is going to be placed on the most significant technology considerations, the adequacy of the workforce, a suitable location and efficiency operating parameters and techniques such as Overall Equipment Effectiveness (OEE) and Total Productive Maintenance (TPM).

5.1 Hot Stamping Technology

Once all of the materials that are currently used in the automotive industry have been commented, a deeper focus is going to be placed on hot stamped steel, studying its properties and performance, the automotive components currently developed through this technology and the demand it is facing.

Hot stamping, also called press hardening, is an innovative process by which advanced ultra-high strength steel is formed into complex shapes more efficiently and with a significant weight reduction than with traditional cold stamping.

The process involves heating steel to temperatures of 900ºC, point at which it achieves the austenitization phase and becomes malleable. Therefore, it can be formed and then rapidly cooled in especially designed dies, converting the material into very high strength steel. Full martensitic transformation in the material causes an increase of the tensile strength of up to 1500 MPa.

According to A.T. Kearney, hot stamped steel is going to keep growing in the near future, and will increase its weight on an average car value distribution by more than 5pp in the next 10 years.

Although new lighter materials such as aluminium and composites are going to replace some of the production that has been traditionally manufactured with steel, the product mix switch within steel, from mild to ultra-high strength steel and hot stamped, will make these types of steels vey relevant in the next ten years.

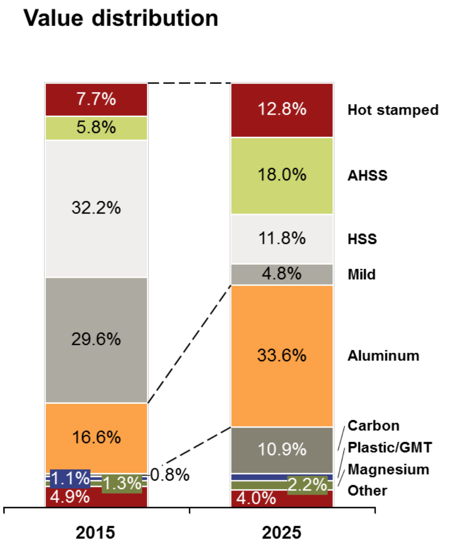

Figure 42. Materials value distribution for automotive manufacturing - A.T. Kearney

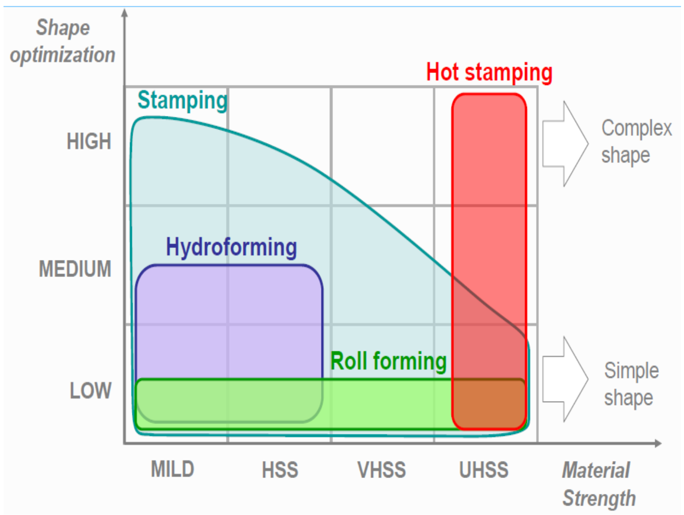

Figure 43. Shape optimization by stamping process - Gestamp

5.1.1 Hot stamping steel

Currently, the most popular steels for press hardening are Usibor 1500 and 22MnB5 from ArcelorMittal and MBW steels by ThyssenKrupp. Alloys in hot stamping usually contain Boron, Manganese and/or Chromium in order enlarge the process time on martensitic transformation and achieve its ideal characteristics.

These steels can be both hot and rolled formed. They differ in the fact that hot rolled steel is rolled to its final dimensions while hot (over 1000 ºC) while cold rolled steel is rolled to its final dimensions at room temperatures. This allows for tighter thickness tolerances, can improve surface finish and gives it a small amount of work hardening. Nevertheless, it also adds an extra step to the manufacturing process, increasing cost.

Moreover, a key element of commercial hot stamping steel is its coating. Heating uncoated steel leads to excessive scaling of the surface and loss of carbon content. Coating is increasingly being introduced as it offers benefits not only during the press hardening itself, but also regarding the behaviour during subsequent processes of the press hardened parts. Amongst these benefits you can include weldability, paintability and corrosion resistance. (20)

Hot stamping steel is usually presented as a coil. The coils in hot stamping usually range between 1,5 to 2,5 mm thick and have generally big width and diameter dimensions in order to obtain high steel utilization rates (widths between 0,5 to 2 metres and external diameters from 1,5 to 2,5 metres).

Regarding the benefits of hot stamping, its most distinguishable property is its low weight, which is significantly lower than traditional cold stamping, yet showing excellent strength results. Besides weight reduction, other properties that make hot stamping such a useful technique are listed below:

- Dimensional accuracy – very good reproducibility and no spring back
- Hardness / toughness – excellent plastic deformation properties
- Weldability – very good due to low carbon content
- Excellent fatigue properties
- Very high formability – forming of complex geometries
- High elongation at break
- Material properties not dependent of forming depth
- Well suited for crash applications

5.1.2 Hot stamping process

Hot stamping is an extensive process, which encompasses a series of operations on the steel, of which the most critical are the heating of the material, stamping and cooling.

A traditional hot stamping process includes the following steps:

1. Preliminary stamping to achieve desired raw material formats
   1.b (Pre-deformation in case of indirect hot stamping)
2. Heating of the blank in a furnace
3. Stamping of the piece while hot
4. Quenching
5. Finishing operations such as laser trimming, cutting, blasting…

As it has been pointed out, the hot stamping process currently exists in two different main variants: the direct and the indirect hot stamping method. In the direct hot stamping process, a blank is heated up in a furnace, transferred to the press and subsequently formed and quenched in a closed tool. The indirect hot stamping process is characterized by the use of a nearly complete cold pre-formed part which is subjected only to a quenching and calibration operation in the press after austenitization. The indirect method is generally used when working with complex shape pieces, and an additional deformation capacity is required. (20)

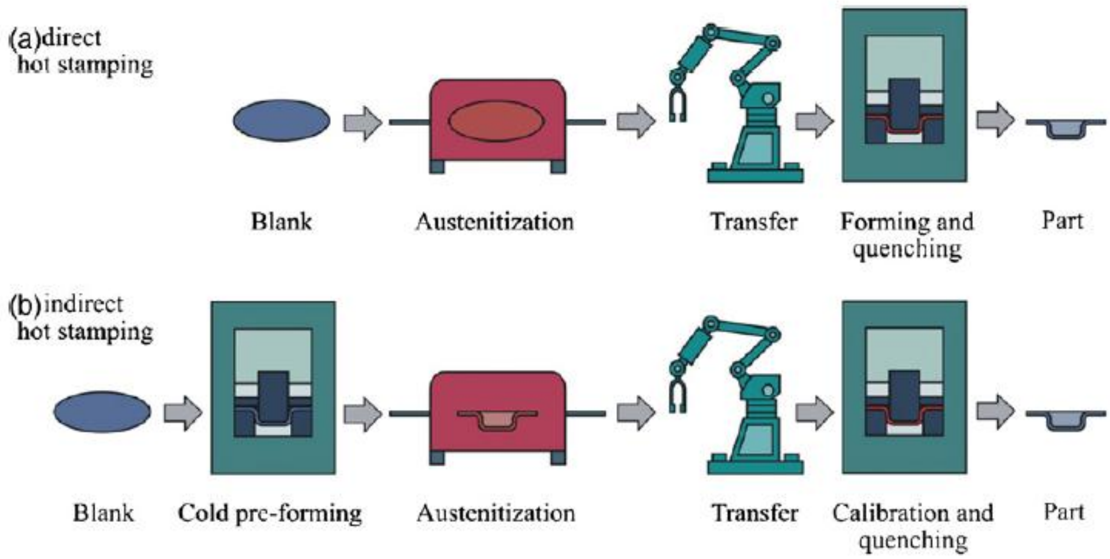

Figure 44. Direct and Indirect Hot Stamping Methods - Karbasian

Furnace:

The heating process is the longest step in a hot stamping line, and depending on the thickness of the piece and furnace, it can last up to 10 minutes. Currently there are three alternatives regarding heating: convection, conduction and induction.

Given its simplicity and flexibility, the most extended heating technique is convection heating, although it offers some drawbacks such as big space requirement and low energy efficiency. Presently 80% of all heating systems in hot stamping applications are roller-hearth furnaces, a type of convection heating. Furnaces of this type can be run with or without protective gas and can reach 30-40 meters. Nevertheless, the high space requirement and the rising investment costs are pushing the industry towards alternative approaches to heat the blanks. Other convection techniques which are also implemented are Double-decker, Multi-chamber and Rotatory, which although reducing space requirements, also still imply other disadvantage such as process and automation complexity.

Within other heating techniques, some of the alternatives being developed are conduction heating, where the blank is clamped between the two pairs of electrodes and the resistance of the material causes the heating of the part, and induction heating, which offers velocities and energy efficiencies. (21)

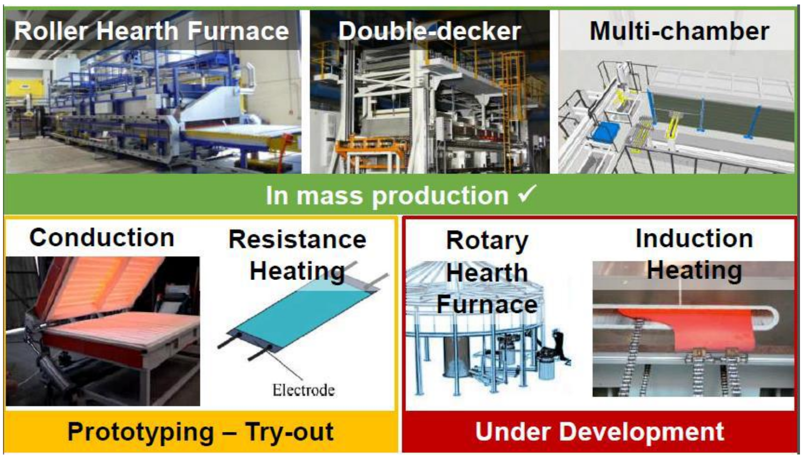

Figure 45. Heating systems in hot stamping - KM-UTT

Press:

As it has already been pointed out, the hot stamping process encompasses two presses. The first press, as explained, is used to achieve desired cutting formats and is generally a mechanical press. Mechanical presses are characterized by a flywheel and offer appropriate speeds, but low positioning capacity and force control.

Traditional mechanical presses are not suitable for use in press hardening, as it requires the press to stop at the Bottom Dead Centre (BDC) to enable part quenching. In order to tackle this aspect, hydraulic presses are normally used, which offer excellent positioning capacities. Nevertheless, although these presses have improved their performance in terms of speed, due to the use of valves and high capacity hydraulic systems, they show low energy efficiencies, high maintenance requirements and are susceptive of wear outs and leakages.

Under such circumstances, there has recently been a great revolution in the use of servo-presses, which can be used both for format cutting and hot stamping. This type fills the gaps of traditional mechanical and hydraulic presses, offering total control the slide position, high speed and reduced vibration and wear. (22)

Figure 47. Hydraulic hot stamping press - LCM Machinery

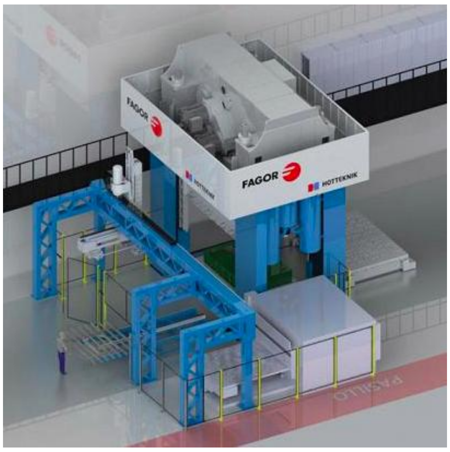

Figure 46. Servo hot stamping press - Fagor Arrasate

<u>Tools:</u>

Tools are a key element within the hot stamping process, as they are exposed to very demanding conditions: high thermal impacts (including quenching) together with fast working speeds. In order to control the cooling temperature, these tools have several channels for water circulation. Tools face a constant repeating process that makes it suffer from wear and tear, and together with high working loads, causes the tool to undergo adhesion and abrasion issues. (23)

Some of the current developments on tools encompass tailored refrigeration and tailored conductivity. Tailored refrigeration consists on adding embedded electrical resistances in the tool areas where a lower cooling rate is desired. In order to achieve the same goal, tailored conductivity focuses on to control the cooling rates by means of conductivity variations through different thermal treatments.

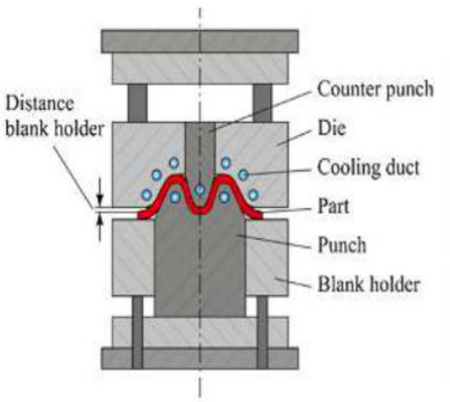

Figure 48. Tool with refrigeration channels - Journal of Materials Processing Technology

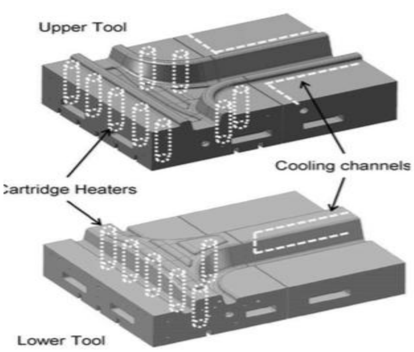

Figure 49. Tool for tailored refrigeration - Journal of Materials Processing Technology

5.1.3 Hot stamped products

Given the benefits of manufacturing strong and complex geometry components, with a significant weight reduction, hot stamping technology has been mainly used to manufacture safety-critical structural parts, such as bumper beams, door and A- and B-pillar reinforcements, and roof and dash panel cross members. (24)

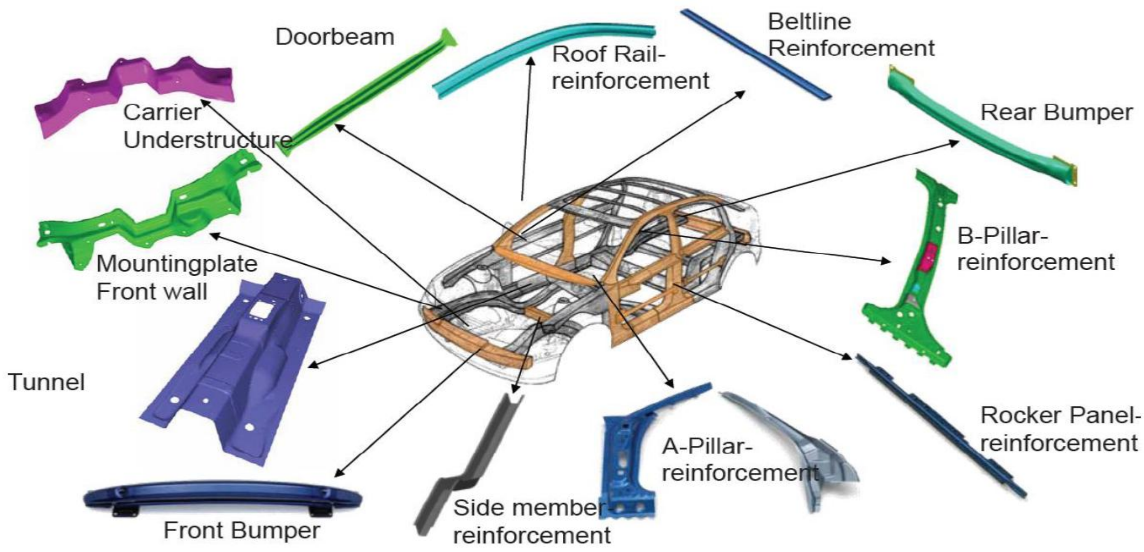

Figure 50. Components manufactured using hot stamping - Benteler

Besides the wide range of products that are currently manufactured through hot stamping, the increasing demand for the technology is expected to maintain, as the range of hot stamping products will go beyond current safety critical structure parts. According to Acerlor Mittal, the hot stamping materials with new coatings will soon be introduced into chassis components and lower parts of the vehicle. (25)

5.1.4 Demand for Hot Stamping

The previously described necessity to reduce vehicle weight to meet environmental standards while maintaining component strength and safety, has pushed Tier 1 suppliers to develop and offer hot stamping technologies. Currently, Gestamp with more than 55 hot stamping lines, Benteler with more than 30 and Cosma with 22 are the leading producers of hot stamped parts.

Since its development in 1977 in Lulea, Sweden, hot stamping has been facing an increasing demand, which has especially peaked during the last years. According to EWI Forming Group, Hot

Stamping has grown with 30% CAGR in the 2007-2013 period (from 95 up to 450 million parts per year). (26)

In addition to the growth of hot stamping at the classic outsourced suppliers of stamped parts, there is also a growing investment by OEMs, including Fiat, BMW, Volkswagen and Volvo. (25)

It is very clear that OEMs are strongly betting for hot stamping in their newest platforms as the best alternative in order to achieve weight and performance requirements, increasing the demand for this leading technology. This strong and sustained growth together with he extension of the current range of hot stamped products will make it an even more promosing technology, with clear room for development and profitability.

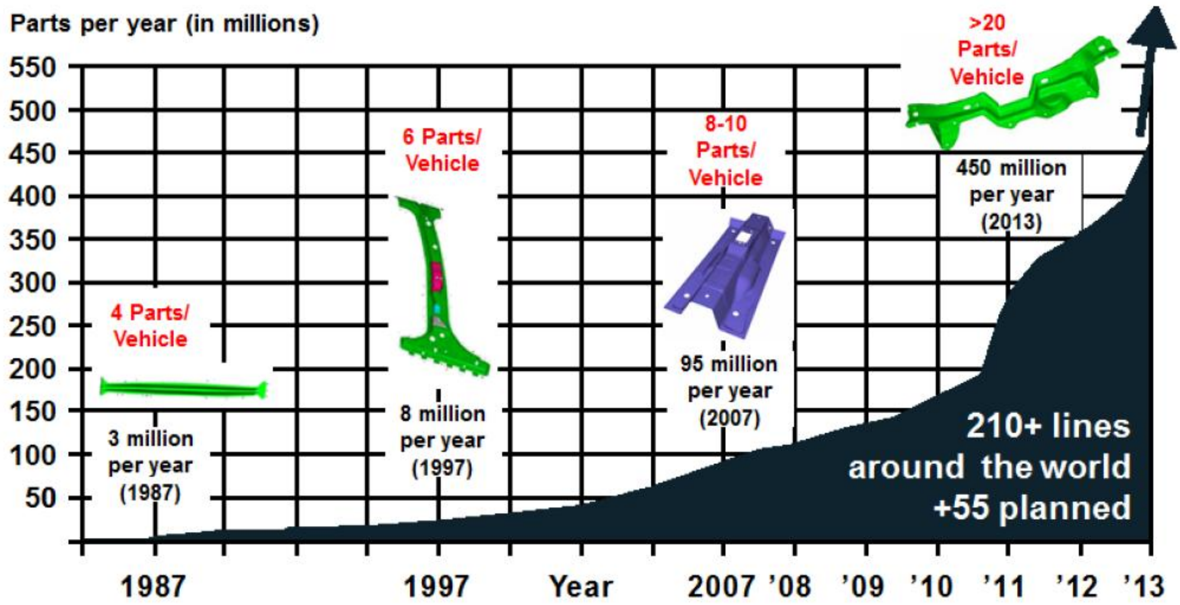

Figure 51. Evolution of annual production of hot stamped parts - EWI Forming Center

5.2 Strategic location

A suitable and strategic location is a key requirement for a plant to be competent and successful. A Tier 1 supplier plant's location although mainly driven by the proximity to OEM's, must also value proximity to its own suppliers, which in the case of the chassis and BIW sector is primarily steel suppliers, and the transportation costs.

In addition, logistics has become a differentiating factor because in order to provide Just in Time/ Just in Sequence delivery, the acceptable distance to the customer's factories in some cases has shrunk to less than 50 km. Hence, a strategic location can make a supplier crucial for an automaker.

5.2.1 Proximity to OEMs

Although rapid advances in technology and increased international competition have contributed to flattening the supply chain in the automotive industry, distance to the OEM assembly plant still matters, especially in Europe.

Physical proximity directly affects many transaction costs, such as transportation, logistics and the costs or difficulties to meet delivery schedules, especially, when talking about JIT production. Furthermore, the proximity to customers is not only measured in kilometres, but is also has a cultural dimension, as sharing a nationality with the customer has been estimated to boost the probability of being selected by 65% (27). Cultural aspects such as sharing a language can highly reduce communication costs, and having the same regional government may allow for mutual benefits, government sponsors and aligned objectives and business practices.

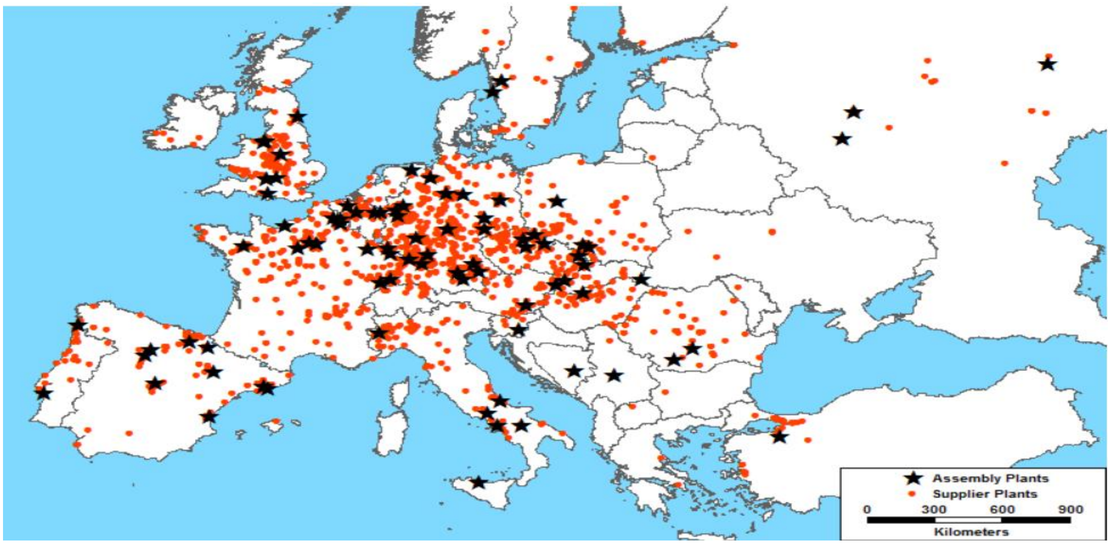

Figure 52. European motor vehicle footprint - ERIEP

If focus is placed in Europe, it is clearly observed how suppliers locate their plants very close to assembly plants in order to reduced the already mentioned transportation cost and be able to achieve a critical position within schedules. It can therefore be concluded, that in order to take a footprint location, suppliers must deeply study where the OEM plants are located, how big the future car production will be, especially the start of new production (SOP), and what are the potential transport connections with them.

If a supplier is considering opening a plant in a certain country, the area within that certain country is especially relevant. If we take the car production in Spain for example, it is very visible that the national car production is very uneven, with all the car production geographically concentrating in assembly plants in the Northern area of Spain, and none in the South.

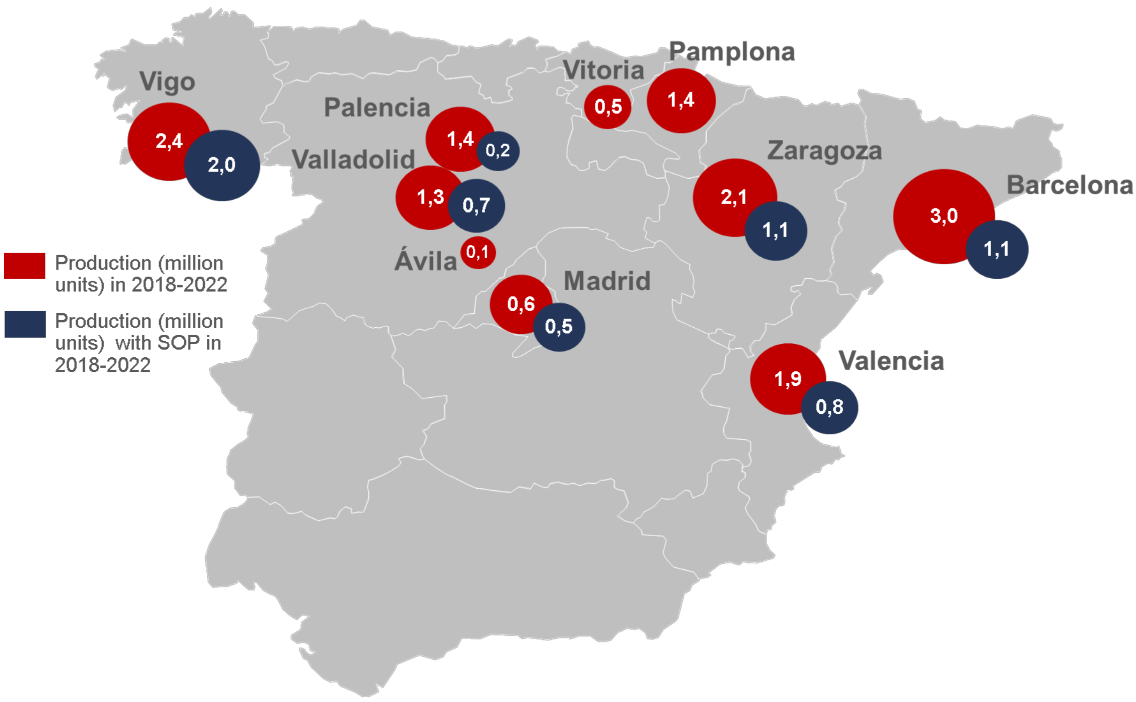

Figure 53. Light vehicle production in Spain based on IHS Automotive

More specifically, the spanish car production encompasses 5 OEMs, and their respective assembly plants:

- Vigo's PSA plant accounts for the production of 2.4 million cars between 2018 and 2022, of which 2 million will actually be new car production
- Palencia's and Valladolid's Renault plants will together produce 2.7 million cars, a third of them being new models
- Zaragoza's Opel plant will be producing 2.1 million, and 52% of its production will have a SOP in the evaluated period

- Martorell's Seat plant, together with other OEM plants in the Barcelona region, account for the production of 3.0 million cars, of which 1.1 will be new models
- Valencia's Ford plants account for a poduction of 1.9 million cars, and 0.8 millions will have a SOP in the 2018-2022 period
- In Madrid, PSA's plant will be producing 0.6 million, and more than 80% of its production will be new models
- Finally, Pamplona's Volkswagen, Vitoria's Mercedes and Avila's Nissan-Renault will together produce 2.0 light vehicles in the 2018-2022, although none of its production will accounf for new models

With a clear picture of the biggest areas of OEM production in Spain, it seems reasonable that most of the automotive suppliers are located in the North, close to the assembly plants, as reflected in the previous map, so as to significantly reduce logistic costs and improve coordination with clients.

If a deeper look is taking into the location of Tier 1 suppliers of chassis and body in white components, two of the biggest market competitors, Gestamp and Benteler, are present in Spain. Both companies together have 22 plants engaged in stamping activities in Spain, and have all of them close to OEE assembly plants, in line with the previously commented premises.

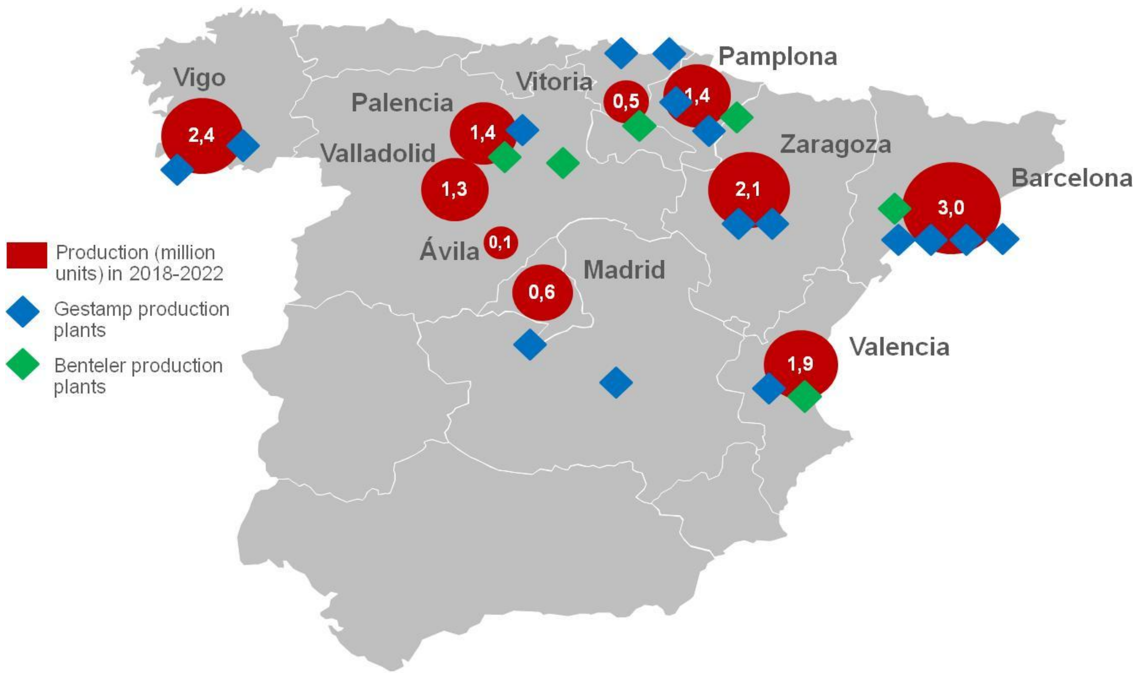

Figure 54. Chassis and BIW suppliers' location in Spain

5.2.2 Steel suppliers

Automakers and Tier 1 suppliers purchase steel directly from steel-makers in the basis of negotiated contracts. Although these large buyers may have enough bargaining power to obtain price discounts given their size and the intensity of the industry, steel-makers and buyers have reciprocal incentives to cooperate in new product development and to coordinate production schedule and supply chains. Therefore, the proximity and accessibility of steel-making facilities next to Tier 1 supplier or OEM plants becomes a very important competitive advantage factor.

Within the manufacturing of stamped components, the steel variety most widely bought is rolled products such as coils, due to the easiness of its attachment to the press. Hence, within the steel suppliers, those who supply rolled products are of especial relevance for the hot stamping industry. As previously mentioned, some of the most well-known steel suppliers of rolled steel products for hot stamping in Europe are ArcelorMittal with Usibor 1500 and 22MnB5, and ThyssenKrupp with MBW steels.

Some of the main drivers that affect the location of steel suppliers are the access and price of raw materials and energy. In the following chapter, these aspects together with a short description of the steel production process and the main players will be presented.

Steel production

The steel industry value chain encompasses all the processes and operations required to transform raw materials (mainly coal, iron ore, electricity and scrap) into finished steel products. Steelmaking is the process for producing steel from iron ore and scrap. In steelmaking, impurities such as Nitrogen, Silicon, Phosphorus, Sulfur and excess Carbon are removed from the raw Iron, and alloying elements such as Manganese, Nickel, Chromium and Vanadium are added to produce different grades of steel. Currently, steelmaking processes can be broken into two categories: primary and secondary steelmaking.

Primary steelmaking involves converting liquid iron from a blast furnace and steel scrap into steel via basic oxygen steelmaking or melting scrap steel and/or direct reduced iron in an electric arc furnace (EAF). Oxygen steelmaking is driven predominantly by the exothermic nature of the reactions whilst in EAF steelmaking, electrical energy is used.

Secondary steelmaking involves refining of the crude steel before casting and the various operations are normally carried out in ladles. In secondary metallurgy, alloying agents are added, dissolved gases in the steel are lowered, and inclusions are removed or altered chemically to ensure that high-quality steel is produced after casting.

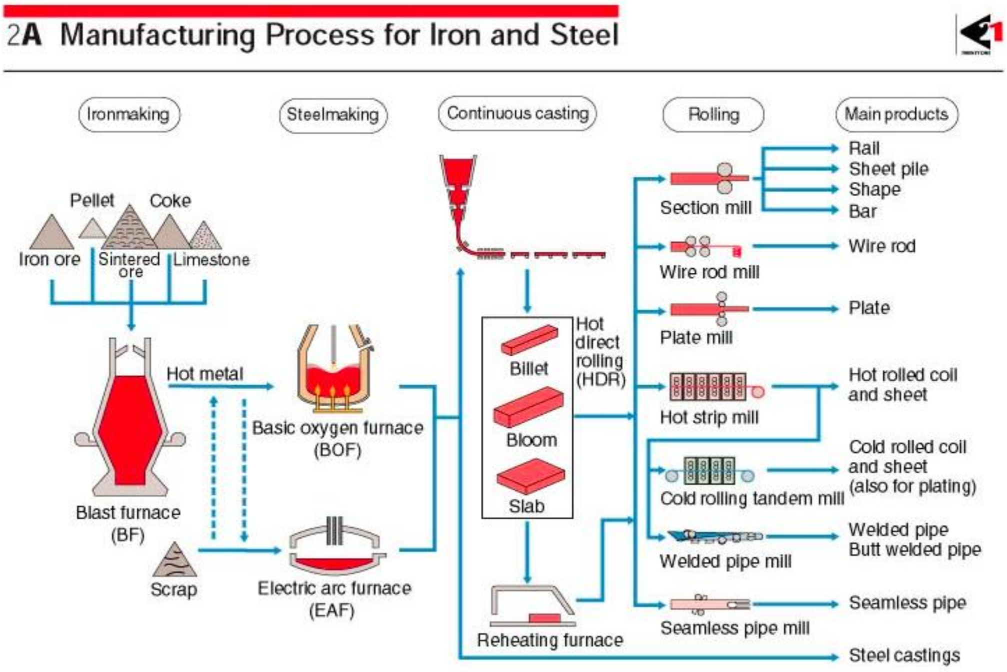

Figure 55. Steel manufacturing process – Kawasaki Steel 21st Century Foundation

Based on the degree of vertical integration, steel-making plants can be broadly classified into two different groups: integrated plants and minimills (secondary steel producers).The first group includes fully integrated plants, where all the production stages are performed, from coke making to product finishing, and partially integrated plants, where coke ovens are not installed and coke making is therefore outsourced. Integrated plants use blast furnaces (BFs) and basic oxygen furnaces (BOFs) to transform iron ore and coke into steel. The minimills group mostly includes plants comprising only steel furnaces and rolling and finishing facilities. The minimills mostly use electric arc furnaces (EAFs) to produce steel, and mainly rely on scrap, and only partially on raw iron, which is usually purchased as processed input. (31)

Major steel producing countries

According to Wold Steel Association, in 2014, the production of steel worldwide was 1,665 million tonnes, of which China accounted for almost have of this production, and the European Union for 10%. The production of hot rolled coils, sheet and strip accounted for 557 million, approximately a third of the total production.

If we take a closer look at the European Union production, approximately 170 million tonnes, the biggest country producers are Germany and Italy, who together represent more than 40% of the EU production. Spain is also a big steel producer, accounting for 8% of the EU production, being the 4th biggest producer in Europe and the 16th in the world.

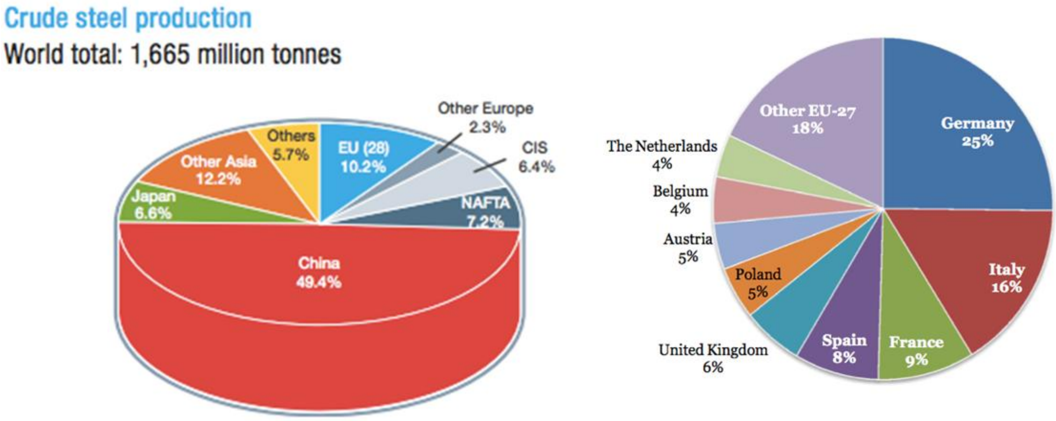

Figure 56. Global and European steel production - World Steel Association

Assuming that steel production for a given country, especially that of rolled steel, is positively related with the availability to obtain steel in that country, it can be concluded, that steel suppliers and BIW manufacturers in that country could be able to reduce production costs and inbound logistics costs. There could be potential benefits for a Tier 1 chassis and BIW supplier plant to be situated in a steel high production country, or close to it, where the abundance of steel production and steel suppliers is higher.

Raw material prices

Besides the tonnes and location of the steel production, another very important aspect that OEMs and Tier 1 suppliers must consider when purchasing steel is its price. The production, and therefore, the cost of steel, relies on the supply of three specific raw materials: iron ore, coke and scrap.

The iron ore industry is highly concentrated. Some 60% of production originates from Australia, Brazil and China. Three global companies dominate the mining industry: Vale SA (Brazil), Rio Tinto PLC (UK/Australia) and BHP Billiton Limited & PLC (UK/Australia). These players control about the 75% of the world trade.

Iron ore is sold to steel-makers on the basis of long-term contracts based on quarterly prices. Price of iron ore was historically influenced by Japanese contracts; however, the industry has repeatedly reported that now Chinese transactions are becoming the benchmark. Given that costs for iron ore are a relevant share of variable costs of production, being independent of the iron ore global cartel can be crucial. (28)

European steel-makers rely heavily on coal imports too. Although Germany and Poland have reserves of coking coal amounting to 5% and 6% of the total world reserves, the European coal production is expected to cease due to the termination of subsidies. Coal prices are negotiated but the price set between Japanese steel- makers and Australian coal suppliers is the basis for all other contracts.

Unlike iron ore and coke, there are no major reserves of scrap. There are three sources of scrap:

- The industry's own circular scrap from steel works and foundries. The supply of this type of scrap is decreasing due to continuous efforts to improve yields.
- Left-over material from steel-processing industries (mechanical engineering, vehicle manufacture, container construction, etc.)
- Old scrap obtained from end products such as cars, household devices, etc. This is the most common type of scrap.

Energy prices

The two main sources of two energy sources are used for the production of steel: natural gas and electricity, the second being especially significant for EAF plants.

Most steel-makers are large gas consumers. Due to their process, BOF integrated plants may consume up to 10 times more natural gas than EOF (28). According to EUROSTAT's 2015 statistics, the price of the natural gas varies significantly between European countries, with some Scandinavian countries, such as Finland and Sweden, and some Southern European countries, such as Portugal and Greece, having the highest natural gas prices (ranging from 0,055 to 0,045 €/KWh). The rest of European countries' natural gas prices range between 0,04 and 0,03 €/KWh, having Spain an average price of around 0,038 €/KWh. Regarding taxes, the countries with higher taxes and levies on their natural gas consumption are the Scandinavian countries, Finland, Sweden and Denmark.

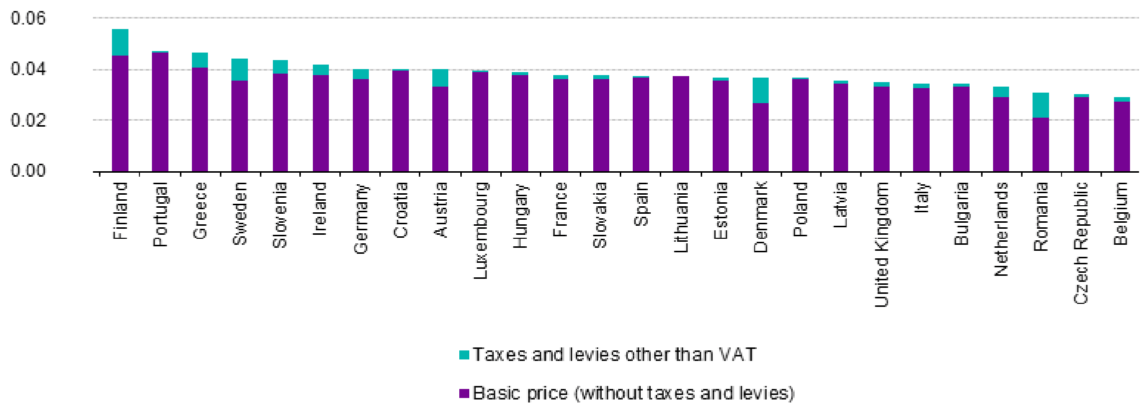

Figure 57.. Natural gas prices (€/kWh) for industry consumption per country - EUROSTAT

As illustrated from a natural gas price perspective, it seems reasonable to think that steel, especially that produced with BOFs, would be cheaper produced, and hence cheaper sold to chassis and BIW suppliers, in countries such as Italy and the Netherlands than in Finland or Portugal.

Regarding electricity consumption, while electricity prices affect traditional integrated producers only to a small extent, they are the largest variable cost category for non-integrated steel-makers adopting EAF. Hence, the access to a stable supply of low-cost electricity becomes a crucial location factor for minimills. Electricity intensity of the BOF process is about one-third of EAF.

According to EUROSTAT's 2015 electricity prices for industries in the different European countries, Southern European steel-makers, on average, face a comparably higher electricity price. Countries like Spain, Greece, Portugal and Italy are amongst the countries with highest electricity price, between 0,12 and 0,17 €/KWh. On the opposite side, Scandinavian countries such as Sweden and Finland face the lowest price amongst all European countries, with electricity around 0,07 €/KWh, almost half the price than in Spain. New Member states such as Poland, Hungary and Czech Republic stand in between. Besides, the countries with higher taxes on ther electricity consumption are Italy and Germany, with 40% of its total price accounting for taxes and levies (other than VAT).

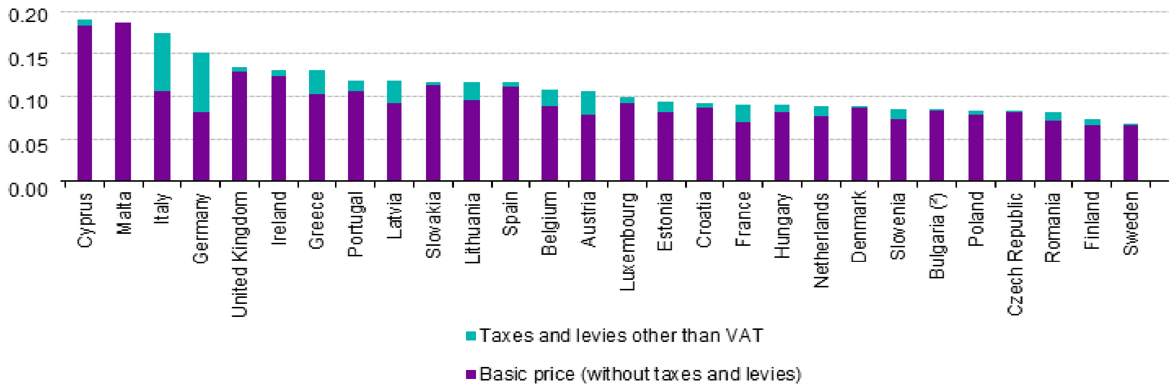

Figure 58. Electricity prices (€/kWh) for industry consumption per country - EUROSTAT

As highlighted from a electricy price perspective, it would be more convinient for chassis and BIW suppliers, which buys steel, especially EAF, to locate a plant in Scandinavian countries like Finland or Sweden, as the cost of steel production and purchase would be significantly lower than in countries such as Italy or Germany.

Players in the steel industry

Boston Consulting Group classifies three different categories of players in the steel industry:

1. Global players, which own a global network of facilities, provide a full range of steel products, are vertically integrated (even in the mining sector), and produce significantly more than 50 million tonnes per year (the only example being ArcelorMittal).
2. Regional champions, which produce between 5 to 50 million tonnes per year, have a strong regional presence, and can be divided into two sub-categories:
   - Type 1 includes companies which have access to low-cost countries and provide high added value products (technology leaders, such as ThyssenKrupp and Riva);
   - Type 2 includes companies which are based in low-cost countries and provide steel commodities (for instance steel-makers located in new member states).
3. Niche specialists, which provide only a narrow range of products, usually very specialised, are present in few locations, and produce less than 5 million tonnes.

According to World Steel Association, the 24 biggest players where (29):

Rank	Company	Tonnage
1	ArcelorMittal (1)	98.09
2	NSSMC (1)	49.30
3	Hebei Steel Group (1)	47.09
4	Baosteel Group (1)	43.35
5	POSCO (1)	41.43
6	Shagang Group	35.33
7	Ansteel Group (1)	34.35
8	Wuhan Steel Group (1)	33.05
9	JFE (1)	31.41
10	Shougang Group (1)	30.78
11	Tata Steel Group (1)	26.20
12	Shandong Steel Group	23.34
13	Nucor Corporation (1)	21.41
14	Hyundai Steel Company (1)	20.58
15	U. S. Steel Corporation (1)	19.73
16	Gerdau (1)	19.00
17	Maanshan Steel (1)	18.90
18	Tianjin Bohai Steel	18.49
19	ThyssenKrupp (1)	16.27
20	Benxi Steel	16.26
21	NLMK (1)	16.11
22	Evraz Group (1)	15.54
23	China Steel Corporation (1)	15.40
24	Valin Group	15.38

Figure 59. Top steel companies worldwide- World Steel Association

5.2.3 Transportation cost

The steel and automobile industries are transport-intensive industries, as they produce heavy and voluminous goods, and almost 30% of all finished steel products travel from one country to another worldwide. Given the importance and intensity of logistics and transportation, these costs yield on average 5 to 15% of the final selling price of the product. (30)

Means of transport

Freight transport within Europe uses three basic means of transport: rail, road and water. The steel and the automobile industry rely on a mix of these three alternatives of transportation, which vary across countries. According to the European Steel Association, due to the deterioration of rail freight in the EU, the steel sector, which has traditionally been the most important user of rail in Europe, is switching towards a bigger use of road transportation, and to a lesser extent, inland waterways and coastal navigation.

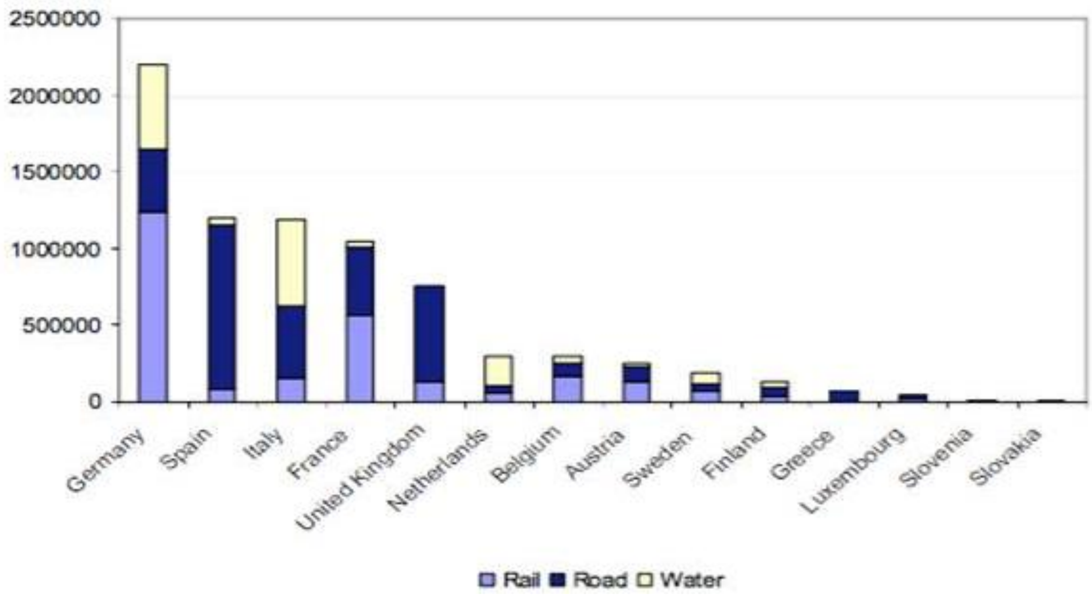

Figure 60. Steel deliveries (metric tonnes) by mode of transport per country - EUROFER

The latest data published by EUROFER reflects a 45% share for road transportation, and 35% and 20% for rail and water transportation respectively (potential air transportation is excluded). As it is clearly observed in the bar graph, the penetration of each of the means of transport varies significantly across European countries: Germany transports more than half of its steel freight through rail, whilst countries such as Spain and United Kingdom transport more than 80% of their deliveries by road. Furthermore, other countries, as is the case of Italy and Netherlands, are highly dependent on water deliveries, given their geography.

Shipping price

One of the most important aspects that conditions whether a certain means of transport is used instead of the other alternatives is its cost.

Supported by a study carried out by the Czech Technical University in Prague Faculty of Transportation Sciences (CTU FTS), an evaluation of the price competiveness of the two main commodities transportation means, rail and road, proves that road transportation is cheaper in every European country that was studied. (32)

The study focuses on prices of a transport route, electricity and diesel fuel, depreciation of vehicles, salaries and handling costs. The result is comparing of shipping costs for carload shipments by road and by rail and the conversion to a comparable unit – ton (t) and ton-kilometre (tkm).

The results of the study compare the unit shipping cost for a particular domestic journey, for a freight of 100 tonnes over a distance of 500 km, and for four variants of transport:

- Variant 1a – The cargo is transported by road in the entire route on toll roads
- Variant 1b – The cargo is transported by road in the main part of the route on toll roads (375 km), and in the marginal parts of the route on toll-free roads (125 km)
- Variant 2 – The cargo is transported by rail in the entire route
- Variant 3 – The cargo is transported by combined transport – by rail in the main part of the route (500km), and by road on toll-free roads in the marginal parts of the route (100 km).

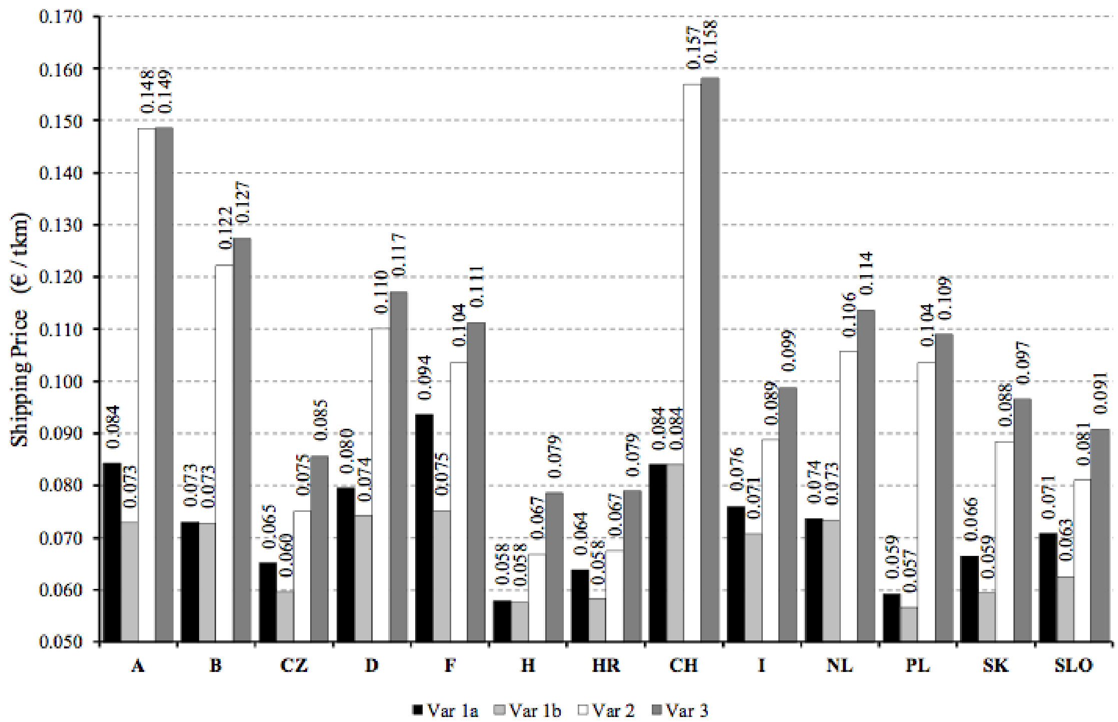

Figure 61. Shipping freight price (€/tkm) per country – CTU FTS

The study clearly points out that for all of the European countries evaluated (in order Austria, Belgium, Czech Republic, Germany, France, Hungary, Croatia, Switzerland, Italy, Netherlands, Poland, Slovakia and Slovenia), the road transportation is in all cases the cheapest alternative, despite travelling on toll roads.

Moreover, it outstands that New Member countries, such as Slovakia, Hungary, Poland and Czech Republic, are the countries with the lowest shipping prices. Due to this reason, the price of transportation from Central Europe often discards potential deliveries to markets outside Europe. On the opposite side, Austria, Belgium, Germany and particularly Switzerland, have the highest shipping prices, especially for rail transportation.

5.3 Adequate workforce

As previously mentioned, finding an adequate workforce is a crucial aspect to optimize a plants footprint and has become one of the biggest challenges which plant management faces. On the one hand, access to talent is becoming increasingly relevant. It is often very difficult to find and retain qualified employees at the new sites and many companies are forced to compete with each other for trained and skilled people. On the other hand, talent shortages within the established network can be a significant threat, which is something all suppliers in established markets are facing.

Besides the adequacy of workforce's skills, suppliers need to leverage the cost advantages of the labour force, particularly in Europe, where it can range from €5 to more than €40 per hour within a 1,000 km radius in Europe. Suppliers need to make sure they get the full benefit of low-cost markets, especially when producing labour-intensive products. (19)

The next section will identify a plants potential labour suitability by means of evaluating the availability, cost and productivity, and education level and skills of the workforce in the different countries, with a special emphasis on Europe.

5.3.1 Labour availability

In order to be able to provide a plant with an adequate workforce it is mandatory to identify and evaluate the supply of automotive workers. According to Oliver Wyman, the most important criteria in plant decision-making is the labour availability, and it is present in 95% of the decisions.

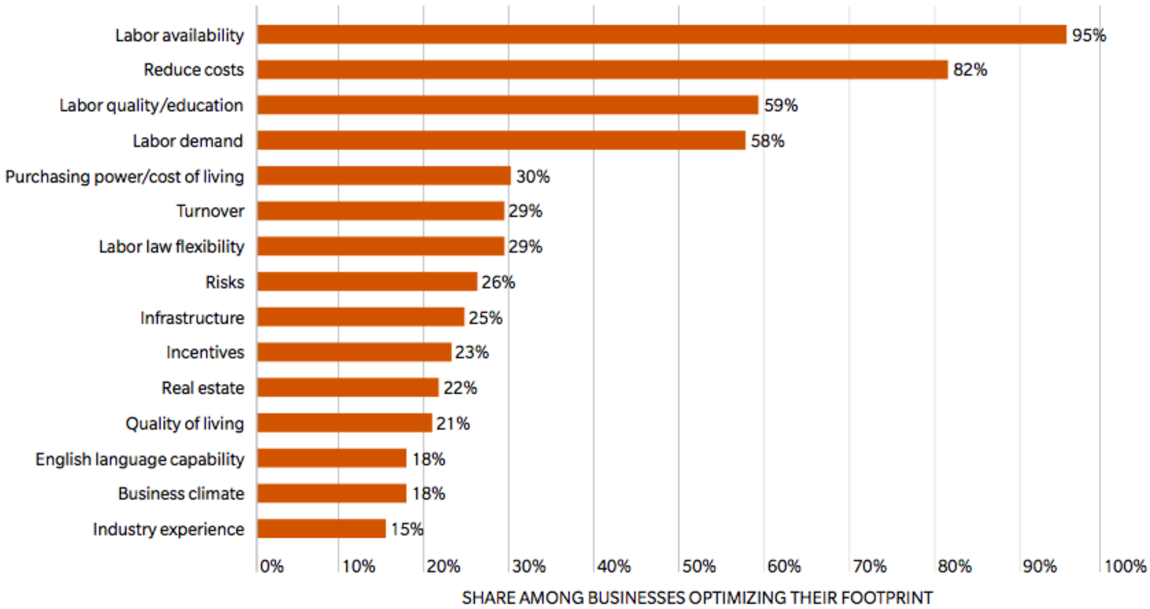

Figure 62. Frequency of appearance in location decision making - Oliver Wyman

A very helpful analysis toward understanding the potential supply a plant could have is to study the macro-economical context of automotive employment globally, with a particular focus on the different European countries. This tool allows to project the importance of the automobile sector in each country, and the size and penetration of the automotive workforce.

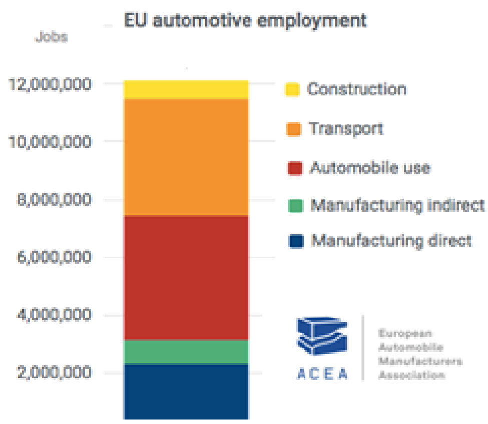

Figure 63. European automotive employment - ACEA

The global auto industry is a key sector of the economy for every major country in the world. According to European Automobile Manufacturers Association's 2015 report, in the European Union, around 12.1 million people work in the automobile sector, which account for 5.6% of the employed population in the area. More precisely, the 3.1 million jobs in automotive manufacturing represent 10.4% of the EU's manufacturing employment. (31)

If the employment is disaggregated by country, it is clearly seen how Germany is the European country with the highest direct manufacturing employment (in units), with more than 800,000 and accounting for 35% of all the direct manufacturing employment in the EU automotive sector. Nevertheless, if we study each country's fraction of direct automotive manufacturing employment per active population, it reflects that two new EU member countries, Czech Republic and Slovakia, have higher ratios than Germany, and hence, automotive sector has a relatively bigger weight in their employment, and may be highly orientated toward the industry.

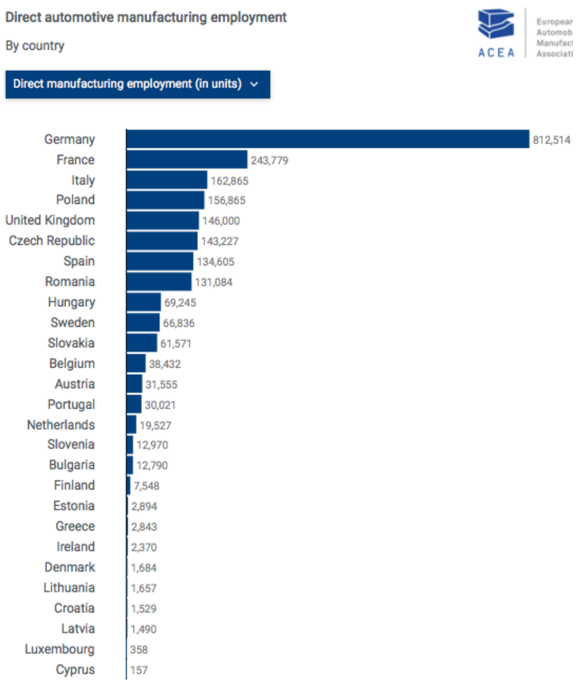

Figure 65. Direct manufacturing employment per country - ACEA

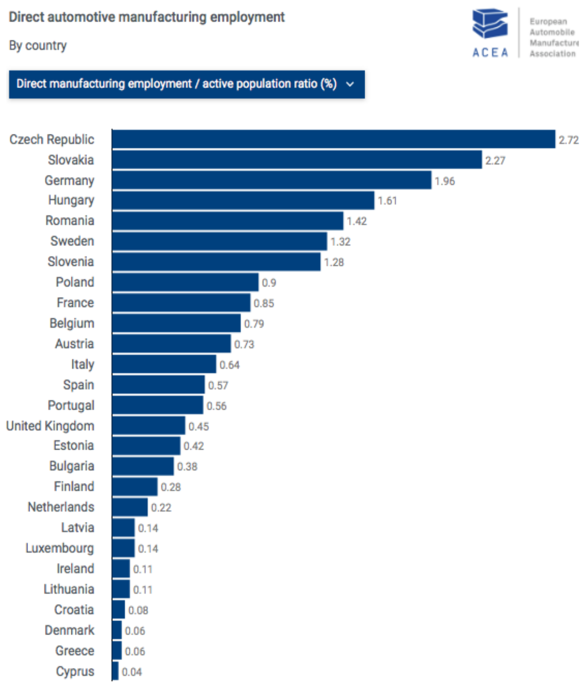

Figure 64. Direct manufacturing employment as % of active population per country - ACEA

5.3.2 Labour cost and productivity

When you run a manufacturing plant in the automotive sector, besides evaluating the employment level and availability in the industry for each country, it is critical to know the salaries/cost of the personnel and their related productivities. These parameters are key in order to estimate future production and cost, and therefore, the plant's profitability.

As previous exhibit illustrate, labour cost is the second most important criteria within location decision making, being relevant in 82% of the decisions. Furthermore, labour cost and location must be deeply studied as salaries can significantly vary within neighbouring countries, especially in Europe.

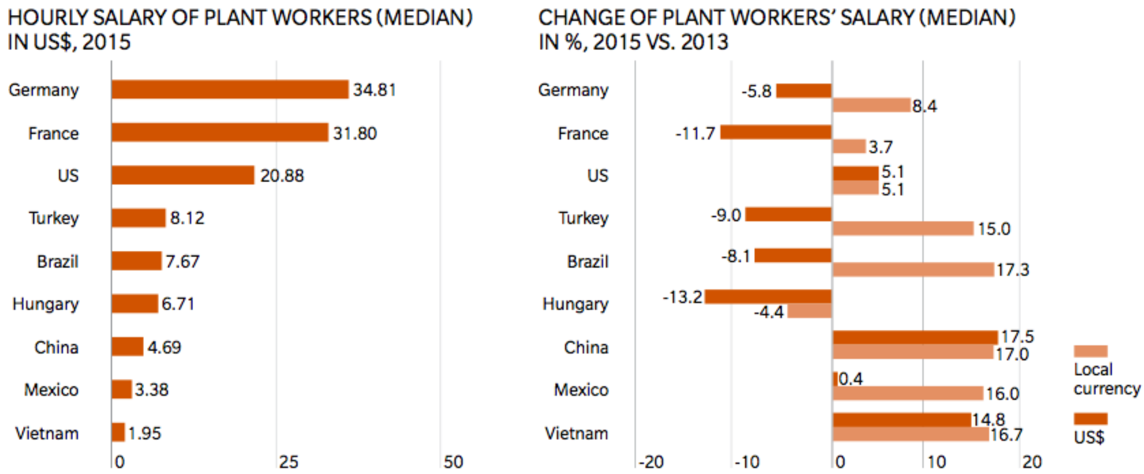

Figure 66. Plant workers salaries - Oliver Wyman

According to Oliver Wyman's report, an average Tier 1 Supplier plant worker has an hourly cost of $35 in Germany, $21 in the US, $8 in Brazil and $5 in China. It is easily spotted how the leading economies with traditional automotive industry such as Western Europe and US have significantly higher salaries compared to emerging economies such as China or Brazil. It is especially meaningful the wage difference between Germany and Hungary, as for countries which are within 200 km, salaries in the first country are more than five times higher compared to the latter. It is also very interesting how some of the lowest paid countries, Vietnam, Chinas and Mexico have experienced important wage increases of around 15-18% during the last two years, and are driving towards Eastern European countries.

The following EUROSTAT benchmarks help to understand the trends for personnel costs in manufacturing industries for the different European countries, as well as the average value added per worker in each country. As the first graph reflects, the highest average personnel costs for manufacturing workers are incurred in Scandinavian countries, Norway and Sweden, with an average annual cost of 65-80 k€. On the opposite side of the graph, new member countries, such as Hungary and Poland, and Eastern countries, Bulgaria and Macedonia offer the lowest annual personnel costs, 4-5 k€, approximately 15 times less than Norway. The average annual personnel cost in manufacturing industries in Spain is 38k€, significantly below countries like Germany and France, where costs surpass 50k€.

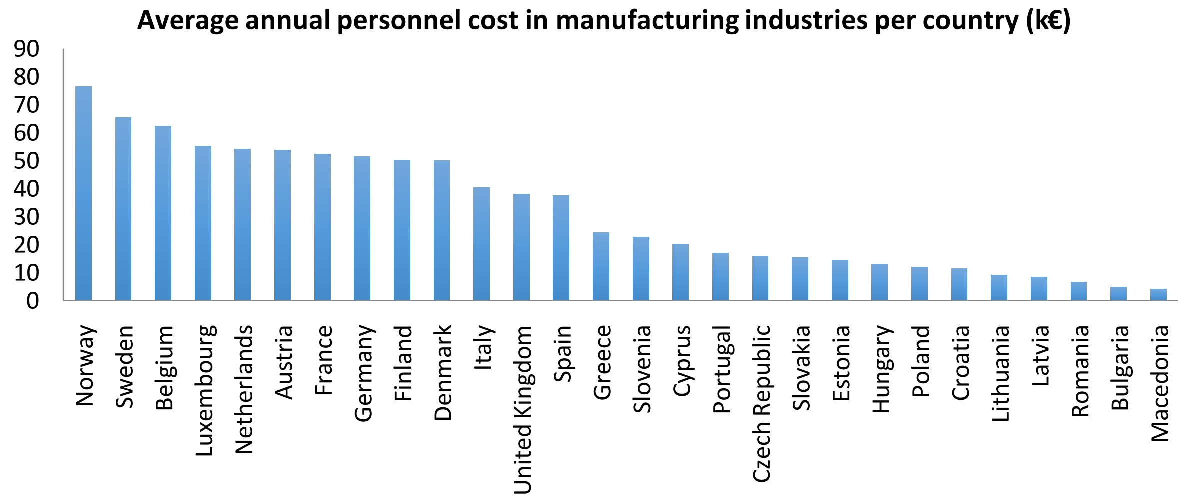

Figure 67. Average annual personnel cost in manufacturing industries per country (k€)

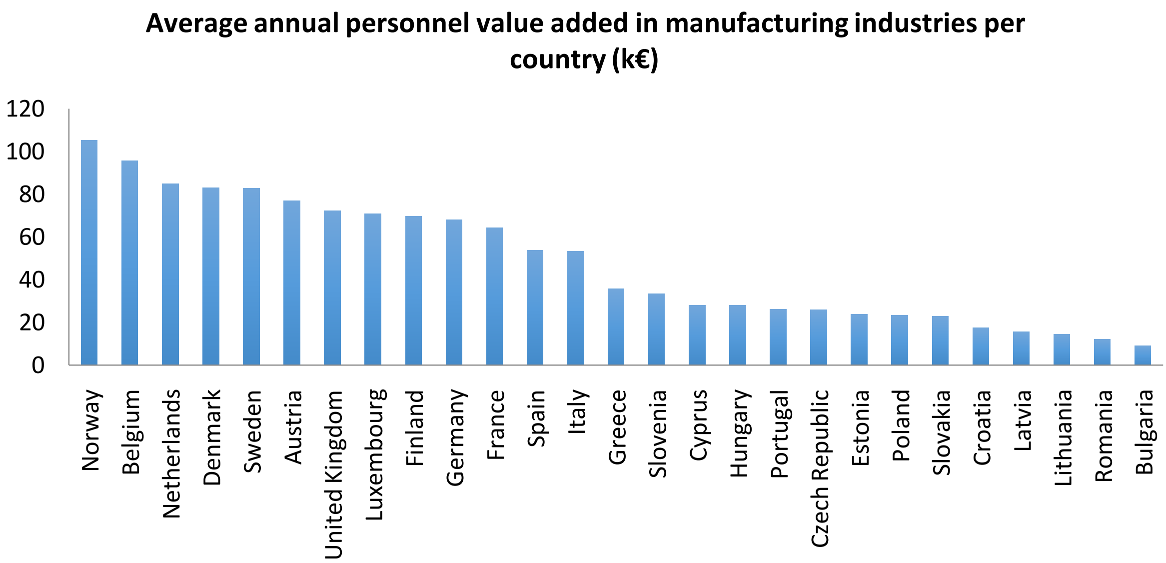

Figure 68. Average annual personnel value added in manufacturing industries per country (k€)

Placing further focus on the value added coming from this personnel cost, it is not strange to see the Scandinavian countries within the countries with highest average value added, and the new member countries and Eastern countries within the lowest. Nevertheless, if a ratio with the two previous graphs is calculated, a very good estimated of labour productivity in manufacturing can be achieved.

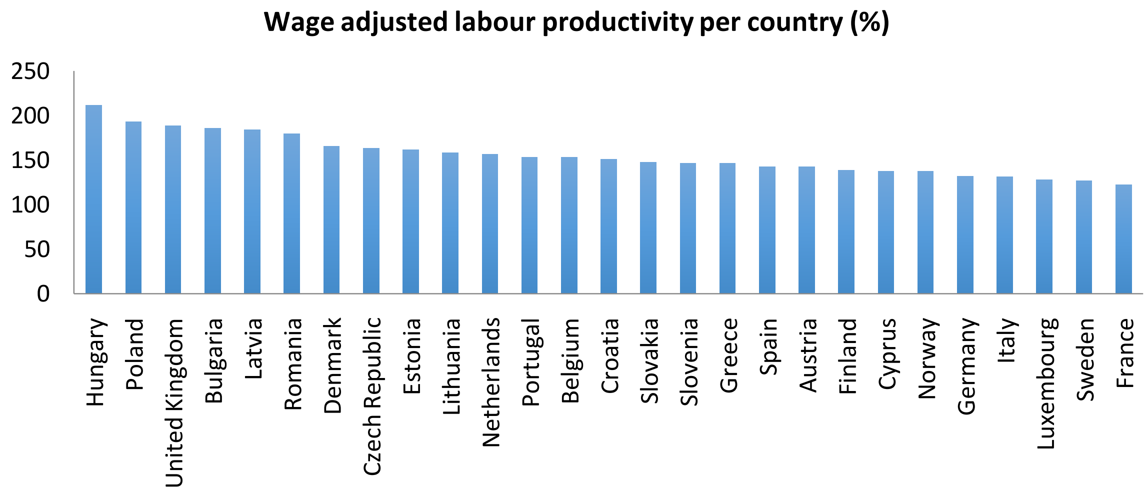

Figure 69. Average wage adjusted labour productivity per country (%)

If a deep insight is taken into the chart above, it highlights how the two highest wage adjusted labour productivities belong to two new member countries, Hungary and Poland. Due to the low cost of their personnel, and the previously observed high penetration of the automobile industry in these countries, every euro spent in personnel wages is more profitable than in any other countries. More precisely, this proves that for every euro spent in personnel, the value added doubles. Other countries considered low cost, such as Eastern countries and ex soviet republics achieve very good productivities. On the opposite side, Sweden and France, due to high cost of their personnel, achieve the lowest productivity values, as they only multiply the value of their cost by 1.2. Spain's wage adjusted labour productivity is around average values, as an average manufacturing worker multiplies the value of its cost by 1.4.

This analysis can therefore conclude that if we isolate productivity, it could be more profitable to locate a plant in new member countries, than in traditional automotive countries such as France, Germany or Italy. Although the average value added per employee in the first countries is low, the low personnel cost allows to have both a bigger workforce and higher wage adjusted productivities, hence, making the plant more profitable.

5.3.3 Labour skills and education

Besides the productivity and cost of the workforce, a very important aspect to consider is the level of education and skills of the personnel employed. Most jobs in the automotive industry are for skilled manual workers, although the structure of jobs is tending to change over time, with an increasing number being created for engineers and other professionals as a reflection of technological advance and the changing organization of the production process.

Labour skills

Overall, in 2016, therefore, just below 55% of the workforce in the industry in the EU were skilled manual workers, whilst it was almost 65% in 1995. By contrast, around 20% of the workforce was engineers, up from 10% in 1995, a rise of almost 100% over this 20-year period. At the same time, the proportion of other professionals (in accountancy, marketing, human resources...) and managerial positions remained relatively flat. (32)

Assuming that an engineer may add more value to the final product than a manual skilled worker, a shift of the employment from the latter to the first means the industry is tending to add increasing value during these last 20 years.

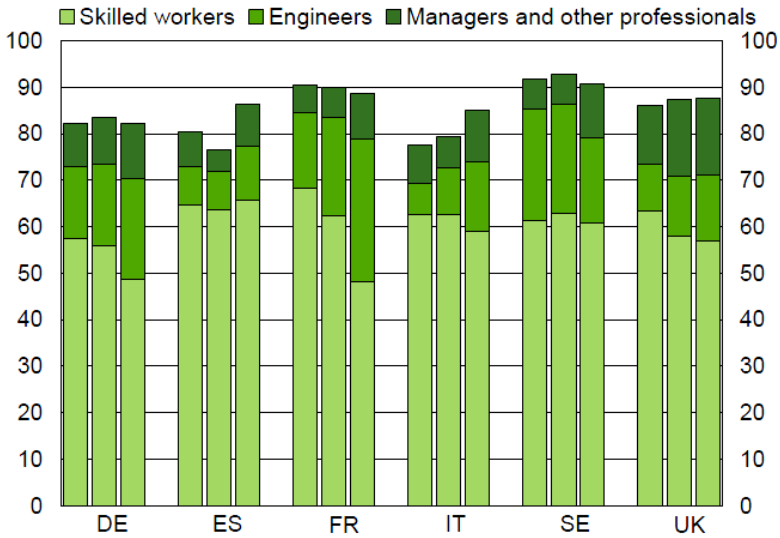

Figure 70. Employment in the automotive industry by occupation per EU country (1995-2006-2016) - Alphametrics

If we look at countries individually, out of the member states, currently the highest proportion of skilled labour workers is found in Spain, where they account for 65% of the automotive employment, whereas engineers only represent 10% of it. This percentage is particularly low compared to other European countries, such as France or Germany, where they respectively represent 30 and 20% of the workforce. The big percentage of engineers in these countries is directly related to the average personnel cost and value added per employee, which were mentioned in the workforce section, and exhibits how a higher concentration of engineers, as opposed to skilled workers, can add more value to the final product, and consequently, account for a higher personnel cost.

Regarding managers and other professionals, it is seen that they account for around 10% of the automotive employment, except for UK, where this percentage is particularly high, with almost 20% of the workforce involved in managerial and indirect labour activities.

If we evaluate the evolution of the workforce during the 20 year period, it outstands that most countries follow the same pattern: there has been a reduction of the concentration of skilled workers, contrasting with the rise of engineering profiles. This shift is particularly significant in France and Italy, where the proportion of engineers has doubled. Nevertheless, in Spain, the proportion of skilled workforce rose to become the highest proportion amongst all countries analysed, and Sweden has experienced a decrease in the percentage of engineers of almost a third.

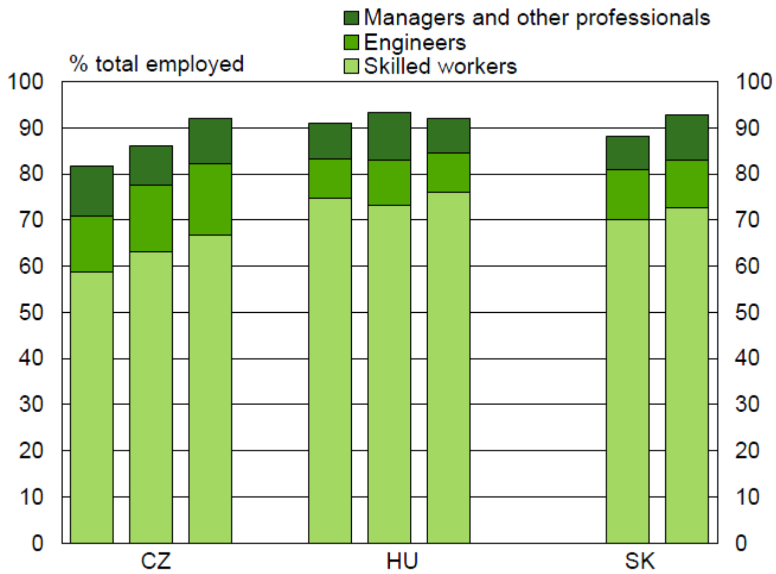

Figure 71. Employment in the automotive industry by occupation for new EU members (1995-2006-2016) - Alphametrics

If a look is taken into the new Member States, the Czech Republic, Hungary and Slovakia, different patterns can be identified. As a general trend, the proportion of skilled manual workers is significantly larger than in the EU15 countries described above. Skilled manual workers, therefore, made up two-thirds of the workforce in the Czech Republic, and over 70% in both Hungary and Slovakia. This high concentration of manual skilled worker explains why average personnel cost in these countries is so law, as well as the average value added, which would increase with higher percentages of engineers.

Furthermore, if we track the evolution of the workforce in the 1995-2016 period, it is reflected that the proportion of skilled manual workers in the industry either increased or remained much the same, as opposing to the evolution in the EU15 countries.

Education level

Reflecting the shift in the structure of occupations in the automotive industry, the proportion of the workforce with tertiary – or university – education has tended to rise over the years. Based on the data comparison for the 2006-2016 period, it is shown that the proportion of workers in the industry with university degrees or the equivalent increased from under 18% to over 25% in the EU. At the same time, the number employed with only basic schooling declined from almost 30% to 20%. (35)

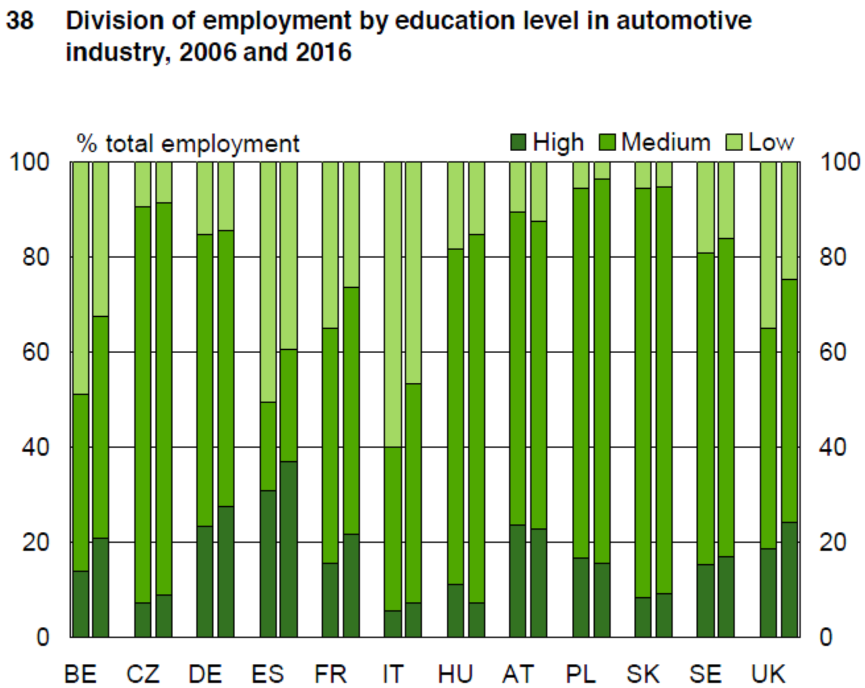

Figure 72. Employment in the automotive industry per education level for European countries (2006-2016)

Studying countries individually, it is remarked that the highest proportion of tertiary education within the workforce is found in Spain, with almost 40% of workers having the highest education. Nevertheless, this covers for the lack of medium education in the country, which the lowest proportion in Europe, just above 20%. The high percentage of low education workers causes average personnel cost and value added in the industry to be lower than other EU15 countries. Germany and France for example, although having an ample base of university workers, heavily dependent on medium education workforce, which represents the highest part of its workers, between 50 to 60%.

Regarding the percentage of worker with low education, Spain and Italy undergo the highest proportion, as more than 40% of its automotive workforce has only basic schooling.

Concerning the New Member States, they all have a very similar division of employment by education level in the automotive industry. Poland, the Czech Republic, Hungary and Slovakia, they all have a workforce mainly made up of medium education workers, accounting for almost

80% of its workforce. Consequently, and compared to the average of other EU15 countries, the percentage of university workers is far lower, under 10% in all cases, standing for the low personnel cost and value added in those countries.

5.3.4 Absenteeism

Perhaps a minor factor regarding the workforce, but that still needs to be taken care of before complety evaluating a potential workforce is the traditional country levels of absenteeism.

Absenteeism refers to the non-presentation by workers at their place of work at a time where their attendance was expected, and is generally attributed to sickness or incapacity. It is a releventant aspect within workforce analysis as absenteeism rates can be above 8% in certain European countries and can therefore have a siginificant impact in expected output, cost and productivity levels.

According to a study by Parent-Thiron et al, absenteeism in Europe ranges from 2% in Romania, to around 9% in Slovenia and Finland. Some trends can be pointed out through the graph below:

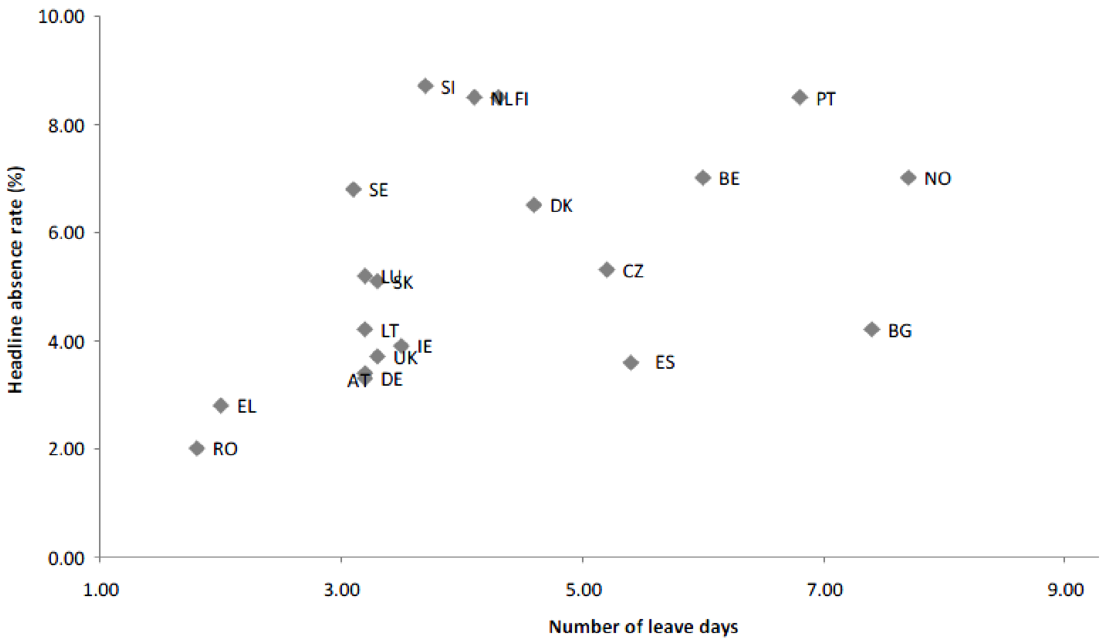

Figure 73. Absence rates in Europe - Parent-Thiron

It is particularly remarkable who the Scandinavian countries, Sweden, Finland and Norway, are all amongst the countries with highest absence rate (more than 6%) because of the generous welfare systems. On the other end of the graph, amongst the countries with lowest absence rate stand central European countries, such as Germany and Austria, and mediterrenean countries like Greece and Spain.

Although some of the factors that condition the absence rate of the workforce are its gender and age, as female and older workforce will tend to have higher risk of absences and sick leaves (33), probably the most significant is the impact of national regulations and absenteeism covering responsabilities. It refers to the responsibility of economically covering an employees absence, and depending on the country, it may be state, the employer or the employee itself. Therefore, this issue direcly affect a plant's personnel cost.

Europe contrasts countries where employers bear the highest cost of time off work, and those where employees are left reliant on whatever social security might still be available. In Germany, Denmark, Austria and Belgium the burden on employers is considerable, when considering one month of sick leave. Elsewhere, including in the UK and Ireland, as well as poorer countries such as Portugal, Italy, Greece and Spain, people may have to rely on the state.

According to a report carried out by The Economist Intelligence Unit, for a sick leave of a month, 100% of the cost is covered by the employer in countries like Austria and Germany, whilst for countries such as Norway and Netherlands, the State is responsible for 50% of the cost, and the employee has no responsibility (34). Due to this situation, German and Austrian employers heavily discourage absenteeim, leading to low absence rates in this countries, whilst Scandinavian employers, with a lower liability rate, are hence more flexible.

In Spain, for a one month absence, the employer must cover almost 40% of the total personnel cost, while the remaining is mainly covered by the employee itself.

It can therefore be concluded, that if a supplier is analysing the potential impact of absenteeism in different countries, they must acknowledge that there is usually a trade-off between the absenteeism level they will be expecting, and the percentage of the personnel cost they will have to cover. This means that if they decide to locate a plant in Scandinavian countries, although they will probably have high absence level, the country government will help to cover the cost incurred, whilst in Central European countries, absence rates will be lower but the plant management will have to cover almost the entire cost.

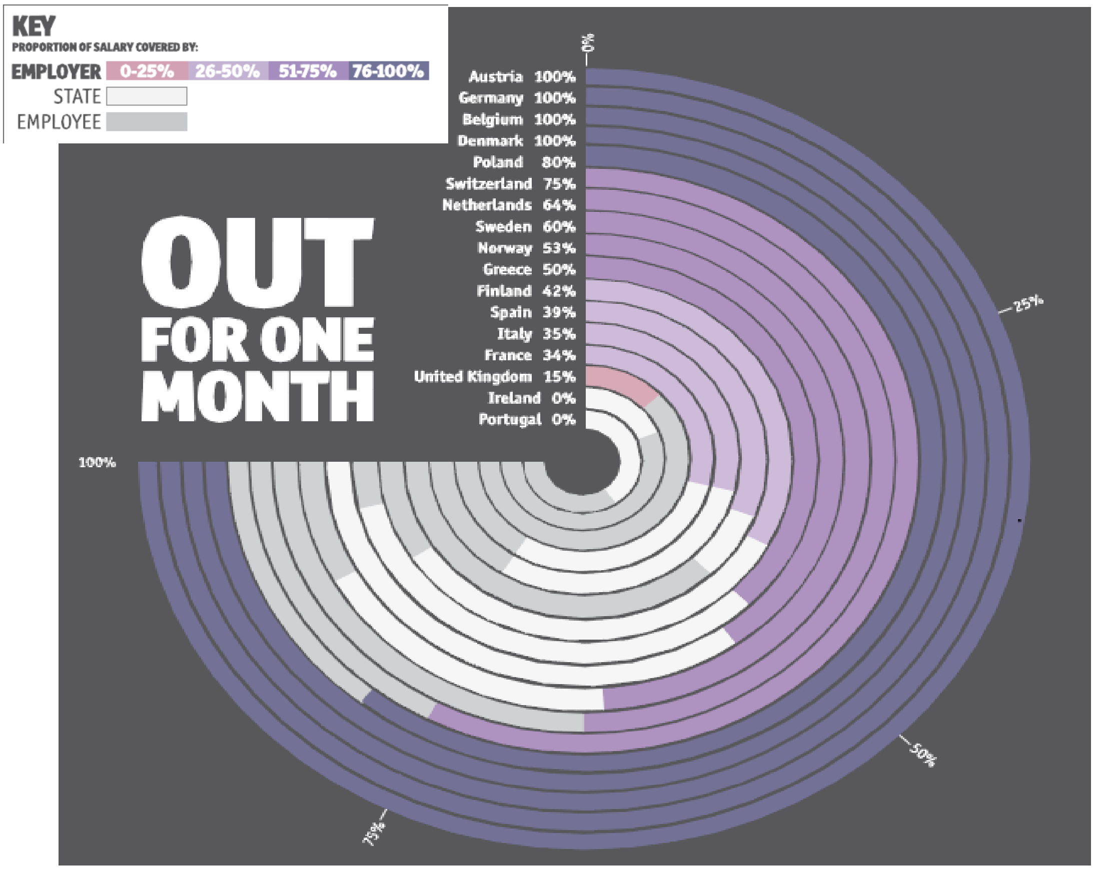

Figure 74. Absenteeism coverage responsibilities per country - The Economist

5.4 Operational efficiency: Overall equipment effectiveness (OEE)

After a plant has been built, with the decided technology developed and in a convenient location, another very important aspect that a plant manager must be able to control once the plant is running is the its operational efficiency. One of the best tools to monitor this efficiency is the overall equipment effectiveness (OEE). It is a crucial metric that indicates how effective machines are running, and therefore, on an aggregated perspective, it can measure how effective the whole plant is.

OEE is very important for plant managers as tracking OEE can help to spot patterns and influences of equipment problems and allows them to see the results of their improvement efforts. Furthermore, an adequate control and monitoring of OEE can lead to the reduction of downtime, repair and quality costs as well as the improvement of labour efficiencies, which together have a clear positive impact in production capacity.

5.4.1 OEE Calculation

OEE quantifies how well a manufacturing unit performs relative to its designed capacity, during the periods when it is scheduled to run. OEE breaks the performance of a manufacturing unit into three separate but measurable components:

- Availability / downtime: a comparison of the potential operating time and the time in which the machine is actually making products.
- Performance / speed : a comparison of the actual output with what the machine should be producing in the same time.
- Quality /defect: a comparison of the number of products made and the number of products that meet the customer's specifications.

When you multiply availability, performance, and quality, you get the overall equipment effectiveness, which is expressed as a percentage. OEE gives a complete picture of the machine's "health"- not just how fast it can make parts, but how much the potential output was limited due to lost availability or poor quality.

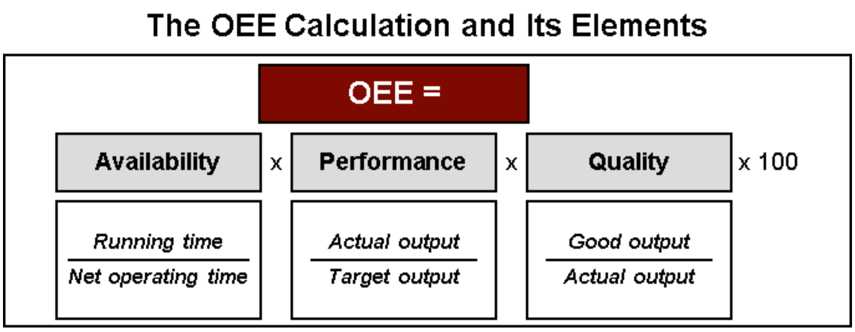

Figure 75. OEE Calculation - A.T. Kearney

OEE loss categories (Down Time Loss, Speed Loss, and Quality Loss) can be further broken down into what is commonly referred to as the Six Big Losses – the most common causes of lost productivity in manufacturing. The Six Big Losses are extremely important because they are nearly universal in application for discrete manufacturing, and they provide a great starting framework for thinking about, identifying, and attacking waste (35):

- Availability/ downtime losses:
    - Breakdowns
    - Setup and adjustments
- Performance/ speed losses:
    - Small stops
    - Slow running
- Quality / defect losses:
    - Startup defects
    - Production defects

Within downtime losses, availability is reduced by equipment failures including tool breakdowns, and the time it takes to setup the machine to run a different product.

Within performance losses, speed losses occur when machines run at speeds slower than they were designed to run, and when minor stoppages occur. Minor stoppages are events that interrupt the production flow without actually making the machine fail, and although they may only last a few seconds, they can add up to big losses at some plants.

Quality losses refer to scrap and rework, which happen when products do not meet customer specifications, and start-up losses, which account for the time it takes machines to reach the right operating conditions at start-up. In the meantime, they produce defective products while operators test for stable output.

Examples of the six types of OEE losses are shown in the table below.

Six Big Losses	OEE Category	Examples
Breakdowns	Down Time Loss	▪ Tooling Failure ▪ Unplanned Maintenance ▪ Overheated Bearing ▪ Motor Failure
Setup and Adjustments	Down Time Loss	▪ Setup/Changeover ▪ Material Shortage ▪ Operator Shortage ▪ Major Adjustment ▪ Warm-Up Time
Small Stops	Speed Loss	▪ Component Jam ▪ Minor Adjustment ▪ Sensor Blocked ▪ Delivery Blocked ▪ Cleaning/Checking
Slow Running	Speed Loss	▪ Incorrect Setting ▪ Equipment Wear ▪ Alignment Problem
Startup Defects	Quality Loss	▪ Scrap ▪ Rework
Production Defects	Quality Loss	▪ Scrap ▪ Rework

Figure 76. Six big OEE losses- Lean Production

Besides OEE, there are two additional metrics that complement OEE and allow to situate plant efficiency in a better context: OAE (Overall Asset Effectiveness) and TEEP (Total Effective Equipment Performance).

Metric	What It Measures	Factors
OEE (Overall Equipment Effectiveness)	How effectively equipment is running when it should be running	Availability Losses (Downtime) Performance Losses (Speed) Acceptance Losses (Quality)
OAE (Overall Asset Effectiveness)	How effectively the plant's management is using its asset capacity	Planned Downtime Losses (Lunch/Breaks, Cleaning, Preventive Maintenance, Training, Team Meetings, Trial Runs)
TEEP (Total Effective Equipment Performance)	How well an organization extracts value from its assets	Shutdown Losses (Time Not Scheduled, No Demand)

Figure 77. OEE, OAE and TEEP - A.T. Kearney

These two measures serve as the starting point to measure aggregated plant efficiency, and allow to analyse factors that are not directly related with the machines themselves, but with the use that the plant management is doing of them. For instance, TEEP would be able to evaluate if the management is extracting value adequately and profitably from machines, being able to fill up the machines capacity, or if the machines are working at low capacities due to scheduled low demands for the assets.

Moreover, OAE helps to detail the adequacy of the machine use by measuring the time the machines must be stopped due to planned downtimes such as lunch breaks, preventive maintenance or team meetings and trainings. Although machines OEE may be very high, an incorrect use of them by the plant management (i.e. low demand scheduled or too long lunch break stops), overall plant effectiveness can be very low and make the plant unprofitable and operationally inefficient. A typical decomposition of a machine's Opening Time is shown below:

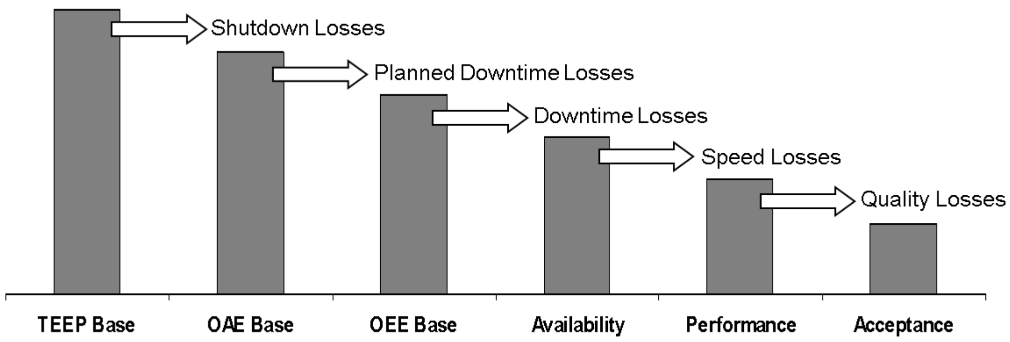

Figure 78. Typical Machine Opening Time Decomposition - A.T. Kearney

5.4.2 Importance of OEE

OEE is very important for plant managers as tracking OEE can help to spot patterns and influences of equipment problems and allows them to see the results of their improvement efforts. More generally, OEE also captures reasons for downtime (due to machine conditions, material status, production personnel or quality issues) and can encompass the entire plant. At the plant level, OEE metrics can be correlated with other plant metrics to provide more KPI's.

Implementing an adequate OEE system brings immediate financial benefits to manufacturing operations. A few major benefits are listed below:

- Reduced Downtime Costs: OEE tracking can avoid potential breakages from machines which would bring downstream operations to a standstill. This would negatively affect delivery commitments to the customer, which consequently impacts cash flow and revenue.

- Reduced Repair Costs: OEE enables predictive maintenance that can considerably reduce repair costs. As the historical database of downtime reasons grows, the maintenance department can discern trends to predict an upcoming failure.
- Increased Labour Efficiencies: Monitoring OEE is very helpful because it not only captures operator downtime reasons, but also productivity data. With this information, management can better judge the proper allocation of resources based on personnel productivity. When the business climate improves, OEE systems could enable managers to identify additional capacity within the existing workforce instead of hiring new labour.
- Reduced Quality Costs: By controlling the quality parameter in OEE, production managers can identify root causes and eliminate further costs associated with rework and scrap. Improving the focus on quality at every stage of production also reduces warranty costs.
- Increased Production Capability: The net effect of reduced machine downtime, higher labour efficiencies and reduced defects is the ability to achieve higher production levels with the same amount of resources.

5.4.3 OEE benchmarks

In general, discrete manufacturing industries seem to have adopted the figure of 85% as being the OEE score that represents what is known as "World Class". For many companies, it is a suitable long term goal. Nevertheless, an OEE score of 60% is the fairly typical/ average value for these manufacturers, indicating that there is substantial room for improvement.

In contrast, an OEE score of 40% is considered a low score, but it not at all uncommon for manufacturing companies that are just starting to track and improve their manufacturing performance.

Figure 79. Benchmark OEE for discrete manufacturers

Besides having a globally shared value for OEE score, there are also World Class Goals for each of the metrics that make up the OEE parameter: Availability, Performance and Quality. (39)

OEE Metric	World Class Value
AVAILABILITY	90.00%
PERFORMANCE	95.00%
QUALITY	99.90%
OEE	85.00%

Figure 80. World class values for OEE metrics - EXOR

It is very important to monitor each of the OEE metric individually. For instance, it would be very different to achieve an OEE goal of 85% with a 95% performance and a 99% quality, than with a 99% performance and a 95% quality, because the second situation would be significantly less desirable.

Although World Class OEE have been set, in practice there is a wide range of variation from industry to industry. While chemical plants have the highest OEE, automotive and packing processes plants have the lowest OEE standards, making comparisons difficult.

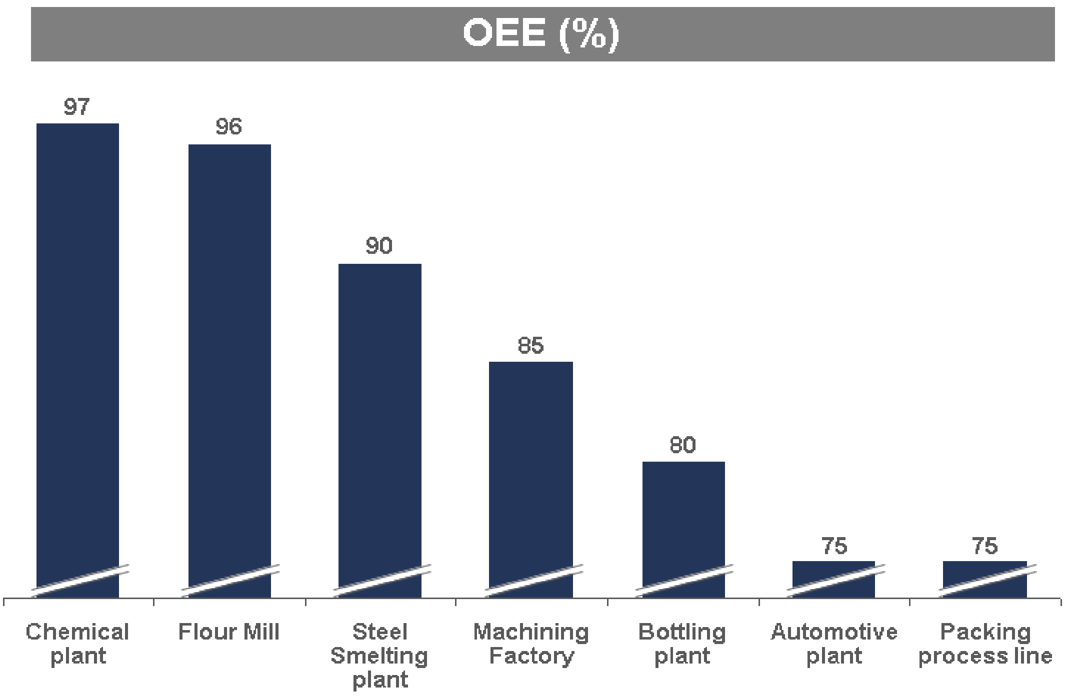

Figure 81. OEE Standard per Industry – Idhamma

5.4.4 OEE in stamping presses

Implementing the above commented OEE procedure in hot stamping lines shows that their OEE is in line with that of discrete manufacturers in the insudtry. The Opening Time decomposition graph below shows how a representative hot stamping line for a Tier 1 supplier of stamped automotive components could look like (A.T. Kearney – Internal Information)

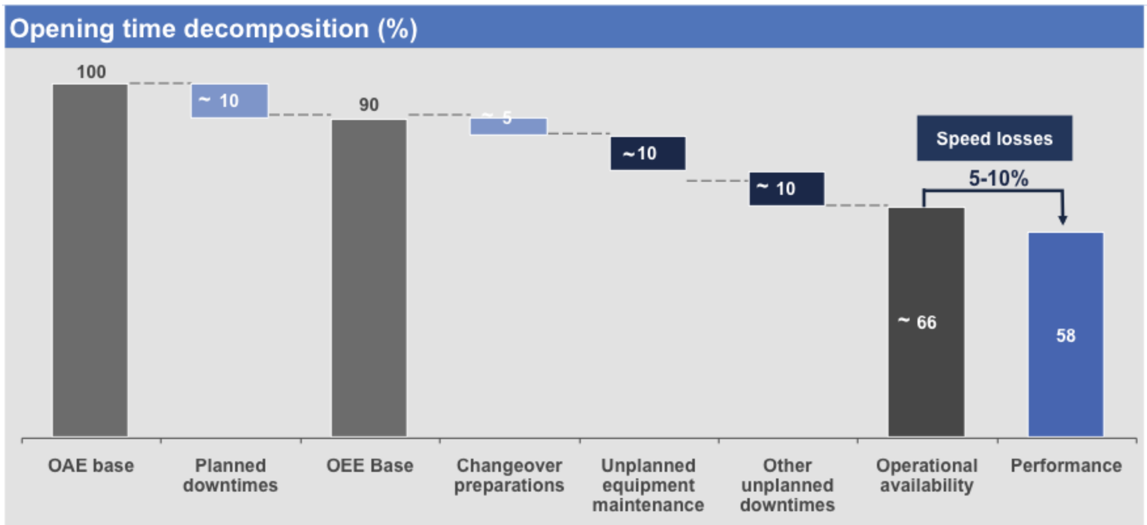

Figure 82. Opening Time decomposition for a representative HS line – A.T. Kearney

As illustrated, from a 100% OAE base, around 10% accounts for planned downtimes losses, around 5% to changeover preparations and 20% for unplanned downtimes. It is relevant to point out that due to the complexity of the machinery in hot stamping industry, unplanned equipment maintenance accounts for a vast majority of unplanned downtimes, vs other possible downtimes such as die or robot downtimes. Furthermore, due to the frequency of minor stoppages and reduced operating speed, speed losses pull down machine effectiveness on average between 5 to 10 pp.

Maintenance in hot stamping is a major issue, as the complication of introducing a heating process prior to stamping adds even more complexity and variability. This concern increases machine downtime loss, with oven breakages accounting for almost 75% of all machine unplanned maintenance.

Besides, if we compare hot stamping lines with other cold stamping machines, it is concluded that hot stamping machines have slightly below average OEE performances and that cold stamping cycle times are significantly shorter, and consequently, cold stamping machines are capable of producing more strokes per hour, and hence, more parts.

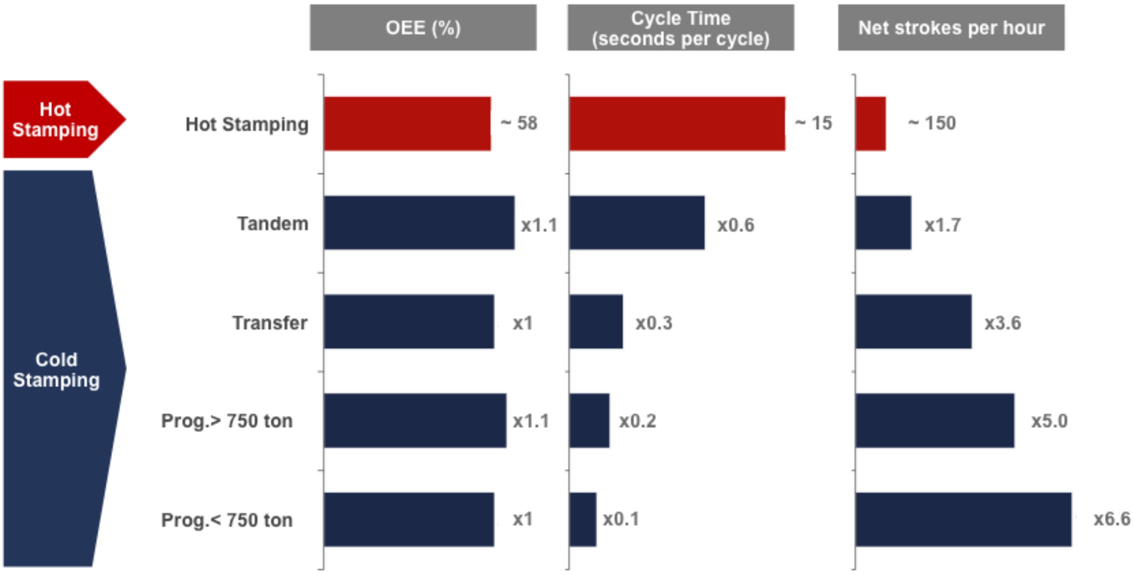

Figure 83. OEE and speed comparison between Hot and Cold Stamping lines – A.T. Kearney

The graphs above (A.T. Kearney – Internal information) bring to light the comparison between machines of a similar age (from 2000 to 2007). It is clearly highlighted that out of the cold stamping machines, progressive presses, especially lighter ones, have the shortest cycle times and the highest net strokes per hour, more than six times higher that hot stamping presses. On the other end of cold stamping presses, the slowest one, tandem presses, are still more than 70% faster than hot stamping presses.

Despite cold stamping lines being faster than hot stamping lines, the improvement in properties, performance and weight reduction of the products manufactured through hot stamping clearly outweigh the additional time and cost which the technology implies.

5.5 Total Productive Maintenance (TPM)

Plant maintenance refers to the methods, strategies, and practices used to keep an industrial factory running efficiently. An adequate maintenance of a plant's assets can significantly reduce the overall operating cost, while boosting the productivity of the plant. Maintenance on plant and equipment is carried out to prevent potential problems arising, to fix existing failures, and to ensure equipment is working effectively.

More precisely, the importance of plant maintenance can be understood by the reduction of equipment breakages, which affect your output planning and lead to loss of production, by the cost reduction due to asset wear out and by the assurance of good product quality. Eliminating defects improves not only quality but all production aspects such as capacity, cycle times, material losses, inventories and delivery times.

Maintenance has been defined as the most basic of all production activities and therefore operators, and employees in general, must become involved in maintenance activities in order to reach excellence in production. High quality products cannot be made unless every operator in the workplace becomes an expert on his/her equipment and knows how to use it to build quality into the process. (36)

The process of involving operators and employees in maintenance activities requires a certain time and framework in order to be successful. One of the best known and most applied framework to achieve plant maintenance excellence is the Total Productive Maintenance philosophy (TPM).

5.5.1 Total Productive Maintenance pillars

Total productive maintenance (TPM) is a complete system for maintenance of equipment that aims at achieving an optimal production environment without defects, downtime, stoppages and accidents. If machine uptime is not predictable and if process capability is not sustained, the organisation cannot produce at the speed of sales. TPM seeks to engage all levels and functions in an organization to maximize the overall effectiveness and productivity of the plant and equipment with minimal investment in maintenance.

TPM has eight pillars that are aimed at proactively achieving reliability of a plant's machines: autonomous maintenance, planned maintenance, quality maintenance, focus equipment improvement, early equipment maintenance, education and training, and health, safety and environment. (37)

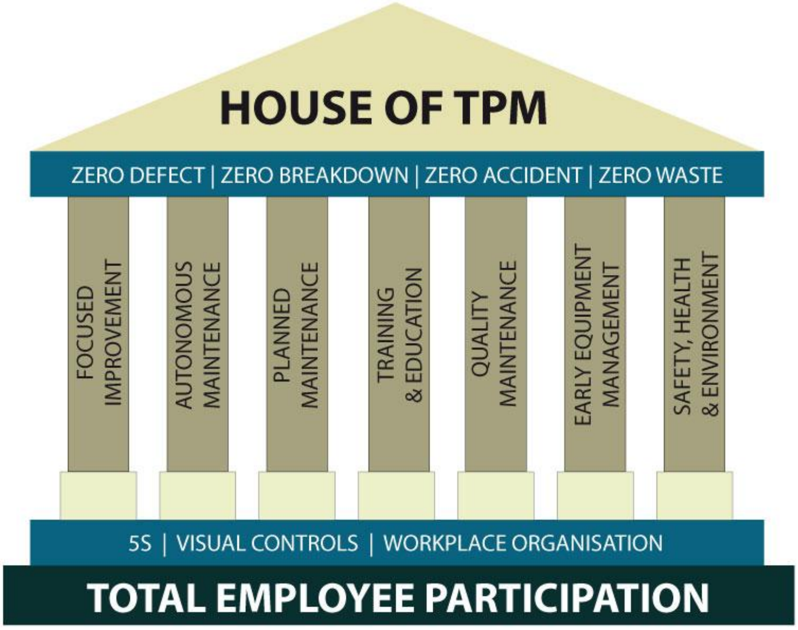

Figure 84. Pillars of TPM – Neville Clarke

<u>Autonomous maintenance:</u>

Autonomous maintenance places the responsibility of basic maintenance activities on the hands of the operators and leaves the maintenance staff with more time to attend to more complex maintenance tasks. Autonomous maintenance has benefits to both the workers and the organization as a whole:

- Operators become more responsible and concerned about the condition of equipment they use on a daily basis
- Skill levels of workers increase as they gain an understanding of the general working of equipment thus achieving the multi-skilling objective of a lean organization
- Machines operate at their optimal level because basic maintenance such as cleaning and lubrication is carried out more regularly
- Problems are identified and corrected before they go out of control leading to major breakdown of equipment.
- Engineering staff are freed-up to carry out higher-level maintenance activities on sensitive and critical equipment thus reducing the overall system downtime

By carrying out the simple activities in this TPM pillar, capital investments are drastically reduced because the organization has reliable equipment and does not have to replace machines as often. This is because the lifespan of machines is drastically increased as forced deterioration is checked through constant monitoring and maintenance.

Planned maintenance:

Planned maintenance is the scheduling of maintenance activities based on observed behaviour of machines such as failure rates and breakdowns. By scheduling these activities around such metrics, the cycle of breakdowns and failure is broken, therefore contributing to a longer service life of machines. The benefits of planned maintenance compared to being reactive maintenance when technical issues arise include:

- By constantly scheduling maintenance activities, the number of breakdowns gradually decrease and this then increases the capacity for productive activities
- Production functions can continue with their activities uninterrupted because they know exactly when maintenance will take place.
- Maintenance is done when the production floor is not very busy
- Capital investments in machinery are reduced as the equipment is utilized to its fullest potential
- Expensive machine parts do not have to be kept in inventory as there is better control of the various categories of parts.

Quality maintenance:

Quality maintenance addresses the issue of quality by ensuring equipment is able to detect and prevent errors during production. By detecting errors, processes become reliable enough to produce the right specification the first time.

Quality maintenance offers a number of advantages including:

- Targeted improvement activities address quality issues that arise from time to time in the workplace by coming up with permanent countermeasures
- Defects are minimized or completely eliminated
- Cost of poor quality is reduced by getting quality right the first time. This happens because errors are caught before they move down the value stream which reduces the amount of rework that has to be done to correct them.

Focus equipment improvement:

Focus equipment improvement, looks to achieve sustained improvement using OEE measurements, which has been previously described in detail. Its activity consists of cross-functional teams measuring equipment- or process-related losses and thinking and generating specific improvement ideas and activities to reduce the losses.

Early equipment maintenance:

Early equipment maintenance uses the experience gathered from previous maintenance improvement activities to ensure that new machinery reaches its optimal performance much early than usual. Using the input from the people who use these machines on a daily basis, suppliers of the equipment can improve the maintainability and operability before the installation of the next iteration of their products.

Working with an ample group of stakeholders, the plant is able to run highly reliable and productive equipment, and at the same time, enjoying an important reduction in maintenance cost.

Education and training:

Education and training looks towards filling the knowledge gap that exists in an organization when it comes to total productive maintenance, and encompasses all levels in the organization. Ensuring that employees are trained gives the organization a reliable pool of knowledgeable staff that can drive the initiative competently.

The technical staff is taught higher level skills such as preventive maintenance and analytical skills to help become more proactive to problem solving. At the managerial level, managers also learn the TPM skills so as to become competent mentors to their juniors as well as be involved in coaching programs.

Health, safety and environment:

The health, safety and environment pillar of total productive maintenance ensures that all workers are provided with an environment that is safe and that all conditions that are harmful to their well-being are eliminated.

This pillar works towards making machines safe to use by the operators by putting in place features as guards, works standards, use of personal protective equipment and first-aid kits in the work-area. Each of these levers are aimed at improving the safety of the machines so as to create a safety environment, improving operators work attitude and therefore, have a more productive work-force.

TPM in office functions:

Finally, TPM in office functions attempts to make the administrative personnel understand and apply the principles of lean in their own operations in order to allow them to provide efficient service to the main value-creating processes. Furthermore, it removes the silo mentality and encourages horizontal cooperation within the workforce.

6. Defining the potential ruthless competitor

6.1 Definition of ruthless competitor

A ruthless competitor is a market player that has been able to implement a strategy that has allowed it to achieve a sustained competitive advantage, and which is therefore, very hard for current or potential competitor to implement and duplicate the benefits of such a strategy. A ruthless competitor has been able to leverage its competitive advantage and foresee what other companies have not, yet developing the ability to cut cost significantly and benefit from such a performance. (38)

Some examples of ruthless competitors in different industries include Southwest Airlines and Wal-Mart. Southwest Airlines has focused its profit-winning strategy in its superior asset utilization. By structuring flight schedules to return planes from the gate to the air in as little as 20 minutes, they fly its planes 20 to 30 percent more hours than other major airlines. Moreover, by deploying a point-to-point route network, instead of the hub-and-spoke model used by most major carriers, they minimize the impact of flight delays and gain maximum use of its assets.

In a different way, Wal-Mart, through the early introduction into rural areas, managed to achieve a continuing competitive advantage and become a ruthless competitor. Its prime geographic footprint, together with its point-of-purchase inventory control system, has allowed them to take full advantage of its rural locations by decreasing the probability of stock outs and by reducing inventory costs. (40)

6.2 Characteristics of a potential ruthless competitor in the stamping industry

As previously commented, the stamping sector is a competition intense industry dominated by few players who have achieved leadership through global coverage and breath of capabilities. The players in the market are currently very focused in developing lightweight products, which are cost effective and meet safety and environmental regulations.

Besides, the chassis and BIW suppliers may undergo significant threats which could impact the profitability levels that they have been achieving in the past. Amongst these challenges, the most significant are the increase of production complexity, lead by a higher integration of suppliers within OEMs' value chains, and the intensification of market competition dragged by the globalization and shift towards emerging markets and the downstream expansion of raw material providers.

In order to withstand the onslaught of such situation, chassis and BIW suppliers should not only use their abilities to see these threats coming, but should try to become ruthless competitors.

Some of the hallmarks that a ruthless competitor in the chassis and BIW supplier industry should present are shown in the figure below:

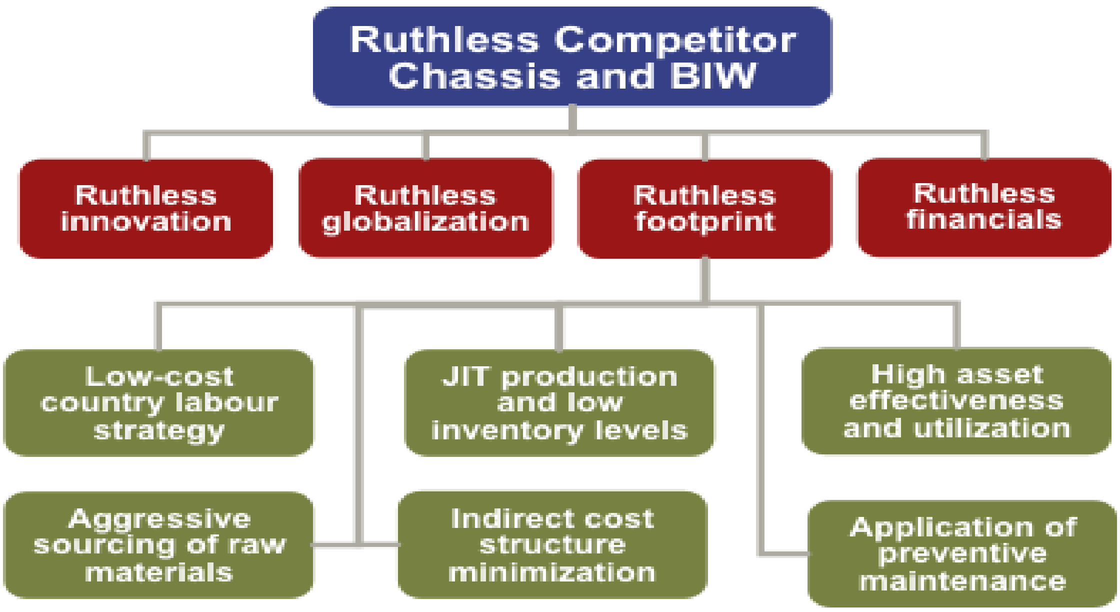

Figure 85. Hallmarks for a ruthless competitor in the chassis and BIW industry- A.T. Kearney

A player in the chassis and BIW industry should try to become a ruthless competitor by means of a ruthless innovation, ruthless globalization, ruthless performance and/or ruthless footprint. Although briefly describing some of the potential drivers towards achieving the first three hallmarks, emphasis in the next chapter is going to be placed on the levers that could potential allow a player to develop a ruthless footprint.

As already mentioned, the vehicle material mix in the automotive industry is increasingly turning from mild and cold stamping steel to high strength and hot stamped steel, as well as towards aluminium and composites. The greatest challenge on these alternatives remains on the high manufacturing cost they imply. Nevertheless, developing innovative and cost effective R&D and manufacturing capabilities that would allow to early adapt to these future alternatives would bring significantly benefits and would definitely be a source of sustained competitive advantage.

Besides, the global light vehicle production is rapidly shifting towards emerging markets and Asia will in the short run account for more than 40% of the production. Despite this fact, many chassis and BIW suppliers have a very weak presence in these markets, as they have more than 75% of their geographical share position in consolidated markets such as Europe and North America, where the overcapacity doesn’t allow for significant growth. For this reason, if players are able to rapidly and efficiently shift their geographical share toward emerging markets, and settle close to OEM future production, they could achieve higher sales and profit growth than their competitors, while drastically reducing costs, and become a ruthless competitor.

Furthermore, being able to maintain healthy financials, with appropriate leverage ratios and appealing profitability and activity ratios, can become a very useful driver in order to attract investors and access low cost capital. EBITDA margins above the previously described average amongst the biggest players in the sector of 10%, as well as a stable Return on Capital Employed (ROCE) of 15% would definitely allow to achieve extra capital easily and business expansion.

6.3 Ruthless footprint

Given the pressure placed on cost, efficiency and operational excellence in the automotive industry, one of the most important areas where a ruthless competitor could outstand from its peers is in its footprint decisions.

Although it is impossible to comply with the following competitive advantage drivers simultaneously, some of the typical attributes that a potential ruthless competitor in the chassis and BIW industry should cover are detailed below.

Low-cost country labour strategy:

Plant workers' salary varies significantly around the world. Setting up a facility in a low-cost country such as emerging markets could drastically reduce personnel cost and become an immediate source of advantage. As previously reflected, automotive plant workers salary in Vietnam for instance is below $2 / hour versus $35 in Germany, barely accounting for 6% of the latter.

Although sometimes a supplier facility's location is strongly linked to the OEM assembly plant, salary differences amongst bordering countries could also be significant, as it the case of Czech Republic and Germany, where the salaries in the first country represent a 30% compared to the latter.

This clearly proves that if a competitor is able to have a low-cost labour without severely hindering other potential benefits such as distance to OEM, it will easily achieve a competitive advantage which could make it a ruthless competitor. Furthermore, although labour from low-cost countries may imply lower productivities and lower employee education, the difference in personnel costs usually offsets this personnel quality gap.

High asset effectiveness and utilization:

If a supplier's stamping facility is able to achieve higher asset effectiveness than its peers it means it is being more productive and hence, can deliver the product orders faster and at a lower cost. In this sense and within hot stamping industries, if a player is able to have an OEE above 65% and scrap rates below 2%, it would have the capacity of delivery pieces at an above average rate, with excellent quality performances, and should have achieved a situation where it is significantly more competitive than its peers.

Moreover, if asset effectiveness is high, production rates and volumes can be estimated more easily, and plant management could more precisely match demand to supply capacity. This would mean a better asset utilization, which would reduce unit cost per piece, acquiring an additional competitive advantage.

Common ways of achieving high asset effectiveness come through the application of lean manufacturing and appropriate maintenance strategies.

JIT production and low inventory levels:

As previously explained, OEMs are increasing the value added by suppliers in their value chain and increasingly incorporating suppliers' operations into their own. OEMs are tending towards manufacturing strategies of Just in Time production (JIT) and hence the integration and distance to suppliers has become critical.

Therefore, a short distance to OEMs would not only mean low logistics and transportation costs, but allows for a better implementation of JIT production. This requirement makes the integration and distance between suppliers and raw material producers another key aspect. JIT production can have immediate benefits in resource utilization and inventory levels reduction. A competitor that is able to minimize their outbound and inbound inventory and maximize its finished good and raw material turns, (respectively above 100 and 50 in manufacturing industries) could obtain a substantial cost reduction and competitive advantage.

Aggressive sourcing of raw materials:

Raw material cost accounts for a significant portion of total costs in the automotive industry, approximately between 50 and 60% of total production cost in stamping. A competitor that due to is size, location, positioning or visibility and control over the supply chain, can negotiate better prices for raw material can hence, have a major opportunity to become a ruthless competitor.

Besides, if a player effectively captures the value of material scrap in the part price, it may face a good chance of obtaining an important cost advantage, as up to 30% of input steel is unused and considered waste. (39)

Application of preventive maintenance:

If a chassis and BIW supplier efficiently applies total productive maintenance and lean tools it will definitely have an improved asset effectiveness and a reduction in the maintenance cost. The application of preventive maintenance is especially important in the hot stamping industry, as it can improve OEE up to 5pp, as the time for unplanned equipment maintenance and other downtimes drastically reduces, as well as the improvement of quality and speed performances.

Furthermore, a preventive behaviour as compared to a reactive one, significantly reduces the cost of maintenance. Regarding manufacturing facilities, maintenance cost can be reduced to 5% of asset replacement costs, which compared to an average of 10%, may become an advantage for a ruthless competitor.

7. Modelling of competitiveness success factors through a case study

In order to quantify the identified success factor that define the competitiveness of a hot stamping Tier 1 supplier's plant and determine their potential cost impact, a cost model has been designed and developed. The model, moreover, will be very useful to analyze the cost sensitivity to these success factors and to identify levers of improvement and their cost reduction potential. All the information and numerical input that has been used has been found publicly available or fictional values have been considered.

7.1 Definition of the case study

The case study that has been used to model the influence of the competitiveness success factors previously identified and that could allow a competitor to become a ruthless competitor is represented in the image below.

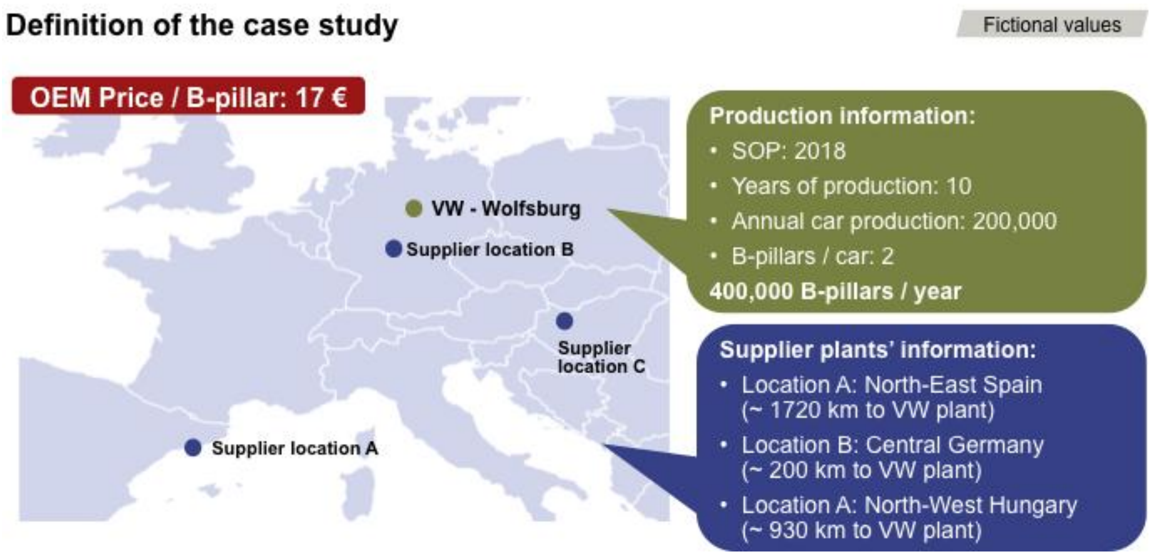

Figure 86. Case study definition

A Tier 1 BIW supplier has been awarded the contract to manufacture the right and left hot-stamped B-pillars for the production of a car model, in this case, the VW Golf, for a price of 17 € per component. This assembly will take place in the OEM's plant in Wolfsburg (Germany), beginning in 2018 and lasting 10 years, with an average annual car production of 200,000 cars. Given that each car contains two B-pillars, the total B-pillar production accounts for 400,000 pieces per year.

As it is reflected in the image, the Tier 1 BIW supplier has the capacity to deliver this contract from three European plants: Plant A in North-East of Spain, situated 1720 km away from the assembly plant; Plant B in the centre of Germany, situated barely at 200 km away from the OEM; and Plant C in North-West of Hungary, 930 km away from Wolfsburg. Given this initial situation, the proximity to the OEM and the potential coordination and JIT advantages that could be developed, suggests that the B-pillar manufacturing should take place at Plant B. Nevertheless, a study and comparison of current competitiveness and cost performance and the profitability of the project in each of the plants should be carried out.

The actual performance parameters and features of each plant are listed below:

Plant A:

Figure 87. Plant A (Spain)

Plant A in Spain, is one of the supplier's best performing plants, presenting an average 63% OEE in hot stamping with very high quality standards (2% scrap rate). Furthermore, it has set in place effective preventive maintenance techniques, responsible of such a good performance, and that have significantly reduced the cost of maintenance in the hot stamping lines. Regarding personnel, the plant has slightly below average salaries compared to the overall supplier network, in line with production in a South European country. This low personnel cost trades off with below average productivities and above average overhead rates, approximately requiring 55% indirect workers per every direct worker.

Plant B:

Figure 88. Plant B (Germany)

Plant B in Germany is currently amongst the worst performing plant in hot stamping across the BIW supplier's plant network. Its poor maintenance performance has pushed the hot stamping OEE down (54%) and the quality standards have diminished (4% scrap rate). The situation is further inconvenient given the high cost of German labour. Nevertheless, the plant counts with a well-prepared German workforce, with an education that could lead to productivities above average and overhead rated below average (45%), hence reducing the cost disadvantage.

Plant C:

Figure 89. Plant C (Hungary)

Plant C in Hungary is a well performing plant in all its manufacturing activities, including hot stamping. The plant has partially introduced total productive maintenance techniques, and this is reflected on good OEE ratios (59% for hot stamping) and average quality standards (3% scrap rate). Besides, the most significant advantage for the plant is the personnel cost. Given that it is in one of the New Member State, labour is very cheap compared to plants in other European countries. Nevertheless, this effect is slightly hindered with below average productivities and above average overhead rates, which require hiring a larger number of employees.

7.2 Description of the cost model

As commented in previous headings, an Excel model has been designed in order to quantify the influence that some of the success factors can have on a plant's competitiveness. For this case study, the plant competitiveness will be given by the unitary B-pillar manufacturing cost that each of the three plants may offer.

The cost of manufacturing the B-pillars has been divided into three categories: raw materials costs, production costs and outbound freight costs. The parameters that will serve as input variables for the model and will determine how big each of these three costs is are stated below. Moreover, a learning curve has been added to the model in order to reflect how each plant is able to set up the ramp-up of production, how long do they take and what additional cost will it represent. Some of the input variables that change across plants and their values, which will then be discussed about, are attached below.

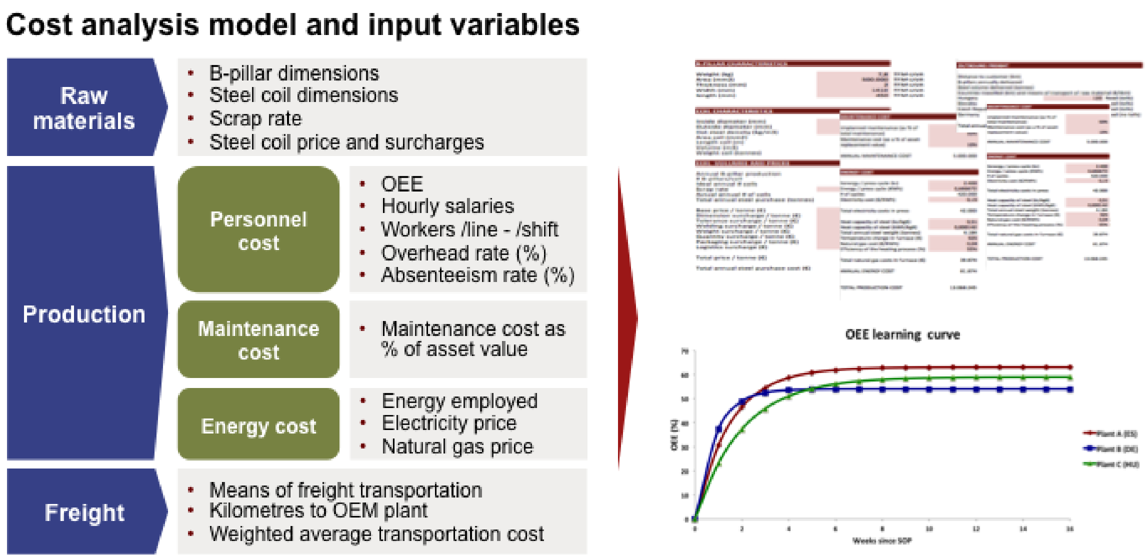

Figure 90. Model structure

Input variables

Publicly available / fictional values

		Plant A(ES)	Plant B (DE)	Plant C (HU)
Raw materials	Scrap rate	2%	4%	3%
		50 € (~50 km)	75 € (~100 km)	100 €(~200 km)
Production	OEE	63%	54%	59%
	Number of shifts	3	4	3
	Line workers / shift	9	8	12
	Line workers' hourly salary	20 €	31 €	10 €
	Indirect/direct labour headcount ratio	55%	45%	65%
	Indirect workers' salary	26 €	40 €	15 €
	Absenteeism rate (%)	5,0%	3,2%	1,3%
	Maintenance cost as % of asset value	6%	13%	9%
	Electricity cost (€/KWh)	0,12 €	0,15 €	0,09 €
	Natural gas cost (€/KWh)	0,038 €	0,040€	0,039 €
Freight	Means of transport	Road (tolls)[1]	Road + Train	Road (tolls)[1]
	Distance to OEM's plant	~ 1720 km	~ 200 km	~ 930 km
	Weighted average transportation cost (€/tkm)	0,086 €	0,117 €	0,067 €
Working capital	Weeks sales of inventory	1,5	0,5	1

Figure 91. Input variables which change across plants

7.2.1 Raw materials costs

Raw materials are a very significant cost in the production of such a body component like a B-pillar, normally representing around 50-60% of the cost, given that a lot of steel is needed to produce such a high number of pieces. In order to calculate how many steel coils are required, some of the input variables are the dimensions of the B-pillar (length, width, thickness…) and the dimensions of the coil.

The dimensions of the B-pillar are determined by the OEM, and for this case scenario, they will be taken from publicly available information found online. (23) (42)

Therefore, the three plants would be manufacturing the same B-pillar with the following dimensions:

- Length: 1.410 mm
- Width: 450 mm
- Thickness: 2 mm

As it can be observed in the figure below, the length and thickness of the B-pillar will determine the width and thickness of the coil, which will be 1.410 mm and 2mm respectively. The other coil parameters, such as inside and outside coil diameters, are chosen by the suppliers overall corporation team from a set of coil dimension ranges offered by the steel supplier, in this case ThyssenKrupp, and will be the same for the three plants. The diameters chosen are 800 and 1.500 mm respectively. (43)

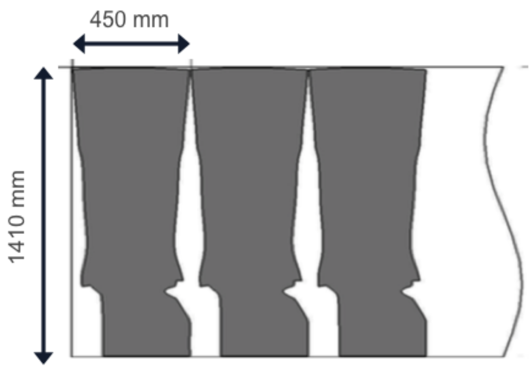

Figure 93. B-Pillar dimensions

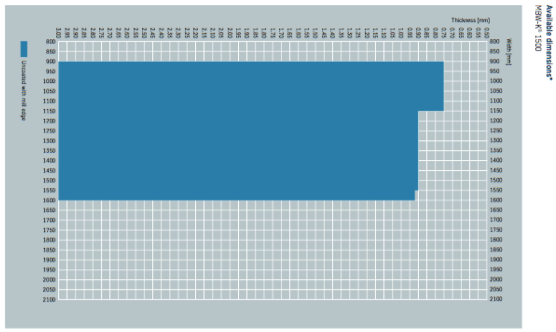

Figure 92. ThyssenKrupp hot stamping steel coils dimensions offer

If both the coil and B-pillar dimensions are known, the number of B-pillars that can be manufactured with a single coil can be calculated. As both parameters are the same for all plants, this would turn out to be the same. Nevertheless, the other variable that must be taken into account is the scrap rate, which determines how many of the manufactured pieces aren't good enough to be delivered to the customer. This parameter varies across plants, and hence, the higher a plant's scrap rate, the bigger the number of steel coils it will have to buy.

Once the number of annual steel coils that each of the plants would have to buy is determined, the next step would be to estimate the price at which they will buy this steel. Currently, the supplier management is in control of the steel purchases and has a partially agreed price with the steel supplier. The price of steel is split as followed (13):

- Base price / ton (€): 500
- Dimension surcharge / ton (€): 50
- Tolerance surcharge / ton (€): 15
- Welding surcharge / ton (€): 15
- Weight surcharge / ton (€): 20
- Quantity surcharge / ton (€): 10
- Packaging surcharge / ton (€): 10
- Logistics surcharge / ton (€): 50 - 100

As it is observed, both the base price per ton as all other surcharges are already fixed with the supplier and hence, uniform across plants. Nevertheless, the single surcharge that may differ amongst plants is the logistics surcharges, which is varies (within a given range) as a function of the distance to the steel supplier plant: the close the plant is to one of the steel supplier's plant, the lower the logistics surcharge.

7.2.2 Production costs

As it is reasonable to expect, the cost of production is very significant to determine the total cost of manufacturing a car component, and the cost performance can vary widely across plants. For this exercise, production costs will encompass the personnel involved in the production, the maintenance costs of the assets in the line and the energy needed for production.

<u>Personnel costs:</u>

Although the automotive industry is a capital intense industry, the number and cost of the workers that are involved in a production line represent a significant amount of the overall production cost, and can vary significantly across different plants.

In order to quantify the personnel cost for a given production line, the starting point should be the expected OEE ratio. The potential OEE for the line in each plant will be assumed to be the OEE that is currently being performed in hot stamping in each plant. With an expected line OEE and an expected cycle time per B-pillar of 29 seconds (40), you can estimate the number of machine working hours needed.

The amount of machine ours needed represents the time that the line must be opened and running and defines what the number of shifts should be. Normally, lines may be running 3 shifts (three 8-hour shifts per day during weekdays) or 4 shifts (which represent an extra 12-hour shift on Saturday and Sunday).

On the basis of the average productivity and value added per employee in each plant, it is possible to estimate the number of line workers needed in the line per shift. As it was reflected in previous chapters, value added per employee tends to be higher in Northern European countries and lower in New Member States. To this number, the effect of absenteeism should also be taken into account, as the number of employees will increase slightly. Besides direct line workers, the production in the line also needs a series of indirect workers that account for the work needed regarding maintenance, logistics, planning… The proportion of indirect workers per direct workers is defined as the labour overhead rate and varies across plants. It is preferable to have low overhead rates as this reduces the number of employees required. As in line with productivities, this rate tends to be more efficient in North Europe and higher in Mediterranean and East European countries.

In order to calculate total personnel cost, the size of the workforce previously estimated must be multiplied by their salaries. This is very relevant as salaries are very different from one plant to another, and result in big personnel cost differences. As a general rule, indirect personnel have, on average, higher salaries than direct line workers.

Maintenance costs:

Maintenance is a critical parameter within the production in a stamping line. On previous headings, important features such as Total Productive Maintenance and preventive maintenance have been introduced. It is very clear that the further these features are implemented in a production line, the better the line will be running, with reduced maintenance costs and improved OEE rates. On the basis of how implemented these features are and what is the traditional cost of maintenance as a percentage of the replacement value of the assets involved in production in each of the plants, the expected maintenance cost in each location has been estimated.

As it has already been commented and is reflected on the following figure, unplanned maintenance heavily affects final OEE rates. While planned maintenance proves to have big cost and production benefits, unplanned machine and die maintenance account for the highest downtimes and severely hinder potential performances.

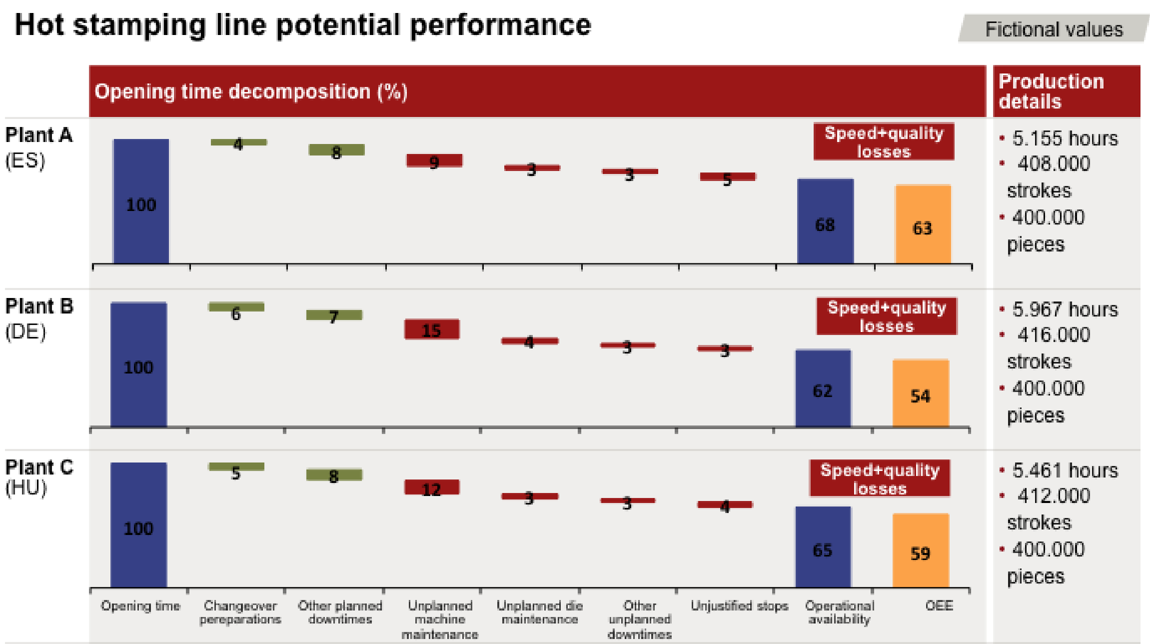

Figure 94. Potential OEE performances in the different locations

Energy cost:

Energy and utilities, although not amongst the highest cost in manufacturing, is also an important component that should not be ignored. Within a stamping production line, the highest energy usage accounts for the electricity consumption in the press, laser station and handling robots, which together approximately account for a power of 300 kW. Furthermore, the other most important energy consumption is the natural gas at the furnace. The furnace is used daily to heat a vast amount of steel up to austenization temperatures, and hence the daily volume of gas employed is very significant.

Regarding the cost of this energy, the model calculates the average energy needed for one line cycle (kWh), and multiplies it by the potential number of cycles per year in each plant. Although the price of electricity and natural gas may slightly vary across countries, as detailed throughout the project, no big cost differences are induced by prices. Rather, the major energy cost differences are stimulated by higher scrap rates, as they determine how many extra unnecessary pieces must be produced, and hence, implying extra heating, cooling, pressing and laser activities.

Learning curve:

A learning curve in a production line represents the improvement in accuracy and skills gained toward achieving the expected and steady state OEE performance. It takes plant during the ramp-up stage and it is a measure of the sophistication of the plant and the education and skills of the workers. On the basis of these parameters, the learning curve may be steeper in one plant as compared to another, and the improvement towards stable production may be faster.

An important impact of the learning curve stage is the additional machine and personnel hours that are incurred during the ramp-up, and which are taken into account in the model. During these months, output of production and OEE are not as high as they are intended to be, and this must be compensated with extra shifts in order to reach expected output levels.

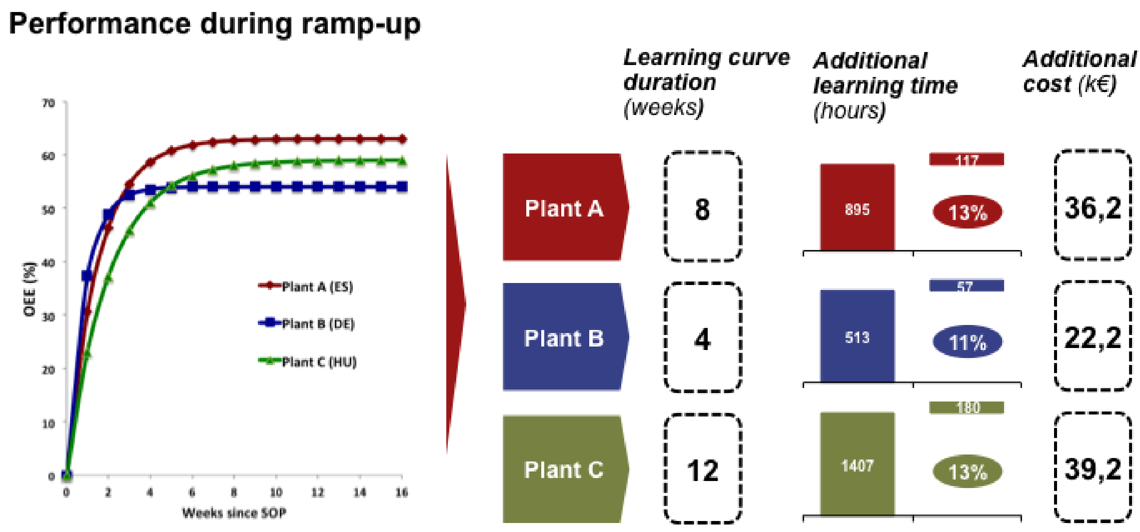

Figure 95. Ramp-up in the different locations

7.2.3 Freight costs

During the definition of the success factors for the competitiveness of a stamping plant, the proximity to the OEM's assembly plant was underlined. One of the cost elements most directly affected by this factor is the cost to ship the finished goods. The further away the location of the supplier plant is, the more expensive and loner the transportation will become. This proximity, moreover, will also determine the ability to have Just in Time production, lower inventories and better coordination with the OEM, as will further be quantified.

Besides the distance to the OEM, the shipping cost is heavily impacted by the means of transport and the countries through which transportation takes place (32). Rail transportation tends to be higher that road transportation, and transportation in Eastern countries tends to be cheaper than in Central European countries, and is dependent on whether transportation involves tolls.

The designed model takes into account the expected means of transport and the countries involved in the shipment, and calculates a weighted average transportation cost (€/tkm) which is then multiplied by the distance to the OEM and the total weight of finished goods shipped.

7.2.4 Measurement of investment profitability

The model designed quantifies the potential profitability of the B-pillar manufacturing in the different plants by means of three distinct measures: operating margin per piece and total annual operating margin, the Net Present Value (NPV) of the project (10 years of production) and the Return on Capital Employed (ROCE).

<u>Operating Margin:</u>

The annual operating margin is easily calculated as the sales from B-pillar manufacturing: 6,8 million euros (17 € times 400,000 units), minus total annual manufacturing cost incurred (raw materials, production and freight). As the model hasn't introduced any variation in price or costs throughout the years, the operating margin for every year will be the same.

In order to calculate operating margin per piece, it is computed as the price by which the OEM buys each B-pillar, in this case, 17 €, minus the unitary cost incurred in the production of each B-pillar sold. This cost is therefore calculated as total manufacturing cost divided by the annual number of B-pillars sold (400,000 units).

Both measures should yield the same margin.

<u>Net Present Value (NPV):</u>

Net present value for a project is a calculation that compares the initial investment to the present value of the future cash receipts from the investment, discounted at the required rate of return.

The initial investment for our project encompasses the investments required to acquired the hot stamping line (press, furnace, laser…) and the development of the stamping tools. These parameters are centralized and taken care of by the supplier's corporate management and will be uniform across plants. The investment in the hot stamping line will account for 8 million €, and the development of the dies is estimated as 200,000 €. Furthermore, the lifetime for all assets is expected to cover the whole duration of the production (10 years), and will have a 30% residual value by the end of the period.

On the other hand, the future cash flows that will annually be obtained are considered to be the annual operating profits gained as a result of the difference between the price paid by the OEM (sales), and the manufacturing costs incurred. In order to compare these future cash flows to the initial investment, they will be discounted at the company's required rate of return. The cost of capital is the cost of funds, both debt and equity, by which a company finances a business. In this case, in line with the cost of capital in the Auto parts sector, the required rate of return at which future cash flows will be discounted is 8,1%. (46)

As operational earnings are considered to be uniform during all 10 years of production, they can be considered as an annuity, and discounted to present value following the next formula, where *r* represents rate of return and *n* years of the project.

$$PV\ of\ Earnings = Annual\ Earning\ \frac{1-(1+r)^{-n}}{r}$$

This value together with the discounted value of the sale of the assets at the end of the project (30% of its initial value) must be compared against the initial investment. When the discounted cash inflows are bigger than the initial cash outflow, the NPV is positive, and the project would positively impact the company. On the other hand, a negative NPV would mean the project is not profitable, and the project will not be worth its cost of opportunity, and other projects or manufacturing locations should be considered.

Return on Capital Employed (ROCE):

Return on Capital Employed (ROCE) is a financial ratio that measures a company's profitability and the efficiency with which its capital is employed. It is defined by the formula:

$$ROCE = \frac{Operational\ earnings}{Capital\ Employed}$$

ROCE is especially useful when comparing the performance of companies in capital-intensive sectors such as automotive, where the effectiveness and utilization of assets and capital employed is critical.

As previously commented, for the B-pillar manufacturing project, earnings are considered to be operational profit as a result between price of sale and manufacturing cost incurred. Capital employed is the capital investment necessary for the business to function and is represented by fixed assets plus working capital requirement.

Fixed assets are long-term tangible assets that are not consumed or sold during the normal course of business, and in this case, will refer to the machinery involved in the line and the tools developed, which as already clarified, will account for an initial investment of 8,2 million €. As all fixed assets, although they won't appear explicitly in the income statement, they will be reflected through the depreciation element. The model estimated that the life of these assets will approximately be 10 years, and will have a uniform decrease in value throughout the years (straight depreciation), down to 30% of its initial value by the end of the project.

As fixed assets are affected by depreciation, the value of the assets sinks as the project progresses. This positively impacts ROCE, as the capital employed tends to be uniformly reduced. For this reason, ROCE increases throughout the years of the project, being lowest at the beginning and highest at the end.

Working capital refers to cash and short-term assets expected to be converted to cash within a year less short-term liabilities. This measure in our case will mainly focus on the finished goods inventory. If a plant is able to have low inventories, the cost of its inventories will be lower, and hence, the capital employed will also be lower, contributing to higher ROCEs.

Inventory cost can be decomposed as the manufacturing cost of each piece in inventory and the average number of pieces in inventory. For this reason, inventory (and hence financing) costs will be higher in plants with higher manufacturing costs as well as in plants where inventory levels are high. Inventory levels, measured as week sales of inventory, are higher the longer the distance to the OEM, and shorter when proximity and JIT production allow for high production coordination with the OEM.

7.3 Model results

Based on the model structure and input variables detailed, the model is able to calculate the annual manufacturing cost for the B-pillar production in each of the plants, and its related unitary manufacturing costs.

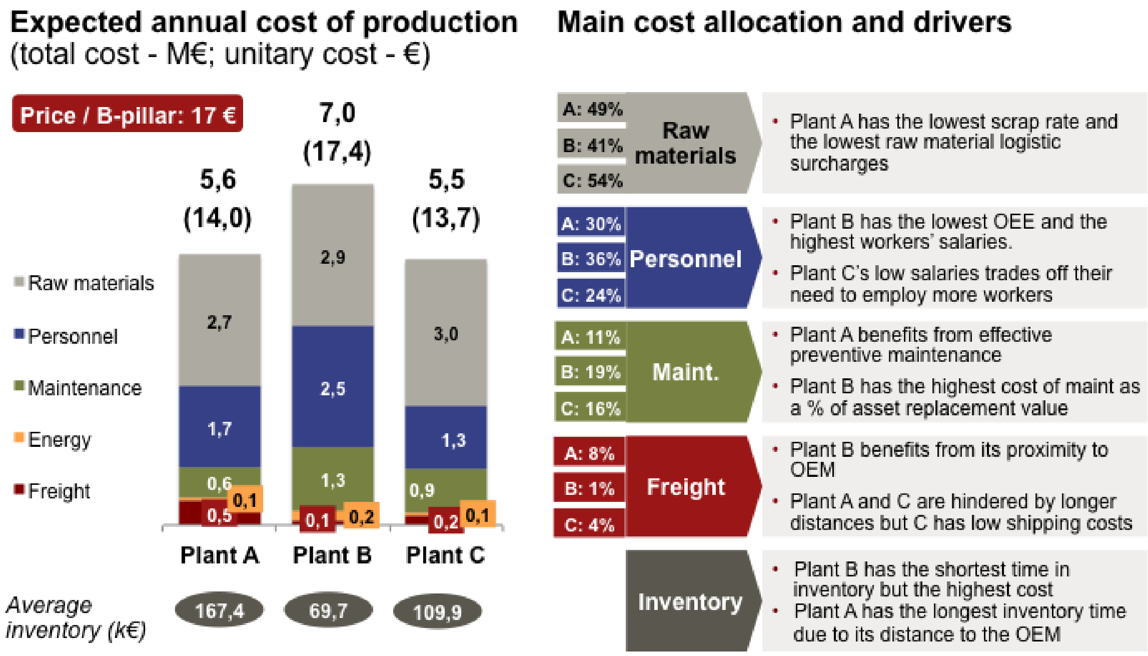

Figure 96. Annual cost production, cost allocation and drivers

By means of this output, it is clearly observe how Plant B (DE) accounts for a manufacturing cost far higher than the two other plants, 21% and 20% respectively compared to plants C (HU) and A (ES). This increase in cost is reflected in a unitary cost per B-pillar of 17,4 €, compared to 13,7 and 14,0 € in the other locations. As the graph, this cost difference is mainly due to significantly higher personnel and maintenance costs.

To be able to understand the cost outputs of the three plants, the total manufacturing costs have been disaggregated into their most important components and the reasoning behind it.

Raw materials costs account for between 50 and 60% of total manufacturing costs and as it reflected, it is very uniform across plants. The reason behind it is that most of the price of the steel coils is centralized by the supplier corporate team. The only potential cost difference yield as a results of different scrap rates, which imply different steel consumption, and the logistic surcharge as a result from the distance to the closest raw material supplier. Regarding this aspects, Plant A has the lowest scrap rate (2%) and the closest distance to supplier. Plants B and C have higher scrap rates (4% and 3% respectively), and longer distances to suppliers, with respectively 50% and 100% more logistic surcharges than Plant A.

Regarding personnel costs, it is clearly seen that Plant B has significantly higher costs than the other plants, accounting for 47% and 92% more expenses than Plant A and C respectively. The straightforward reason behind it is that Plant B has the lowest OEE, requiring the highest machine hours, and it has also the highest line workers' and indirect workers' salaries. On the other hand, Plant C counts with the definitely cheapest workforce, which allows it to account for the lowest personnel cost. Nevertheless, Plant C faces the highest overhead and lowest productivities, slightly hindering its cost advantage.

Concerning maintenance, once again Plant B has the highest cost due to the lack of a proper maintenance strategy. A potential hot stamping line in Plant B would be heavily affected by unplanned downtimes as no total productive maintenance techniques are set in place, severely raising the cost of maintaining the assets. On the other hand, Plant A has effectively introduced preventive maintenance strategies, which is reflected both in reduced maintenances costs, as well as the highest OEE.

Although freight represents a smaller portion of the cost, below 10% in all plants, is an important parameter which varies considerably across plants. Plant B, although using rail transportation (more expensive than road transportation) is able to benefit from its proximity to the OEM and shows 84% and 63% more cost effective freight costs than plants A and C respectively. Long distances affect these plants, although plant C is able to slightly tackle this cost gap with relatively low transportation costs.

Energy costs as expected, account for a very small piece of the cake and is very uniform across the three plants. Plant B suffers slightly higher energy costs as it has the highest scrap rate and highest machine hours, and to some degree higher electricity and natural gas prices.

Lastly, although inventory costs are not considered manufacturing cost, it is imperative to know what is the average inventory cost in each plant and how good are their finished good turns. Plant B although having the highest manufacturing cost, is able to have the lowest average inventory cost because they proximity to the OEM allows it to have a sales week of inventory of 0.5 weeks versus 1 and 1.5 weeks in plants C and A. For this reason, although these plants have more competent manufacturing costs, their long distance to OEM makes them have high inventory levels and low finished goods turns.

Once the manufacturing cost in the plants has been estimate, it has to be placed in context with the prices paid by the OEM and the initial investments in order to calculate the profitability of the production in each of the plants. The illustration below shows the unitary profit per piece in the three plants, as well as the NPV and the average annual ROCE in them. As plants A and C have a unitary cost of 13,7 and 14,0 € respectively, on the basis of a unitary price of 17 €, the operation profit in both plants would be almost 20%. Inversely, Plant B's unitary costs is above the price they OEM has determined to pay, having a negative operational margin of -2,5%, which would mean that manufacturing the B-pillar production in Plant B would incur losses.

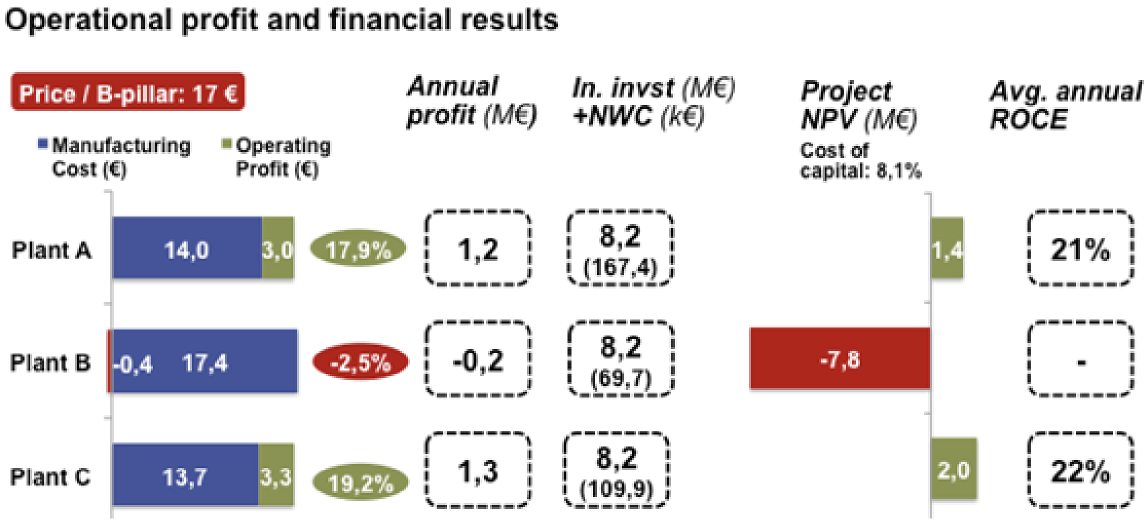

Figure 97. Operational profit and financial results

While annual profits in Plants A and C would stand for an annual profit of 1,2 and 1,3 million €, with average annual ROCEs of 21% and 22%, Plant B would be incurring losses of 200,000 every year. This is clearly perceived by the NPV of the project in each of the plants. Whilst production plants A and C would positively affect the company, achieve returns above required and increase its value (respectively by 1,4 and 2,0 million €), the production at Plant B would have a very big negative NPV, and production under this circumstances would clearly have a negative contribution to the company.

Before the cost competitiveness comparison was developed, and imagining a relatively uniform cost across the three plants, the supplier's management would have always preferred to manufacture the B-pillar production from Plant B. This is very reasonable, as the proximity to the OEM's assembly plant would allow developing certain soft advantages to a higher potential. These soft advantages include better coordination and JIT with the OEM, as well as better cultural understanding and probable country legislation benefits.

On this basis, and before completely rejecting the idea of manufacturing in Plant B, it is critical to analyze where this cost competitiveness loss comes and try to identify potential levers to tackle and overcome these drawbacks.

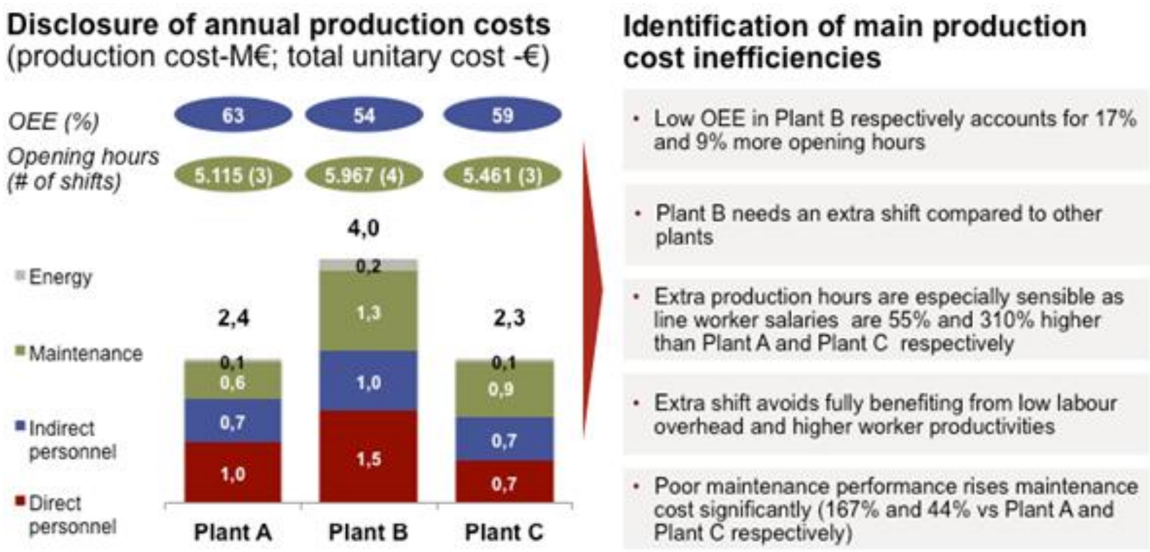

Figure 98. Annual production costs and inefficiencies

If we focus on the production cost per plant, where Plant B suffers from the highest cost inefficiencies, it can be easily remarked that poor OEE and maintenance performances are the main drivers that account for around 70% more production costs than the other plants.

More precisely, the low OEE in Plant B requires that the line must be opened respectively 17% and 9% longer than Plants A and C. Furthermore, this extra time make and extra shift necessary. This extra shift is very meaningful because the line workers in Germany have salaries which are respectively 55% and 310% higher than in Spain and Hungary. For this reason, direct personnel is 50% and 100% higher than in Plants A and C, and the positive effect achieved from lower overhead rates and higher productivities is not being fully enjoyed.

Emphasizing on the root causes of a low OEE performance, maintenance is a major source of effectiveness loss. As previously represented, hot lines in Plant B suffer significantly more from unplanned downtimes than the other plants, and machine and die unplanned downtimes account for the loss of 10pp and 4pp more than Plant A and C. This is rapidly translated into higher maintenance costs, where the lack of any preventive maintenance strategy pulls costs up 167% and 44% more than in plants A and C.

7.4 Performance improvement levers

Plant B has been proved to suffer from critical inefficiencies baskets, which make it very cost uncompetitive as compared to the other plants. Nevertheless, due to some potential soft advantages that could be achieved as a result of proximity to OEM, it would be very useful to identify some improvement levers that would allow Plant B to perform at effectiveness and cost-efficiency levels close to the other plants.

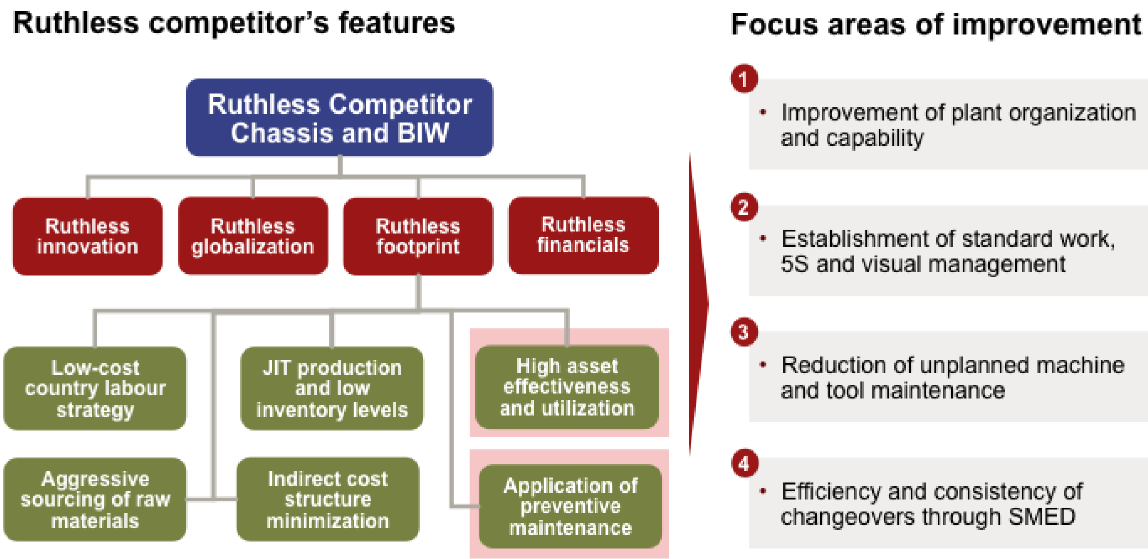

Figure 99. Ruthless competitor's features and focus areas of improvement

In order to improve the performance in Plant B, it should try to acquire some of the features that a ruthless competitor in the chassis and BIW industry would enhance. These characteristics were already described in a previous chapter, and encompass ruthless innovation, ruthless globalization, ruthless financials and ruthless footprint. As the root causes of the inefficiencies faced by Plant B are related to footprint decisions, it should focus on the latter.

Regarding the accomplishment of a ruthless footprint, some of the strategies that a Plant could enhance are illustrated above:

- A low-cost country labour strategy
- An aggressive sourcing of raw material
- Focus on JIT production and inventory levels
- Indirect cost structure minimization
- High asset effectiveness and utilization
- Emphasize on the application of preventive maintenance

Some of this options can't be applied in our given situation and some of them would already been partially implemented. A low-cost country labour strategy makes no sense in our case, as the plant location is already determined and the personnel costs in Germany are very high. Sourcing of raw materials for the performance in this project is centralized by the supplier and is not one of the major sources of competitiveness loss. On the other hand, Plant B would already benefit from JIT and would enjoy the lowest inventory levels out of the three plants, so no further development of this lever should be needed. Moreover, Plant B has the lower overhead rates which is strongly due to an appropriate indirect labour and cost structure.

It is therefore clear, that the performance levers that would best apply to our given case study are the accomplishment of high asset effectiveness and utilization, and the emphasize on the application of preventive maintenance. It was been remarked how low OEE and maintenance performance are the two main drivers of the lack of cost competitiveness, and hence, achieving a ruthless behavior in these fields could reduce cost and increase effectiveness significantly.

Within these fields, the four areas of enhancement that will raise OEE and reduce maintenance cost should encompass the improvement of the plant and line's organization and capability, the establishment of standard work, 5S and visual management, the reduction of unplanned machine and tool maintenance and the efficiency and consistency of changeovers through Single-Minute Exchange of Die (SMED).

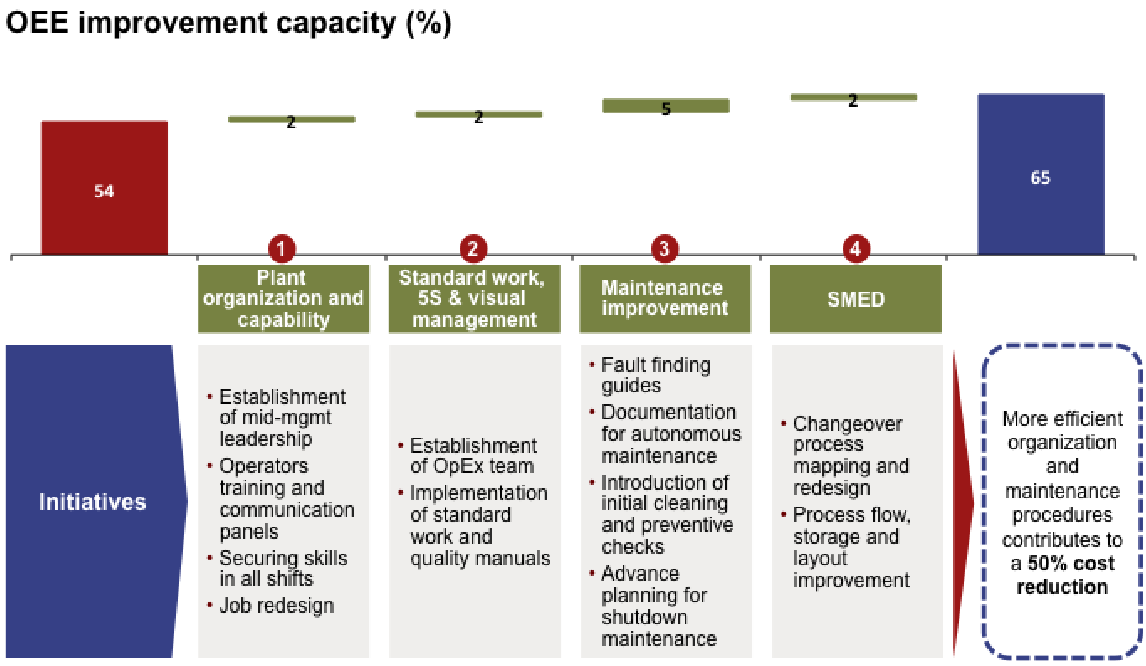

Figure 100. OEE improvement capacity

Within plant organization and capability, some of the best-practices that should be introduced into Plant B are the establishment of middle management leadership and higher operators' engagement and communication. Systems for submitting ideas and regular revision of operators' initiatives and proposals can enhance the motivation and personification of goal accomplishments and increase effectiveness. Clear team meeting areas and performance charts motivate workers and make them aware of plant / project / station progress. Moreover, an appropriate job redesign and distribution of talented workers to secure skills in all shifts will allow for more uniform OEE as well as avoid long downtimes due to machine stoppages and unplanned maintenance. The improvement of organization around the production line and its capability could be translated into a 2pp OEE increase.

Another key enhancement initiative is the development of an Operational Excellence team that will ensure that standard work, 5S and visual management are set in place in every production line. Up to date central 5S board as well as area 5S boards, with regular 5S audits in place would ensure efficiency and improvement of the workplaces. Other examples such as TV screens installed at key locations for communications and visual alarms at stations to highlight material shortage and breakdown would be significantly useful. These initiatives, together with clear work instructions including quality, safety and TPM at individual stations would allow OEE to increase in another 2 pp.

Moreover, the lever that would probably bring the highest effectiveness increase, around 5pp, is the improvement of maintenance techniques and application of a preventive maintenance strategy. Amongst other elements, this initiative includes the development of documentation and fault-finding guides for autonomous maintenance that would allow line workers to solve daily maintenance issues and liberate the maintenance team for more complex maintenance problems and the introduction of initial cleaning and preventive checks that would effectively reduce unplanned downtimes. Furthermore, maintenance would be scheduled in advance and would better coordinated with production demand.

Finally, in order to optimize the changeover between tools in the production line and further reduce effectiveness loss, Single-Minute Exchange of Die (SMED) lean method should be introduced. This technique, which allows for a more efficient mapping and design of the changeover, together with a superior tool storage and layout can further improve OEE by 2pp.

These techniques, which can be simultaneously implemented and together contribute to performance improvement, can jointly raise the OEE by 11 pp and reduce the total maintenance cost by 50%.

If these initiatives were to be implemented, the annual production cost for the B-pillar in plant B could be reduced in 30%, resulting in a unitary cost reduction of 18% and a cost per piece of 14,2€.

More precisely, the motivations for the performance improvement achievement are detailed in the illustration below. An improvement in OEE of 11pp, reaching 65% would allow to significantly reduce the amount of annual machine opening hours, 1010 hours, accounting for a reduction of 17%. Furthermore, this drop can favour the elimination of the fourth shift, and the line could run 3 shifts, as the other two plants would be doing.

Furthermore, the decrease in line opening hours provides extra personnel benefits, as the number of line workers would be reduced by one fourth, and it would also have a proportional reduction in indirect employees. This workforce diminution would translate into an annual personnel cost reduction of 508,000 €, which would represent a 22% of the previous labour cost.

The improvement of the current maintenance structure and performance would provide and additional 700,000 € reduction annually, which would account for 50% of the previous maintenance costs in the line.

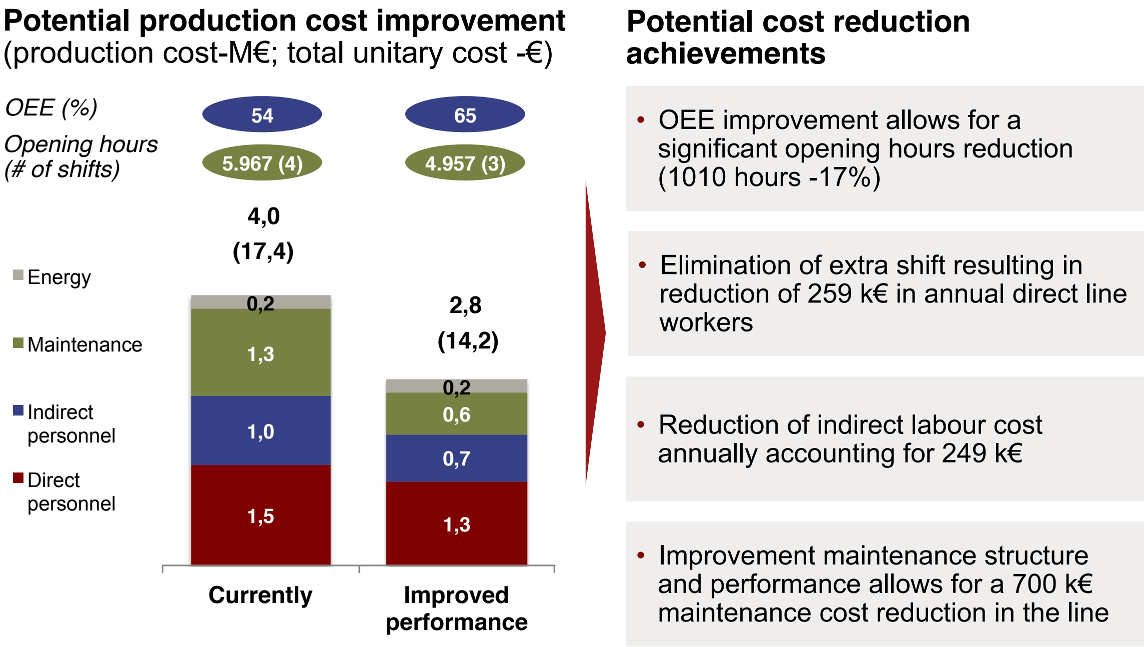

Figure 101. Potential cost reduction achievements

The potential cost reduction achievement would therefore have a substantial impact on the profitability of the B-pillar production in Plant B. The improved performance would allow the plant to obtain an operating profit of over 16%, close to those in Plants A and C (respectively 18% and 19%). The profit situation would therefore significantly vary, as the previous negative 200,000 € annual profit would turn into annual positive profits of 1,1 million Euros. Furthermore, relatively high positive annual returns would definitely return the initial investment and achieve the companies required yields, hence positively creating value for the company totalling 700,000 €.

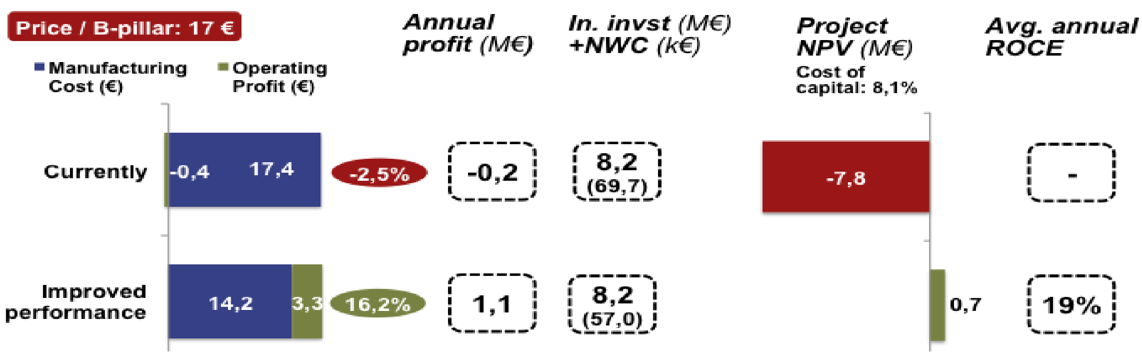

Figure 102. New operational profit and financial results

Finally, the benefit from enjoy low inventory and net working capital levels would provide an average annual ROCE of 19%, almost as high as the other plants, which with relatively higher NPV (1,4 and 2,0 million Euros in plants A and B respectively), are only able to achieve slightly higher average annual ROCE (21% and 22%).

In order to contextualize the potential competitiveness of Plant B with improved performance levers, it is critical to study the impact of possible OEE variations, and understand how this competitiveness compared to the other plants would be altered.

With the expected outcome from improvement measures, Plant B would be able to offer a unitary B-pillar cost of 14,2 € against 14,0 and 13,7 € in plant A and C. Although the price offered in the other locations may be slightly below the achieved in Plant B, the supplier would preferred to manufacture the B-pillar production here, as the benefits from soft features such as proximity, reduced inventory levels, better coordination and image would definitely offset the cost gap.

Nevertheless, these soft features have a limited value and in case the potential competitiveness at Plant B was below expected, the cost gap might be too big to be offset by these soft benefits. So as to evaluate this decision, a sensitivity analysis has been carried out.

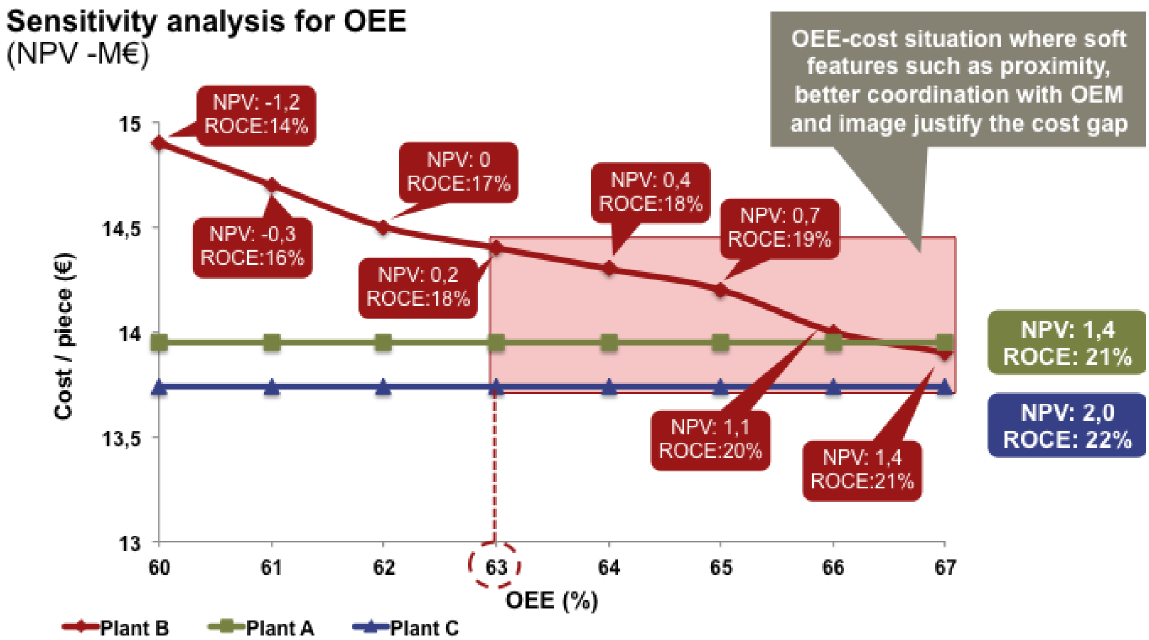

Figure 103. Cost sensitivity analysis for OEE

From this exercise, it is clearly highlighted how further improving the OEE performance beyond expected would further contribute to achieve higher competitiveness, and a 67% OEE (2 pp above expectation) would allow to provide a price and a return as competitive as Plant B.

Nevertheless, if the results of the performance improvement weren't as successful as expected, the competitiveness of Plant B would be very much questioned. The analysis illustrates that the cost offered varies approximately linearly with OEE, and hence, as the expected OEE decreases, so does the cost per piece. More precisely, it can be remarked that the bottom limit where the previously described soft benefits are estimated to just offset the cost gap with the other plants is 63%. With this effectiveness, Plant B would be reducing their NPV by 500,000 €, but still have operating profits over 15%, NPV of 200,000 € and an average annual ROCE of 18%. In case the potential effectiveness of the hot stamping line in Plant B kept decreasing, the exercise proves that any OEE below 62% would have negative NPV, and hence, given the required return, it would be reducing the company's value.

7.5 Conclusions extraction

The case study that has been developed, with its corresponding model design and quantification of potential ruthless improvement strategies, has been very useful to highlight several aspects and conclusions that have been already described in previous chapters. These conclusions encompass ideas about cost structure, profitability measurements, impact of ruthless success factors and competitiveness sensitivity to those factors.

The disaggregation of the cost of manufacturing a B-pillar production has allowed as to illustrated where the biggest cost pools are found. It has been useful to reinforce the idea of how important raw materials are personnel costs are within total costs. Raw materials supply, which was already commented in the success factors description, accounts for around 50-60 % of total cost in a normal plant situation, and hence, it is important to be able to optimize this cost. Aggressive raw material sourcing was therefore identified as an important ruthless competitor strategy, and moreover, potential proximity to raw material supplier plant has been proved and quantified to establish important cost benefits.

Regarding personnel, the case study has been very useful to remark the potential of a low-cost labour country strategy. Plant C, with location in Hungary, benefits from very low personnel costs, which given a uniform workforce in the three plants, would mean a reduction of 66% and 47% of personnel costs with respect to Germany and Spain. Nevertheless, and by means of the model design, the case study has also illustrated the effect of productivity and education of workers. In this sense, Plant B in Germany, is able to reduce its personnel cost disadvantage by requiring a lower number of workers involved in the line, 7 and 17 with respect to Spain and Hungary.

Furthermore, the education and skills of the workforce is especially representative during the first months of production, in the ramp-up stage, where stable OEE and performance have not been reach yet, and the skills and talent of the personnel play a critical role towards shortening this period as much as possible.

Regarding other aspects of the cost structure in a production line, the case study reflect that maintenance cost represents an important portion of the cost of manufacturing, and is a critical driver for performance definition. Maintenance cost usually accounts around 5-15% of the replacement cost of the assets involved in the line. The influence of an ineffective maintenance has clearly been remarked throughout the case study, and together with OEE, has been identified as the main drivers of competitiveness loss in Plant B.

For this reason, the ruthless competitor’s strategies in which focus has been place on have been are high asset effectiveness and utilization and the application of preventive maintenance techniques. In order to specify potential areas of improvement in these fields, some of the improvement areas which have been described and particular initiatives have been brought up are improvement and plant capability; establishment of standard work, visual management and 5S; reduction of unplanned machine and tool downtimes; and efficiency and consistency of changeovers through SMED. The case study help to quantify what the potential impact of the implementation of these strategies could be, both in performance and cost, and reinforce the idea of great benefits: 11pp OEE increase and 50% maintenance cost reduction.

Another field in which the case study has emphasized on is the financial evaluations of this type of project. The potential manufacturing in the different locations has been compared in terms of operational profitability, NPV and ROCE. Potential production at desired and expected levels yield operational profits between 16 and 20 %, and proved to be above the average annual EBITDA margin that were presented for the main BIW competitors, and that averaged 10%.

Other important financial considerations have been the cost of capital used to compute NPV, and that has been considered to be 8,1%, (in line with the industry of auto components), and the ROCE. This concept has been explained in depth, and the case study has been used to highlight expected average ROCE of around 20% given implementation of successful levers, which is in line with required 15% ROCE in the industry.

Besides actually estimating profitability and competitiveness after estimating the outcome of potential improvement levers, the case study is very valuable at studying for the sensitivity of these values to possible situation variations, and the consideration of identified soft skills.

On the one side, this exercise shows how although mathematically there could be a slight cost gap between production in Plant B with respect to the other locations, the effect of soft skills such as proximity to OEM (which has been long discussed), coordination, low inventories and image, all of them which are hard to quantify, could offset this cost gap.

On the other hand, the sensitivity analysis illustrates how potential variations from the expected OEE outcome can vary the competitiveness of Plant B. If OEE is 2pp above expected, Plant B would be even more competent than Plant A, but if OEE is more than 3pp below expected, the production would have a negative NPV. This definitely reflects that profitability and competitiveness are very sensitive to OEE, and hence, how reliable it is to achieve the OEE goal should certainly be considered.

8. Conclusions

The main goal of the document is to present the trends and circumstances that the automotive industry is currently experiencing, and with focus on the supplier sector, understand the importance of competitiveness and identify and quantify the critical success factors that would provide a component manufacturer, in this case, in hot stamping, with a ruthless manufacturing footprint.

The document begins with an exposition of the characteristics that presently define the automotive industry and its role on global economy. It constitutes a basic driver for macroeconomic expansion, heavily contributing to job creating, technological advancement and industrial and research development.

The sector has been enjoying a significant growth since the recession, and profitability, especially that of component manufacturers, has been relatively high. Nevertheless, the industry will be facing a series of challenges that make their returns uncertain. OEMs and suppliers will encounter an intensification of complexity, cost-pressure and weight focus, they will experience a shift of the centre of gravity towards emerging markets and an increase in the digital demands, and they will face a change in the industry landscape, as manufacturer components will be required to add increasing value to the final product.

This intensification of cost-pressure and weight focus forces OEMs and suppliers to manufacture increasingly light-weight vehicles, that are cost-effective and comply with environmental and safety regulations. For this purpose, body in white and chassis components become critical, as they represent almost 40% of a car’s weight, and it is expected that 15% of the investment toward achieving fuel efficiency goals will rely on them.

The market of body in white and chassis component stamping is very competitive, with a few big players dominating the sector by means of global coverage and breadth of products. These competitors present high revenues, between 2.000 and 8.000 million dollar revenues and operate on 10% EBITDA margins on average. Although there are also many small local players, which dominate a certain region, the industry is tending to consolidation through M&A activity.

In order to tackle the need to produce light components, the industry has come up with new technologies and materials to replace traditional mild steel which allow for a significant weight reduction. These innovative materials encompass Ultra High Strength Steel (UHSS) and hot stamped steel, and aluminium and composites. These last two technologies, although offering the highest weight reduction, are still under development and their high manufacturing costs hinder their general expansion.

As it has been highlighted, the stamping of body in white and chassis, and more precisely, hot stamping, is highly competitive, which makes the identification of competitiveness success factor very important. Under these circumstance, in order not only to maintain past profitability but to successfully tackle future industry challenges, manufacturers must search to become a ruthless competitor by means of an optimized footprint.

The four main levers that have been identified and evaluated to provide a successful competitiveness are:

- A deep know-how on hot-stamping technology, its processes and materials, as well as the wide range of product offer and increasing demand
- A strategic location that would allow benefiting from Just in Time (JIT) production with the customer, appropriate raw material sourcing and reduced logistic and shipping costs
- An adequate work-force, which shows a successful balance of personnel cost, skills, productivity and education
- High operational efficiency based on lean techniques and good Overall Equipment Effectiveness (OEE) and Total Productive Maintenance (TPM) performances

Nevertheless, if this document just held on to a descriptive level, the utility of it would be limited. By means of designing a model to quantify the impact of the identified competitiveness success factors, it allows to build a further perspective, a real case scenario.

The case study defines a body supplier which must manufacture a B-pillar production from one of its locations. The model is designed to illustrate detailed cost breakdowns and study the main cost drivers in each plant in light of the identified success factors.

The model and its application to a case study are very useful in order to highlight improvement initiatives, and their potential impact on cost and performance. It proposes a series of initiatives which prove to achieve an 11pp OEE increase and a 50% reduction in maintenance costs, regarding the fields of plant capacity and organization improvement; establishment of standard work, 5S and visual management; reduction of unplanned machine and tool maintenance; and efficiency and consistency of changeovers through SMED.

Furthermore, the application to a case study allows to contextualize manufacturing performances within a financial evaluation and to come across with concepts such as operational profit, required cost of capital, average annual ROCE, which in the auto-component industry are standardized to be >12%, 8,1% and >15% respectively. Finally, the employment of a model allows to carryout sensitivity analysis and evaluate the impact of other potential soft skills such as coordination, culture impact or image.

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