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Development of an evaluation strategy for Chinese transmission component supplier

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Genderklausel

Für die vorliegende Arbeit wurde wegen der besseren Lesbarkeit auf die gleichzeitige Verwendung weiblicher und männlicher Personenbegriffe verzichtet. Gemeint und angesprochen sind natürlich immer beide Geschlechter.

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Kurzfassung

Diese Arbeit versucht die Frage zu beantworten, wie eine Lieferantenauswahl und Evaluierung für chinesische Getriebelieferanten in der Automobilindustrie aus der Sicht eines Unternehmens mit begrenzten betrieblichen Mitteln zur Lieferantenbewertung durchzuführen ist.

China bleibt der größte Treiber des globalen Marktwachstums. Dies gilt insbesonderes auch für die chinesischen Automobilindustrie. Auf Seiten der Lieferanten wurden große strukturelle Veränderungen bei den lokalen Anbietern beobachtet. Ziel ist es den wachsenden Qualitätsanspruch der Kunden zu gewährleisten und um die globalen Qualitätsstandards zu erfüllen. Gleichzeitig drängen neue Wettbewerber sowohl Lokal, als auch aus dem Westen auf den Markt. Letztere heben sich besonders durch die technologische Führerschaft sowie durch ihre bestehende Kundenbasis hervor. Bei der Lieferantenauswahl müssen mehrere Faktoren in diesem dynamischen Umfeld berücksichtigt werden. Dies erweist sich als schwierig, nicht zuletzt wegen der gewaltigen Preis- und Qualitätsschwankungen am chinesischen Markt. Aus Ressourcenmangel können manche Firmen daher keine umfangreiche Lieferantenbewertung durchführen.

Diese Arbeit beschäftigt sich damit, einen Überblick über die chinesische Lieferantenlandschaft für automobile Getriebekomponenten zu verschaffen. Die Inputdaten für die Erstellung der Lieferantenlandschaft wurden aus Datenbanken, sowie aus für die industrie relevante Konferenzen über ein Zeitraum von 6 Monate gesammelt. Weiters wurde eine Lieferantenbewertungsmethode entwickelt um die Lieferantenauswahl zu unterstützen. Das für die Lieferantenauswahl verwendete Bewertungsmodel basiert auf dem bewährten Model von Sherry R. Gordon. Die Komponenten spezifischen technischen Anforderungen wurden aus vorhandenen Qualitätsstandards und von Lieferanten bereitgestellten Produktspezifikationen sowie mittels Literaturrecherche abgeleitet. Die Implementierung dieser Evaluierungsmethode wird anhand von zwei Lieferanten für Getriebesynchronisierungseinheiten demonstriert. Die dafür notwendigen Informationen bezüglich der Lieferanten werden mittels einer elektronischen Befragung ermittelt. Es kann gezeigt werden, dass diese Methodik die Anzahl der Getriebelieferanten auf eine überschaubare Menge reduziert kann, die anschließend einer vollständigen Evaluierung unterzogen werden können. Vorteil dieses Verfahrens ist die Möglichkeit fehlende Informationen mithilfe der Einführung eines Unschärfewerts zu kompensieren. Die Anwendung dieser Methodik auf ein breiteres Lieferantenspektrum ermöglicht einen präziseren Vergleich der Lieferantenleistung.

Abstract

This work aims to answer the question of how to engage in a supplier selection and evaluation process for Chinese automotive transmission component supplier from the viewpoint of an enterprise with limited resources for supplier screening activities.

The economic growth of the Chinese automotive industry has attracted many global players into the market. From the supplier side, many established local firms have undergone drastic changes in order to adapt to the growing demand for quality and global standards from the customers. At the same time, competition arises from established western suppliers with a large record of international clients as well as new local entries. When selecting the suitable supplier to work with, western enterprises have to consider many factors in this dynamic business environment. This tends to be difficult due to the typical cost and quality volatility for the Chinese supplier market. With thousands of local suppliers at choice, some enterprises struggle to execute an extensive supplier evaluation, due to the lack of available resources.

This work focuses to give an overview of the Chinese automotive transmission supplier landscape, by including the current strategic localization. The supplier landscape was created based on the information acquired through supplier databases, as well as through information of supplier conferences. Furthermore a supplier evaluation method will be developed in order to identify suitable supplier candidate during the selection process. The model used for the development of the supplier evaluation method is based on the practice-proven model by Sherry R. Gordon. The component specific technical requirements have been derived through existing quality standards and supplier product specifications for the transmission parts as well as literature research. The implementation of this evaluation method will be demonstrated for two suppliers of transmission synchronizer assembly systems. By using the information provided by the suppliers through an electronic survey it can be shown that this method can reduce the number of transmission component suppliers to a manageable amount for extensive analysis. The advantages of this evaluation strategy is its ability to handle missing information by introducing an uncertainty value. Further expansion to a broader band of suppliers allows for a more precise comparison of their strength and weaknesses.

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1 Introduction

The automobile industry has undergone an enormous transformation during the last decades. With stagnant market in the USA, Western Europe and Japan, the focus of the automobile industry has turned towards China. The Chinese automotive industry has been the largest since January 2008, overtaking the USA for the first time in history. The monthly car sales during that time hit 790,000 vehicles.[1]

In the modern automobile industry, outsourcing has become a major part of the overall value chain. Therefore companies must change their strategies and place more emphasis on supplier performance and commitment related to quality, delivery, cost reduction, technology capability, financial stability and flexibility. The supplier requirements are also linked to the corporate objectives, which vary from firm to firm.[2] Strong pressure are been applied onto businesses to directly source from China. Deals with Chinese suppliers or trading companies often cause problems for both sides. Many companies are complaining about the quality of the products, which do not meet their standard or about the delivery delay. Despite the good will of the supplier, some of them just do not possess the capability of producing the components according to the specification. It would have been less effort to identify those flaws by extensive background research than fixing the problem after the occurrence.[3]

1.1 Statement of the problem

An extensive supplier evaluation process can be very resource consuming and usually includes a supplier audit. It identifies non conformances in the manufacturing process, engineering change process, invoicing process, quality process, and also the supplier/shipment process. While some companies are scanning their supplier on a regular basis, some simply do not have the capability to invest that many resources into the selection process. Some enterprises often struggle to execute an extensive supplier evaluation, due to the lack of available resources for the hundreds of potential suppliers. Technical and social differences as well as miscommunication on both sides make it even more difficult.

1.2 Research question

Since this work addresses companies with limited supplier evaluation capabilities an evaluation method has to be developed to compensate for the lack of information that for example a supplier audit would provide. It can be considered as part of an extensive

[1] Vgl. URL: http://www.statista.com/statistics/276899/automobile-sales-in-china-by-month/ (30.11.2015)
[2] Vgl. Faurecia: Supplier requirements manual, 2013, S.2.
[3] Vgl. Smith, Peter, 2014, S.8.

supplier evaluation process with limited instrumentations. This work will therefore be dedicated to provide answer to the following research question:

How to conduct a supplier pre-selection process for Chinese transmission component suppliers from the viewpoint of an Austrian enterprise?

1.3 Research and methods

During the sourcing process, from the negotiation of price to delivering the first sample, many suppliers will not be able to meet the product requirements. The more supplier options are available the more likely it is for the procurement to find a suitable supplier who is able to fulfill the requirements.[4] Information of Chinese suppliers can be acquired by using the China Automotive Review directory[5] or via the China auto supplier databases[6] which provide useful information such as factory space, products and sales. That information can then be processed into the internal procurement system of the company followed by an evaluation of the supplier in order to identify the suitable match for the designated task. Chapter 2.1 will further address this topic.

A supplier landscape for transmission components of the Chinese market will become part of this work as it provides insight into the localization strategy of Chinese OEMs and their joint ventures. The supplier landscape will be established by using supplier information through workshops, trade fairs and supplier databases. Since strategic localization has a substantial impact on the decision-making during the supplier selection process, a separate chapter will be dedicated for this topic (Chapter 5).

The evaluation strategy that is being developed and used for this work derives from an Austrian enterprise with over 6500 employees and focuses mainly on supplier for transmission components. The chosen approach for this task is an electronic survey that directly addresses the local component supplier by using common criteria for the automotive industry that have been identified through industrial literature research. The weightings for the final evaluation is the result of a pairwise comparison. Chapter 6 will discuss this evaluation strategy by identifying the key criteria, customer expectations as well as specific requirement for the selected transmission components. This strategy will then be tested by applying this method on Chinese supplier.

This thesis concludes with a critical discussion to identify the need for further research as well as to give an overview of the pending questions that have come up during this work (Chapter 7).

[4] Vgl. Beil Damian, 2009, S.2.
[5] Vgl. China Automotive Review: CBU Directory of Chinese Vehicle, Motorcycle, Component and Parts Manufacturers, China Business Update, Beijing, 2012, S.1
[6] Vgl. URL: http://www.chinaautosupplier.com/index.html (04.09.2015)

1.4 Limits and boundaries

Given the limitation of instrumentation available, a precise evaluation of supplier performance is neither a feasible option nor is it required during the supplier pre-selection process. The available information strongly depends on the supplier's willingness to cooperate. The lack of certain information has to be considered within the supplier evaluation.

There are also some influences that may distort the results of this evaluation method. The lack of product information could lead to an unreliable scoring result, due to the importance of the product quality and its importance in the weighting system. Also the limited knowledge of the technical quality requirements for some specific transmission components could lead to the evaluation result become more conservative. This work would by far exceed the scope of a master thesis if all automotive transmission components would be taken into consideration. Therefore only a selection of transmission components could be evaluated within this work. The general idea can then be carried over to other components.

2 Methodical approach

This chapter will further explain the methodical approach that has been used during this work. It includes the acquisition of existing supplier information though professional supplier databases. This information will then be used to create a supplier landscape in order to identify the local industry clusters for automotive transmission components. In addition to this a supplier evaluation model will be selected as a guideline to create the evaluation form and to identify the relevant evaluation criteria. The information used during the evaluation will be provided through an appropriate survey technique. The data acquired in this way will then be processed with the assistance of a weighting system to mark the priority of the final evaluation.

2.1 Acquiring supplier information

The first step of the supplier selection process is to establish an overview of all existing suppliers relevant to the field of business. In case of automotive transmission component, there are currently two reliable sources that could be used to gather information. Both options offer valuable information and are used during this work.

The China Automotive Review[7], as shown in Fig. 1, offers a comprehensive database of a huge range of automotive suppliers. The database includes a very detailed search and a filtering function to ease the searching process. Upon a fee-based subscription, the user will be granted access to information like company revenue, number of employees and in some cases production volume and contact information. The China Automotive Review database offers both, a Chinese as well as an English client for the searching operation. A refined searching option is available for the user to look for component specific terms. The information are managed and refreshed on a regular basis to ensure up-to-dateness.

[7] Vgl. China Automotive Review: CBU Directory of Chinese Vehicle, Motorcycle, Component and Parts Manufacturers, China Business Update, Beijing, 2012, S.1

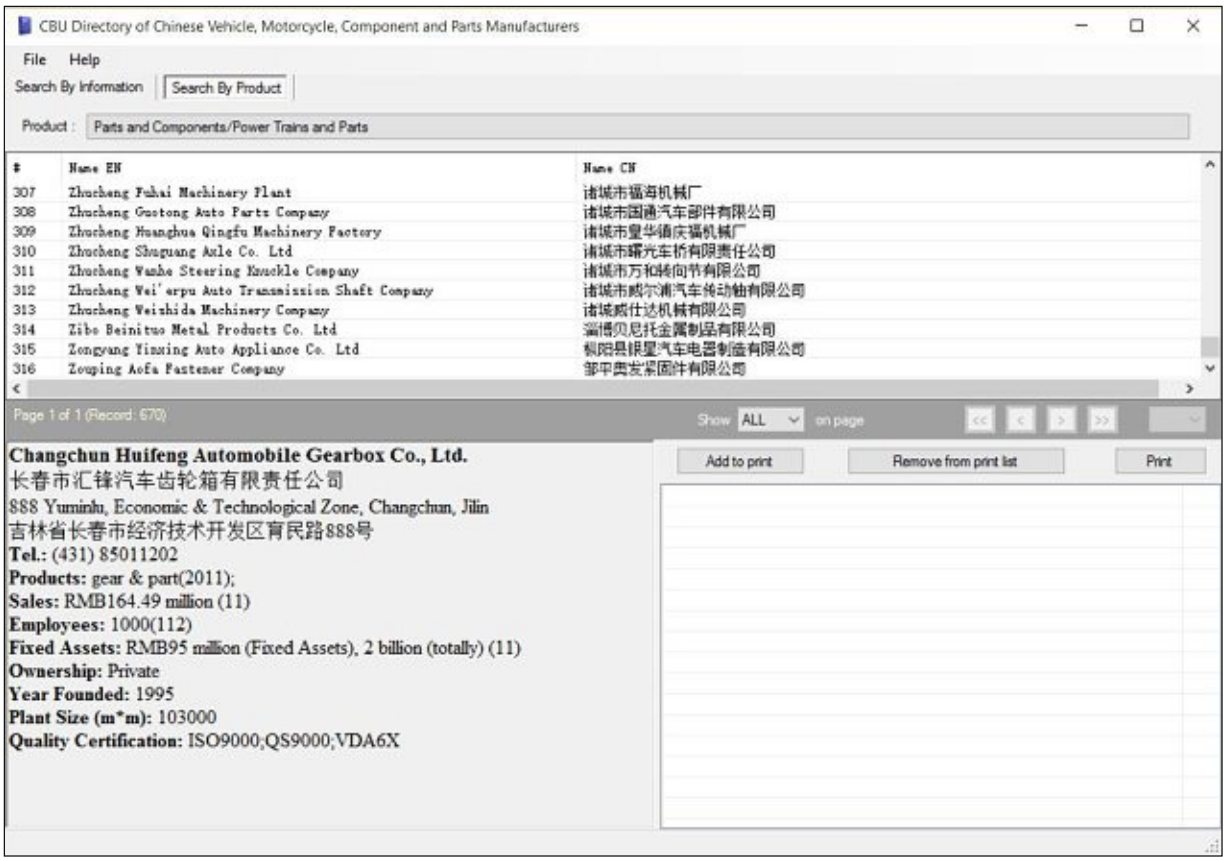

Figure 1: CBU Directory 2012.[8]

The other automotive database is operated by a website called China auto supplier[9] (中国汽车供应商网). During the time of research this website is only available in Chinese. The information that can be obtained here is similar to the China Automotive Review database and are available free of charge (Fig. 2). With only limited searching options available, this database provides with less possibilities of a detailed inquiry. It has to be noted that some information seems to be outdated during the time of this research.

[8] Vgl. China Automotive Review: CBU Directory of Chinese Vehicle, Motorcycle, Component and Parts Manufacturers, China Business Update, Beijing, 2012, P.1ff
[9] Vgl. URL: http://www.chinaautosupplier.com/index.html (04.09.2015)

Figure 2: China Auto Supplier Online Database.[10]

In addition to those aforementioned databases other trading portals like Alibaba and Made-in-China could also be taken into consideration. Since those databases do not entirely focus on the automotive sector and often lack of filtering option which is necessary for detailed supplier analysis, they will not be considered in this work. By using the two databases mentioned above, over 2000 suppliers for transmission components could be identified. The exact number of suppliers for the individual transmission component is depicted in table 1. This large quantity of suppliers can be used as a starting point for further evaluation with the option to separately add in additional suppliers that are not listed within the database.

[10] Vgl. URL: http://www.chinaautosupplier.com/index.html (04.09.2015)

Transmission components	China Automotive Review	China auto supplier
Shafts and Gears	361+	316 supplier in the category of Powertrain and parts
Planetary Gear Sets (AT)	33	
Synchromesh Unit	95	
Seals and Gaskets	321	
Torque converter (AT)	5	
Hydraulic system	298	
Clutch	531	
Bearing	357	

Table 1: The number of Chinese transmission components supplier within the databases.

It has to be said that many of those information are not accurate. Some of those suppliers don't give the impression of been professional business partners due to the lack of web presence or cooperate email addresses. The lack of customer references and other missing information also strengthen this statement. In addition to that it is not possible to determine either the product or the production quality. This leads to the conclusion that further research has to be done in order to identify the key suppliers out of this list.

2.2 Strategic localization

The research paper presented by Andersson and Segerdahl in 2012 suggests a division into several segments to answer the question of localization strategy for supplier bases in order to change the operation setups until 2020 as a consequence of growing markets.[11] With the three major research questions in mind, external factors have been identified.

The research questions are stated as follows:

- What external factors affect supply chain localization decisions and which are most important?[12]
- Which are the most probable supply chain localization strategies for the year 2020 and how do they differ between various companies, industries and products?[13]
- In order to remain prosperous in year 2020, what supply chain localization strategies should the company pursue?[14]

[11] Vgl. M. Andersson; R. Segerdahl, 2012, S.16
[12] Vgl. ebenda, S.2
[13] Vgl. ebenda
[14] Vgl. ebenda

Market factors are highlighted as the most important external factor. Flexibility and speed optimization will therefore lead to the use of faster modes of transportation. This implies a focus of regionalized supplier bases.[15]

Identifying supplier clusters and considering the localization strategy have many advantages especially for the Chinese Automotive Industry. Chinese Automotive suppliers have established strategic industry clusters in the vicinity of the Top Tier Chinese-Foreign Joint Ventures. These operations are often backed by provincial governmental incentives in order to gain an advantage over the competition.[16]

It is therefore important to understand the Chinese supplier landscape within the Chinese Automotive industry since those supplier clusters offer many advantages and tend to be a safer option due to better law regulation and financial stability. Chapter 5 will be dedicated to the topic of Chinese supplier landscape by identifying the industry clusters within mainland China around the Top 10 Chinese-Foreign Joint Ventures. In order to create a supplier landscape, it is important to gather reliable information about the local component suppliers. The following methods have been used to archive this objective:

1. By using the existing information that are available to AVL and its purchasing personnel.
2. Information through various workshops with local component suppliers in the Chinese AVL Shanghai Tech center. This also includes engine component suppliers since the original project was meant to improve the current SRM database usage in China on a larger scale.
3. Visiting of various supplier trade fairs in Guangzhou as well as Shanghai, in order to speak to the suppliers and exchange information.
4. Cooperation with SAIC (Shanghai Automotive Industry Corporation): Main objective was to solve quality issues of their suppliers. This includes onsite plant visits as well as conference sessions with the SAIC personnel to improve the entire supplier handling process, including purchasing, supplier quality management and engineering support.
5. By using the CBU directory of Chinese Vehicles Motorcycle, Component and Parts Manufacturers and China Auto Supplier Database.

2.3 Definition of evaluation strategy

In most cases, manufacturers need more than one supplier to supply the same kind of product for them. That means how to decide the task distribution between those suppliers should also be taken into consideration. According to Ke Chen the

[15] Vgl. M. Andersson; R. Segerdahl, 2012, S.30
[16] Vgl. W. Li; R. H. Gordon, 2011, S.24

automotive supplier management should be divided into four phases, including supplier selection, task distribution, supplier evaluation and decision adjustment. For manufacturers, the ultimate purpose of supplier management is to get optimal service from suppliers to help improve the competing ability of their final product.[17] In other words, all the measures used in the supplier management should aim to get optimal service from suppliers. Figure 3 shows the supplier management process based on service optimization.

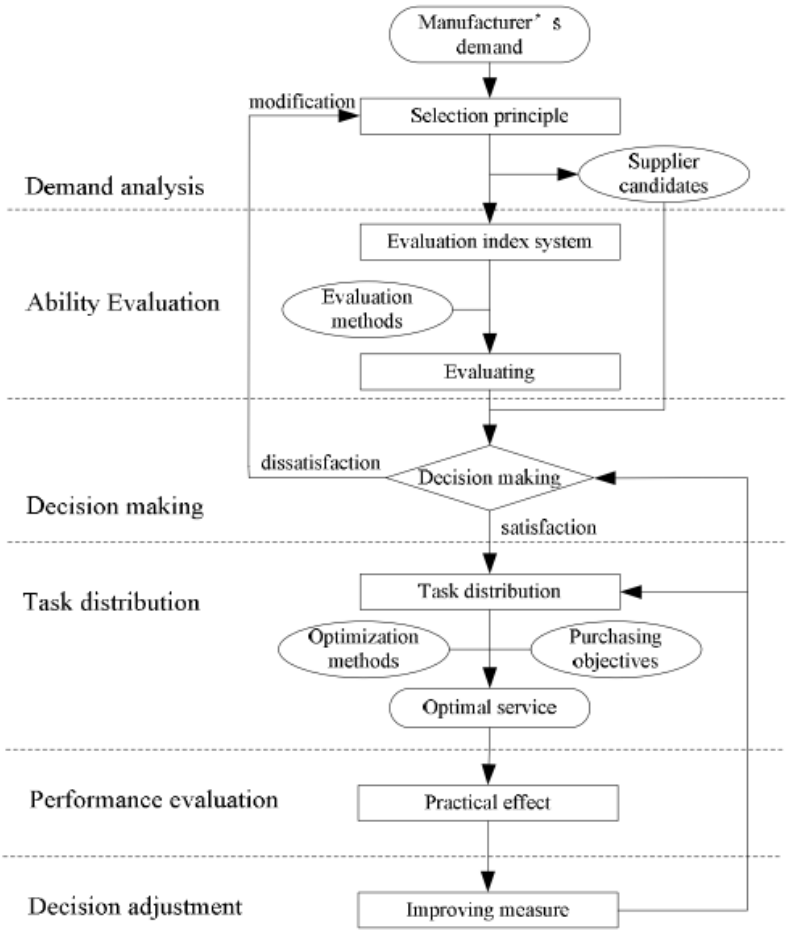

Figure 3: The process of supplier management basing on service optimization.[18]

[17] Vgl. K.Chen; W. Guo; J. Wang, 2008, S.2
[18] Vgl. ebenda

To develop an evaluation strategy, the decision of which supplier needs to be measured has to be made in advance. In order to do this the supply base has to be segmented. Segmentation means categorizing suppliers for the purposes of allocating the appropriate resources to manage and monitor them.[19]

Some of the most common segmentation tools are using dimensional criteria such as risk, cost, quality, delivery, service, technology, product development, responsiveness and communications.[20]

Unless the company is willing to invest in tools for gathering and analyzing performance data, it is limited in its possibility to actually track the supplier with the internal resources originating from both human and information technology.[21]

A classic segmentation method that can be found in many text books is the portfolio method by Kraljic. Suppliers will be segmented into four categories in a matrix with the 2 dimensions Profit Impact and Supply Risk (Fig. 4).

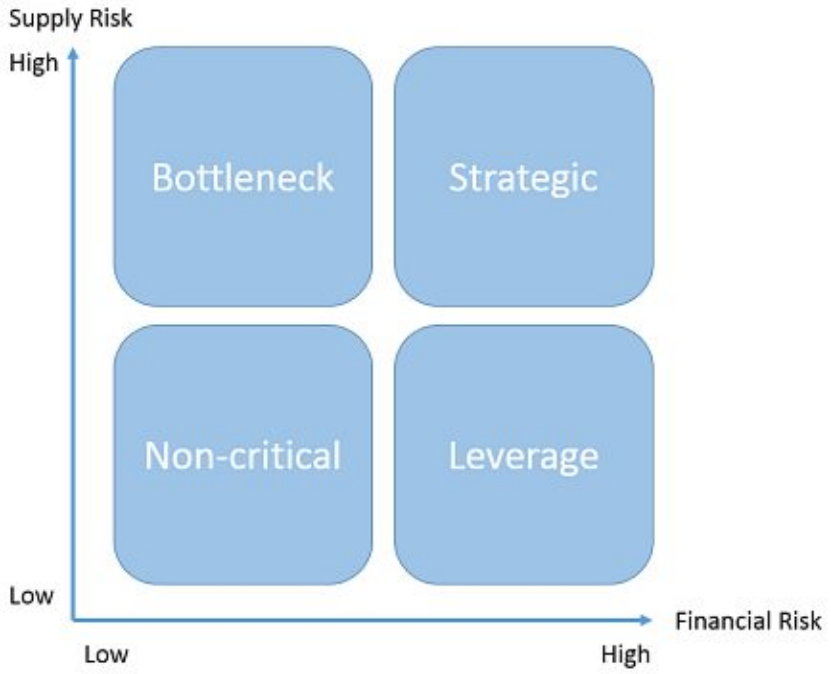

Figure 4: Kraljic matrix.[22]

Non-critical suppliers

On the button left of the matrix are the non-critical suppliers. Those suppliers are easy to replace and their product and services are not critical or of high risk for the company.[23]

[19] Vgl. S. R. Gordon, 2008, S.43
[20] Vgl. Ebenda, S. 57
[21] Vgl. Ebenda, S. 58
[22] Vgl. P. Kraljic, 1983, S.111
[23] Vgl. P. Kraljic, 1983, S.112

Leverage suppliers

When dealing with leverage suppliers, the company should increase the volume of the purchase due to the possible financial impact on the business. The focus should lie on the total cost of ownership and good profit margin.[24]

Bottleneck suppliers

With high supply risk and low profit impact on the company, those suppliers can create a problem if they fail and are therefore should be put into consideration for performance monitoring.[25]

Strategic suppliers

These suppliers are important due to their high value and impact on their customers business and business goals. The target should be to establish a long term partnership with the supplier to archive mutual interest.[26]

A common problem during the application of the Kraljic model is that some suppliers are hard to categorize. This can be the case due of the lack of guidelines for quantifying the factors risk and profit impact.

In the case of this work, a complete evaluation is not possible due to the following reason:

- Only limited possibility for supplier audit is available during the preparation of this thesis.
- Some information can only be obtained through existing business experience with the supplier. This lack of information needs to be considered for this work.

Taking those factors into consideration a new evaluation strategy has to be developed in order to obtain the information needed for the evaluation process. According to Gordon, standalone metrics borrowed from other companies have a low chance of success because they are not part of an overall supplier management program. Furthermore they those metrics do not relate to the overall companies goals and objectives.[27]The method development by Gordon provides with a structured plan on the development of a supplier evaluation strategy. This includes the deployment of the measurement strategy, the supplier qualification as well as the supplier evaluation. Therefore the supplier evaluation of this thesis will utilize the tools provided by Gordon.

[24] Vgl. P. Kraljic, 1983, S.112
[25] Vgl. ebenda
[26] Vgl. ebenda
[27] Vgl. S. R. Gordon, 2008, S.6

2.4 Survey technique

In his book Causal models for supplier evaluation Wolfgang Irlinger stated that supplier evaluation methods can be divided between quantitative and qualitative methods. While the quantitative methods are using equation systems to find the optimal solution, the qualitative methods are an entire subjective estimation and are driven by the impact on certain objectives.[28]

A drawback of the quantitative methods is its ineffectiveness in the case of missing information. This can be a common problem when applying this kind of methodology on Chinese suppliers without previous business records.[29]

One common approach of a supplier selection and evaluation process is through surveys or questionnaires. They provide a structured way to gather information. There are a few key elements that will impact the quality of the survey result.[30]

- The survey deployment methods has an impact on the effectiveness of the survey itself. In the electronic era, hard copy are the most inefficient information gathering method. Telephone surveys on the other hand may help to enhance the relationship because they are more personal. A good and experienced interviewer can increase the cooperation rates.[31] The main problem of conducting a telephone survey is to find the appropriate person at the supplier and to set up the meeting. In order to maximize the results, for this work, a combination of both the telephone and the electronic survey will be used to acquire the necessary information.[32]
- The purpose of the survey must be clarified and communicated with the supplier. The reason of the information gathering and the impact on the business opportunity are of great concern for the supplier. A lack of understanding on the supplier side will result in loss of cooperativeness.[33]
- In case of an electronic survey, it should be well constructed and the survey length should also be taken into consideration. Too many questions may result in an incomplete fill out of the survey. On the other hand, certain questions are essential when evaluating the supplier. Thus the quality of the survey may impact the likeliness of the supplier to complete the survey.[34]
- The confidentiality must be guaranteed since some suppliers don't want their product and financial information to be leaked to third parties.[35]

[28] W. Irlinger, 2012, S.39
[29] Vgl. Ebenda, S.40
[30] Vgl. S. R. Gordon, 2008, S.103
[31] S. Fritz, 2004, S.22
[32] Vgl. S. R. Gordon, 2008, S.104
[33] Vgl. ebenda, S.105
[34] Vgl. ebenda, S.143
[35] Vgl. ebenda, S.106

- The language of the survey should be chosen accordingly. It is easy to perceive the preference in language during the telephone interview. This language should then be used for the electronic survey.[36]
- Furthermore the cultural background can in some cases lead to a distortion of information quality since the supplier may try to make a good impression by adapting their answer to the presumably most desired response of the questioner.[37]

Scorecards are the preferred method of displaying supplier performance since it shows many elements of performance at a glance. At the same time it offers a clear comparison to other suppliers that have been evaluated under the same conditions.[38]

In a new supplier qualification process, information is typically gathered directly from a supplier. Depending on the qualification process, information can be gathered via an RFI (request for information) in an electronic sourcing system, through questionnaires, and through site visits or on-site audits. The level of detail of the information gathered depends upon how critical or strategic the prospective supplier is to the business.[39] RFI surveys are suitable tools for acquiring information about suppliers and their performance. They provide a structured way for feedback and ease the supplier rating process. This can be done via telephone, mail or Internet.

The decision of which process should be used depends on the current situation.

Three options are available for this work:

- **Site visit** should be performed on suppliers which are critical or strategic to the business. If for example the switching costs are too high the supplier can be considered strategic supplier. Suppliers with high spending level and single sourced suppliers should be marked as critical. In order for the site visit to be successful, a cross functional team should be appointed with expertise to see what is missing at the supplier as well as see through attempts to hide issues. Site visit is not a viable option for this work due to the limitation of resources in human and technology.[40]

- An **Electronic survey** is the easiest way to acquire information from supplier and can be done in a very structured way. Problems occur during the interpretation of the information. Suppliers are sometimes unwilling to provide with certain information. This lack of information makes it very hard to do a unified supplier rating.[41]

[36] Vgl. S. R. Gordon, 2008, S.108
[37] Vgl. ebenda
[38] Vgl. ebenda, S.113
[39] Vgl. ebenda, S.109
[40] Vgl. ebenda
[41] Vgl. ebenda, S.104

- By doing a **telephone survey** the communication with the supplier will be raised to a more personal level. Furthermore additional information could be obtained from the comments of the supplier during the phone call.[42]

The method used for this work is a combination of an electronic and a telephone survey. Some supplier visits are also performed in order to verify certain characteristic issues of Chinese supplier.

The reason for choosing this form of information survey is due to its scoreboard compatibility. It enables the possibility to compare the results for each supplier since the questions are stated uniformly. The telephone interview has been used to clarify the purpose of the survey as well as to inquire product specific information using the elaborated requirements. Due to initial communication difficulties during the telephone interview, the conveyed information regarding the requirements of the product quality has to be put into question. This has to be taken into consideration during the supplier evaluation.

[42] Vgl. S. R. Gordon, 2008, S.104f

2.5 Determining the weightings of the evaluation criteria

As stated by Valerie J. Stueland during the 89th annual international supply management conference in 2004: “The majority of supplier evaluations, throughout the variety of industries include some form of weightings. The weighting scales include percentage per criterion and numerical values. Other form of weighting that may not be extremely obvious can be based on the number of subcategories under each criterion heading.” For example if the measures that relate to quality outnumbers the measures that relates to delivery, then the quality factor should be given more weight on the total weighting.[43] There is no clear statement which factor should receive the most weight. This should be determined by industry specific factors as well as the main targets of the company that conducts the evaluation.[44] According to Theo K. Dijkstra: “in many multi-criteria decision problems people have found it very useful to impose a hierarchy on clusters of the aspects or dimensions defining the problem, and to determine the relative importances clusterwise. The verbal intensity of importance is translated into numbers, using scales that appear to work well in practice.”[45]

By using methods like the pairwise comparison, a weighting system can be created.[46]

- If criteria A is more important than criteria B, one can put in a value of 1
- Reversely If criteria A is less important than criteria B, a value of 0 can be used to express this.

The weighting will be evaluated according to the goals of the chosen company and its requirements for the supplier. It has to be said that the resulting weighting differs according to the priorities set by the specific company. This weighting will be used for the supplier rating system in Chapter 6.4.6 of this work.

[43] Vgl. V. J. Stueland, 2004, S.2
[44] Vgl. ebenda, S.3
[45] T. K. Dijkstra, 2010, S.2
[46] Vgl. J. Feldhusen, 2013, S.388

3 Company Introduction

The topic for this thesis has been generated in collaboration with an Austrian-based automotive research and development firm. The idea is to further increase the efficiency and service quality of the supplier selection process for the local and international OEM customers.

3.1 AVL company profile

AVL List (Anstalt für Verbrennungskraftmaschinen List) is an Austrian-based automotive consulting firm as well as an independent research institute. It is the largest privately owned company for the development of powertrain systems with internal combustion engines (ICEs) as well as instrumentation and test systems.[47]

With over 60 years of experience in the automobile engineering, AVL has expanded the business from engine development to offering its customers tailored solutions in development of[48]

- Internal combustion engines
- Transmissions
- Complete powertrain systems
- Hybrid and electric drives

The company has been founded by Prof. Dr. Hans List in 1946 as an independent engineering office and has now expanded to an international technology supplier with over 6000 employees. It is the largest privately owned company for the development of powertrain systems with internal combustion engines (ICEs) as well as for instrumentation and test systems. As part of its consulting business, AVL assist the OEM not only during the powertrain development process but also during supplier selection. In order to ease and to standardize the search of the suitable supplier, a new SRM (supplier relation management) platform has been established. Its objective is to gather key information from the supplier and prepare them for evaluation. The input needed for the evaluation process can be provided directly by the supplier or via a key user within AVL.[49]

In order to enhance business relationship with Chinese customers AVL has expanded to China with the construction of a tech center in Shanghai operating for more than 10

[47] Vgl. URL: https://www.avl.com/web/guest/company (04.09.2015)
[48] Vgl. ebenda
[49] Vgl. URL: https://www.avl.com/web/guest/supplier-portal (04.09.2015)

years. Plans to establish a new tech center in Tianjin has been approved and the construction work began in 2013.[50]

Since AVL is purely a powertrain development company it has an excellent reputation amongst the automotive suppliers since it provides business opportunities by integrating the suppliers into the development process and hence establishing a connection between supplier and OEMs.[51]

3.2 Supplier relationship management

As a design company for powertrain systems. AVL is maintaining a unique relationship with suppliers for powertrain components. During the specification and planning process, certain technical requirements will be defined. Suppliers will be selected according to the given requirements and this information will be redirected to the OEMs. The task of AVL in this case could be compared to that of a mediation company. It establishes the connection between its customers, the OEMs of the automobile industry and the suppliers as part of its service.[52]

This process will be supported by the new supplier relationship management database hereby referred as SRM (Fig. 5). New suppliers can be added through 3 various registration processes.[53]

- Through a supplier self-registration process via the official online SRM portal. By providing the requested information upon registration the supplier will become visible to the SRM admins who will then decide for the information release.
- Supplier with existing contact could be pre-registered by the purchase through existing contacts. A notification message will be send to the supplier with the request to finish the registration process.
- SRM Admins are able to feed the database with information of any supplier at any given time. This includes information of existing business supplier.

[50] Vgl. M. Ksela, AVL opened second technical center in China. In AVL press release, 2015
[51] Vgl. F.J. Fischbacher, 2013, S.5
[52] Vgl. ebenda, S.6
[53] Vgl. AVL List GmbH, AVL Lieferantenregistrierungshandbuch, S.1

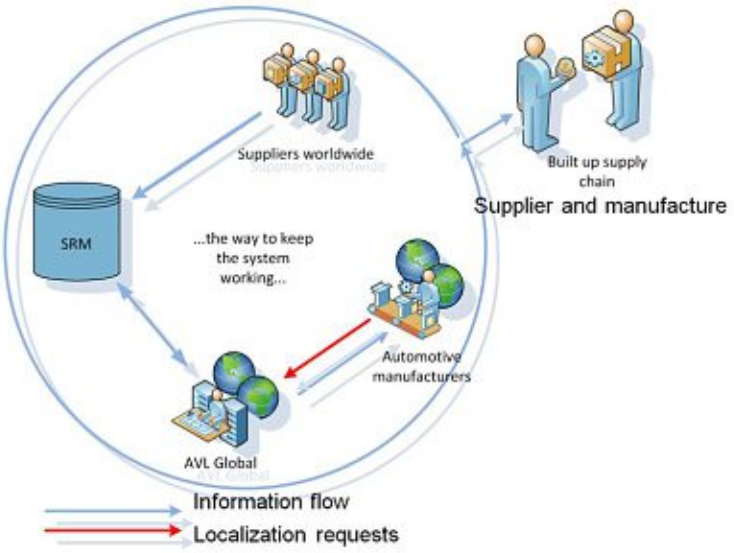

Figure 5: AVL supplier relation management.[54]

The advantage of using technology as part of managing supplier performance is its ability to scale the evaluation process in a way that is not possible through more manual, resource-intensive means. Software can give you the tools to do more with less. When well implemented, this compensates for the missing interaction with the customer to some extent.[55] Since the implementation of the SRM database three supplier workshops have been organized within China. It was intended to provide a platform for information exchange. Suppliers were also asked to register into the SRM platform. During the supplier self-registration process the supplier will be asked to provide with product information. This led to some problems. SRM has a predefined database for the products. To choose the right product, the supplier has to go through the list and mark the product that he is providing with. But some of those products are either not in the list, or could not be found within the list. This leads to an incomplete registration process.[56]

In the SRM approach, where all supplier information will be fed into a unified database may also have a negative impact on the perception of Chinese suppliers. It seems that this concept does not align with the traditional way of Chinese business relationship, where interpersonal relationship plays an essential role in the trust-building process between firms. While a unified request for information could be sent to all the suppliers within the database, Chinese suppliers in general could interpret the lack of work offers despite the large amount of information requests as an incapability of forming a successful business relationship. According to Steven Ganster: “In the North American business arena, SRM is often perceived as a software-based approach to managing relationships and communications. But when companies enter developing markets like

[54] AVL List GmbH, AVL Supplier Relationship Management, S.12
[55] Vgl. S. R. Gordon, 2008, S.131
[56] Vgl. AVL List GmbH, AVL Lieferantenregistrierungshandbuch, S.8

China, SRM ceases to be mainly about implementing software to impose uniformity and provide efficiencies. Instead of focusing on the "management" part of supplier relationship management, the key word in China is "relationship.""[57]

[57] URL: http://www.supplychainquarterly.com/topics/Global/scq200901china/ (01.12.2015)

4 Fundamentals / Theory

This chapter will provide the theoretical background needed for understanding the characteristics of the Chinese supplier business. This includes the common practices that are currently used for the evaluation of Chinese automotive supplier

4.1 Current knowledge on the evaluation of Chinese automotive supplier

Supplier selection is the decision making process by which the buyer has to identify and evaluate a broad spectrum of options in order to find the most suitable candidate that aligns with his target of operation. In return the firm can expect significant benefits form contracting with suppliers offering high value. As an established management science discipline and part of the supplier management process, many literature can be found sorely dedicated to this topic. The supplier selection approach suggested by Akinc minimizes the annual material cost and quantity of the suppliers while focusing on suppliers with a high performance of delivery and quality.[58] Roofhooft and Konings improved a supplier selection and evaluation system by an actively based costing approach. This system allows the calculation of the total cost caused by a defined supplier in the production process of the enterprise.[59] Chan proposed five new performance indicators as an addition to the classical performance criteria: Source usage, flexibility, transparency, trust and innovation.[60] The supplier evaluation and performance excellence by Sherry R. Gordon provides with an established guideline to create a structured supplier evaluation.[61] Further literature will be listed as supplementing literature in within the bibliography.

The high quality requirement for the automotive industry can be related to the passenger safety issues. Suppliers were asked by the car manufacturers to certify their quality management system according to national and regional standard. Due to the many complexities that arises from the large amount of certificates required the urge for harmonization and standardization emerges. The ISO/TS16949 is a technical specification aimed to address the issue of country-specific quality management systems. [62] Today a supplier without a valid certificate has little chance of supplying a Tier 1 supplier with standard parts.[63]

[58] Vgl. U. Akinc, 1993, S.107ff
[59] Vgl. F. Roofhooft; J. Konings, 1996, S.97ff
[60] Vgl. F.T.S. Chan, 2003, S.3549ff
[61] Vgl. S. R. Gordon, 2008, S.8
[62] Vgl. Technical Specification ISO/TS 16949, 2002, S.9
[63] Vgl. Daimler Global supplier magazine, 4th quarter, 2002, S.17

Despite the effort of standardization, supplier performance issues still remain a major concern for the automotive manufacturers. Many firms have therefore established their own internal supplier evaluation approaches to ensure the fulfillment of supplier performance. Depending on their scale of operation, those supplier evaluation criteria can become very strict. With the rapid growth of the Chinese automotive industry, the focus begins to shift towards the development of local supplier for future sourcing operations. According to Ke Chen an efficient supplier evaluation should also consider the suggestions from government, suppliers and other concerned participants. Basing on the result of a questionnaire conducted by China Automotive Technology & Research Center, differences towards to the common cooperate practices could be identified.[64]

[64] Vgl. K.Chen; W. Guo; J. Wang, 2008, S.2

4.2 Characteristics of Chinese suppliers

In order to maintain a well-kept relationship towards the business partner, it is essential to have good relational constructs such as trust, commitment and satisfaction. The Chinese definition of the business relationship differs from that of the western practitioners. “Guanxi” (关系) refers to a special type of personal relationship that is based on mutual interests of the business partners. While conducting business in China, the Guanxi approach is often the most efficient and effective way of daily operations.[65]

Compared to the western business relationship practices, three major differences can be seen.[66]

- The Chinese concept of Guanxi focuses on a reciprocation of favors. If a favor was given by a business partner, it must be repaid with increased value.
- Personal relationship is established through gift-giving and dining.
- It is a utilitarian approach without any emotional attachment thus does not necessarily involve friendship.

For enterprises without an established Guanxi relationship, it is often not a wise choice to directly taking this approach. In this case the focus should be earning the trust through performance before forming the Guanxi tie.[67]

A standard practice in the West is to submit a request for quotation (RFQ) and expect a response without any obligations. In the Chinese business environment however, where business relationship plays an essential role, it is often more than just simply asking for some information. If too many quotes are sent without offering any work, it is often interpreted as a form of incapability of forming any business relationship. The supplier will become less cooperative, especially if the order quantity is not crucial for the operation of the supplier. In order for a successful business relation to form it is important that both parties are able to maintain a sound reputation even during failed decision making. Instead of playing the blame game it is recommended to look for a solution that will demonstrate a good character for both parties. This step may require one party to take on some initial risk and take a small hit, but will pay off in the long run since it lies within the nature of Chinese business culture to remember and repay favors that they owe.[68]

[65] Vgl. Z. Chen, 2011, S.569
[66] Vgl. ebenda, S.570
[67] Vgl. ebenda
[68] Vgl. URL: http://www.getyourstuffmadeinchina.com/working-with-chinese-manufacturers.pdf (03.03.2015)

4.3 China specific problems and methodology of acquiring supplier information

When selecting a supplier in China, a due diligence can prevent the risk of contracting a supplier who is involved in any kind of financial lawsuits.[69]

Before 2013, information regarding Chinese companies that have defaulted on court ordered payments were not accessible to the public. This also includes companies who don't or can't pay for the damages done during some business activities. In 2013 the Chinese government released a master list with the name of all the companies that have bad business records. The list is available online and is written in Chinese.[70]

Background checks can also be conducted by using paid services offered by international companies such as GloBIS or China Checkup. Their services range up from legitimacy verification, financial information to expert analysis. A full historical report can be expensive, thus making this only a viable under the circumstance of a small group of suppliers. By narrowing the potential supplier pool to a manageable amount, makes it easier to increase the focus and quality of the information of those supplier. A common approach is the evaluation of the supplier financial condition.[71] This approach will be further discussed in Chapter 6.1.3.

Nevertheless it is recommended to conduct a due diligence prior to signing a contact in order to minimize the risk and provide the decision makers with more accurate information.[72]

[69] Vgl. A. Wurzer, 2009, S.20
[70] Vgl. URL: http://shixin.court.gov.cn/ (08.09.2015)
[71] Vgl. R. J. Trent, 2007, S.167
[72] Vgl. KPMG: Mitigating risk in your supply chain – The power of due diligence, 2011, S.9

5 Supplier landscape

In March 2014, the sales of passenger cars in China have reached 2.169.100 units. With global players such as VW, Toyota and General Motors entering the market, the local manufacturers have also been pressured to improve their standard in order to be able to compete on domestic ground. Although designs are still largely imported, the amount of locally sourced content has risen, with a range of contracts awarded to Chinese and Joint Ventures between Chinese and foreign suppliers. As for today, all of the top ten global first tier suppliers have set up operations in China.[73]

Chinese suppliers have gained competiveness in terms of unit costs. This can be derived from low wages as well as from the incentives provided by the provincial governing bodies. Yet most of them still have substantial lack of product development capabilities, as demonstrated in the example of UK's MG Rover. Rover had initially contemplated a Joint Venture with Brilliance in 2002, and then sold the intellectual property of two models and several engines to Shanghai Automotive Industry Corporation (SAIC) in 2004 in the hope of a full merger that did not happen. The remaining assets were sold to Nanjing after Rovers financial collapse in April 2005. It is obvious that the main motivation of this merger is to acquire the technology and manufacturing equipment.[74]

The reason for this strategic changes are:

- Companies can no longer limit their cost saving efforts internally and have to work with suppliers to reach their strategic goals since the external spending of a company can account for 60% or more in different types of industries.[75]
- Suppliers with specialized technologies and competencies will have a substantial impact on the customers innovation and overall product quality performance[76]
- Suppliers day-to-day performance demonstrated in delivery time, production quality, and reliability is influential to a buying firm[77]
- Many companies rely heavily on their suppliers to provide good quality products and services and even meet legal and regulatory requirements.[78]

In order to be lean during the manufacturing process, the supplier base has to be reduced to an absolute minimum. This underlines the importance of adapting a supplier

[73] Vgl. N. Oliver, 2009, S.10
[74] Vgl. ebenda
[75] Vgl. C. H. Heberling, 1992, S.39ff
[76] Vgl. J. H. Dyer; K. Nobeoka, 2000, S.346
[77] Vgl. Tan; Kannan; Hanfield, 1998, S.1
[78] Vgl. S. R. Gordon, 2005, S.20

evaluation technique that can help the company to identify the suppliers most suitable for their manufacturing requirements.[79]

While existing suppliers expand their capabilities through mergers, acquisitions, and partnerships, new suppliers as well as foreign suppliers have entered the Chinese supplier market. In such a dynamic supplier landscape, it is important that buyers have a clear understanding of available suppliers that meet their unique needs in terms of quality demand as well as geographic coverage.[80] In comparison with the OEMs, the supplier base is highly fragmented with the top 10 suppliers only accounting for 20% of the total sales revenue in 2004.[81]

The following wave of globalization marks the beginning of operation expansions like the deployment of R&D and extensive local sourcing activities.[82]

By using the five-stage model from the Boston Consulting Group, suppliers as well as OEMs can be put into 5 different categories:[83]

- Home players serve China only by exporting low volumes from their home bases.
- Exporters have a minor local presence. Key functions are under tight control from headquaters.
- Explorers have some independent functions in China, but the headquaters still has major impact on overseas decision making.
- Settlers act relatively independent from headquarters and have local staff performing many key functions.
- Global players have strong autonomy for local operations, global responsibility for certain products and functions and are most advanced in the localization ladder.

Most of the supplier have departed from solely being a home player to progress into becoming global players. The reason why Suppliers tend to be ahead of their OEM partners in terms of localization strategy is due to the fact, that most of them are being pressured to operate in low-cost countries. Furthermore it is much more feasible for the supplier to shift their advanced operations to China because their business tends to be less complex than that of their OEM partners. The following picture illustrates the position of Chinese automotive suppliers in comparison to the OEMs (Fig. 6).[84] In terms of localization, suppliers are leading their OEM counterparts in each category.

[79] Vgl. J. Xia, 2009, S.2
[80] Vgl. ebenda
[81] Vgl. N. S.Lang, 2008, S.6
[82] Vgl. ebenda, S.8
[83] Vgl. ebenda, S.9
[84] Vgl. ebenda, S.10

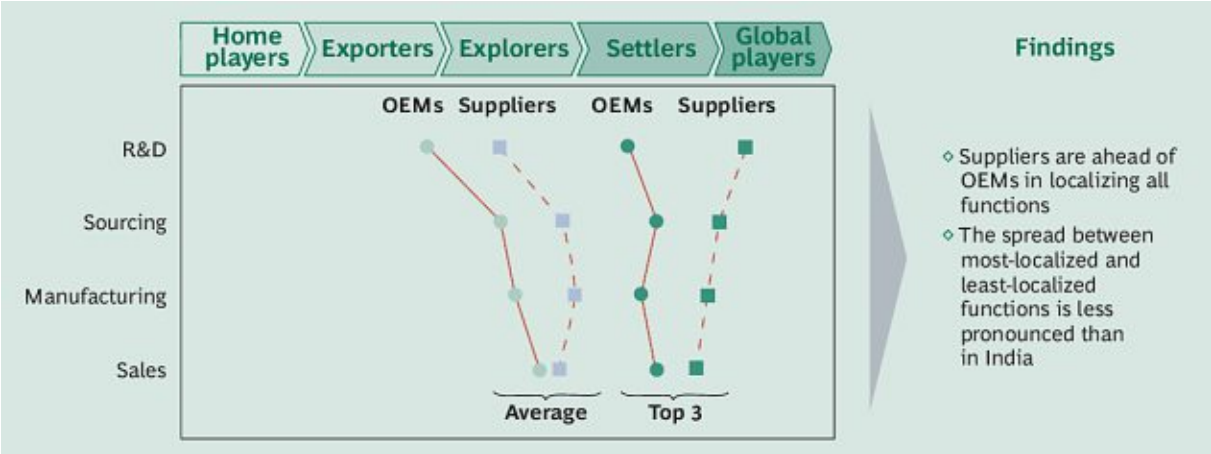

Figure 6 : Position of Chinese Supplier in comparison to the OEMs.[85]

This exhibit reflects data from 57 automotive OEMs and suppliers that are active in China.[86]

A majority of the suppliers have established industry clusters by following their OEMs. Clusters are also the result of the current economic and population development, thus well developed areas with great customer presence and large amount of educated workforces are preferred.[87]

This can be illustrated by looking at the Top 10 Chinese local OEMs. This also includes the foreign OEMs that are obliged to form a joint venture with their Chinese partners in order to gain access to the Chinese market. The following picture showcases the important locations from which those 10 OEMs handle most of their value adding processes (Fig. 7). It has been created to visualize the local industrial clusters. Their corresponding joint venture partners are shown in table 2.

[85] Vgl. N. S.Lang, 2008, S.10
[86] Vgl. ebenda
[87] Vgl. ebenda, S.8

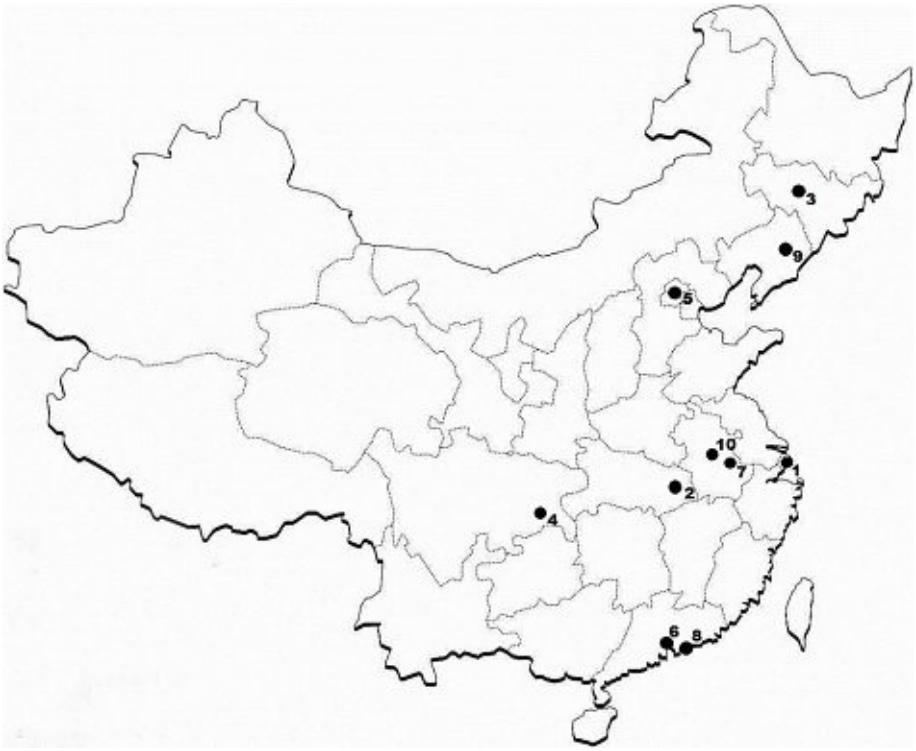

Figure 7: Top 10 Chinese Local OEMs.

Top 10	Name	Sino-Foreign Joint Ventures
1	SAIC	General Motors, Volkswagen
2	Dongfeng	Nissan, Citroen, Honda, Kia
3	FAW	General Motors, Volkswagen, Audi, Mazda, Toyota
4	Changan	Ford, Mazda, PSA, Suzuki,
5	Beijing Auto	Daimler Benz, Hyundai
6	Guangzhou	Honda, Toyota, Fiat, Mitsubishi
7	Chery	Qoros
8	BYD	Daimler
9	Brilliance	BMW
10	JAC	-

Table 2: Chinese-Foreign Joint Ventures for the Top 10 Chinese Local OEMs.[88]

In order to create a supplier landscape, it is important to gather reliable information about the local component suppliers.

This work will mainly focus on suppliers of automotive transmission components. Thus a list with potential transmission component suppliers has been created with information acquired using the methods mentioned in Chapter 2.2. This information will be used to identify the local clusters for the supplier landscape.

[88] Vgl. URL: http//chinaautoweb.com/auto-companies/ (12.03.2015)

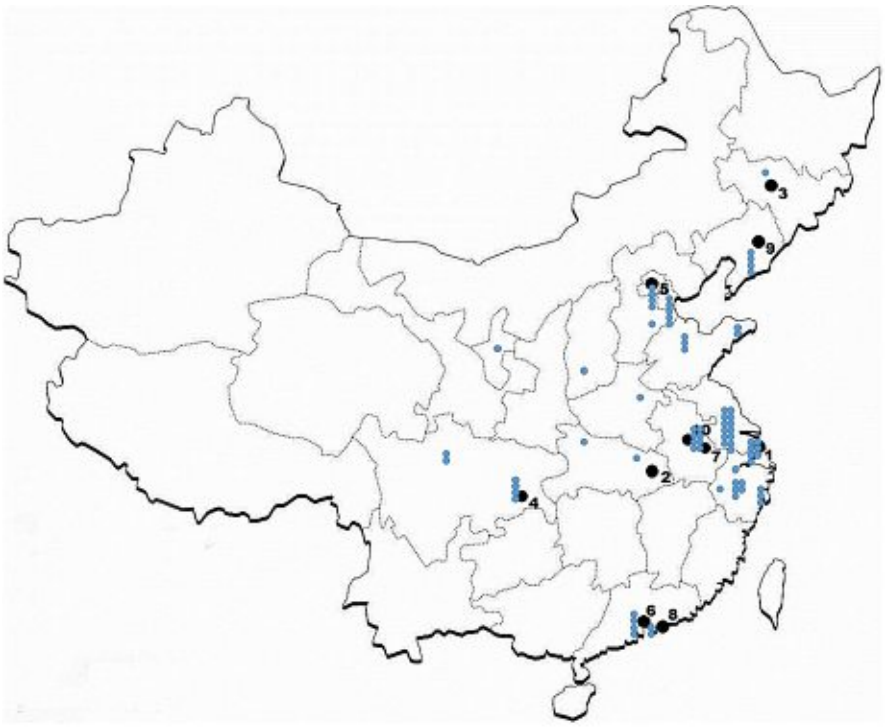

Figure 8: Chinese automotive transmission component supplier landscape.

In figure 8, each dot represents a transmission component supplier that has been previously identified through the five methods mentioned above. The observation of the concentration of suppliers at the eastern coast of China suggests that industrial clusters have formed around specific regions.

This is mainly due to a combination of the following reasons:[89]

1. Infrastructural advantages
2. Customer intimacy
3. Regional government incentives
4. Qualified labor through better education

It should be mentioned that similar images could be observed through a variety of different industries with a predominated share at the eastern part of the country.[90]

[89] Vgl. Boston Consulting Group: Sourcing from China, 2007, S.1
[90] Vgl. URL: http://www.chinasourcingblog.org/2011/11/chinas-industrial-clusters.html (23.03 2015)

6 Development of evaluation strategy

The development of an evaluation strategy begins with the development of measuring criteria. Depending on the goals of the company conducting the evaluation as well as the related industry, the criteria that have to be measured may vary. After identifying the measuring criteria, the expectations toward the desired supplier performance have to be defined. This allows the implementation of a weighting system that will furthermore be used in the supplier evaluation and rating system. The implementation of this evaluation system will then be demonstrated for two suppliers of transmission synchronizer assembly systems.

6.1 Development of measuring criteria

As a technology consultant, AVLs strategic objective is to become a joining link between supplier and OEMs worldwide by establishing a well-founded database and by actively integrating supplier into the localization projects.[91]

Nowadays procurement is closely linked to strategy formulation by senior management and effective management of the supply chain partners affects firm performance. One such critical and highly researched domain in procurement literature is that of supplier selection. However, too many supplier evaluation criteria have been used across studies and there is a need of consolidation (Fig. 9).[92]

[91] Vgl. F.J. Fischbacher, 2013, S.6
[92] Vgl. A. K. Kar, 2014, S.91.

Snapshot of different supplier evaluation criteria used across literature		
Product quality	Delivery reliability	Warranties
Product pricing	Production capability	Technical capability
Management capability	Supplier's reputation	Financial position
Labor relations	Service quality experience	Past business records
Reciprocal arrangements	Cultural fitment	Communication barriers
Geographical distance	Foreign exchange rates	Trade tariffs
Trade restrictions	Buyer's commitment	e-transaction capabilities
Quality management	IT standards	Cost reduction capability
Documentation	Design capability	Supply variety
Lead time/response time	Indirect costs	Response flexibility
Innovation	Facility planning	Safety adherence
Domain experience	Exporting status	Conflict resolution systems
Customs duties	Product line diversity	Intimacy of relationships
Inventory position	Electronic data interchange	Value-added productivity
Total cost of acquisition	Risk perception	Certification and standards
Research and development	Organizational culture	Availability of parts
Sub-component pricing	Regulatory compliance	Self-audits
Billing accuracy	Cost reduction performance	Indirect costs
Service quality credence	Supplier's commitment	Skill level of staff
Exporting status	Packaging capability	Intellectual property rights
Data administration	Improvement commitment	Procedural compliance

Figure 9: Supplier evaluation criteria.[93]

The requirement to the supplier of the automobile business has shifted during the recent years. Suppliers are required to offer more value-added processes such as full design control, testing and validation and global availability. The Era calls for a more competitive supplier that will take on value-added services. By choosing a partner that can take on more value-added services plays an essential role in performance excellence.[94]

[93] A. K. Kar, 2014, S.91.
[94] Vgl. URL: http://www.automotiveworld.com/analysis/suppliers-analysis/oems-need-the-right-suppliers-suppliers-need-the-right-partners/ (10.11.2015)

By covering all supplier selection criteria, the complexity of the survey would increase. As a good reference for the supplier evaluation criteria and in order for a supplier to pass the selection process, it has to fulfil the basic expectations of the OEMs in terms of financial stability, Development capability, Technology and Service (Fig. 10).

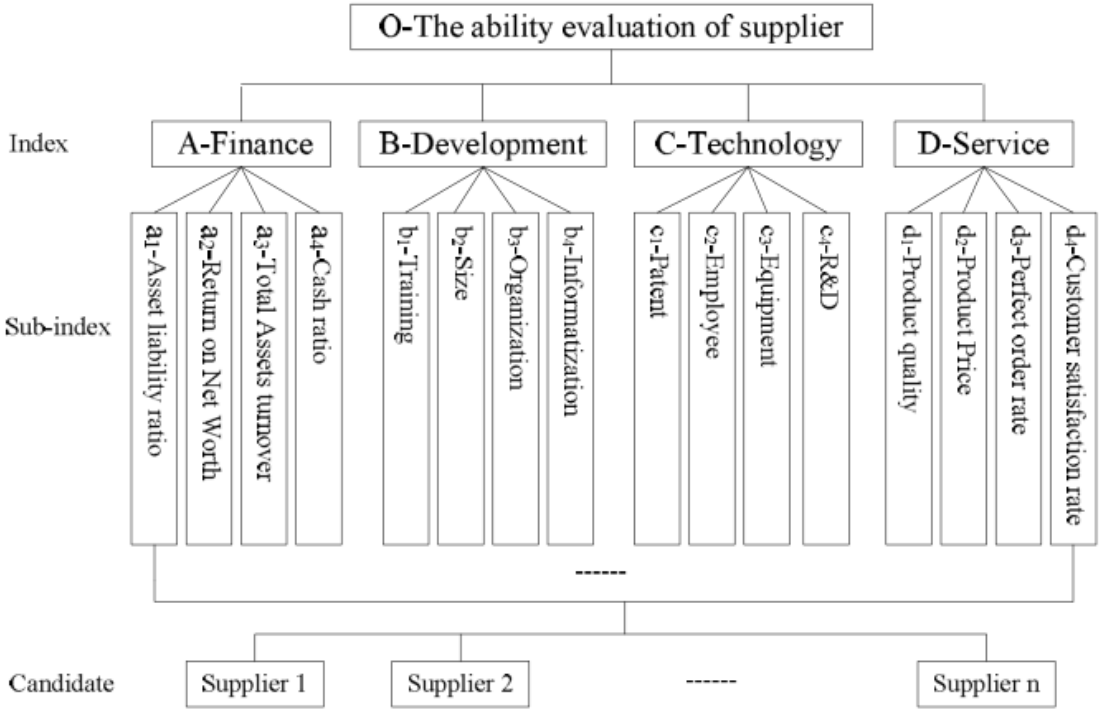

Figure 10: The ability evaluation index system[95].

[95] K.Chen; W. Guo; J. Wang, 2008, S.2

6.1.1 Service

First and foremost the importance of the product quality must be emphasized. During the past few years 3rd party quality inspection companies have been assigned to provide full time support on site at the supplier in order to ensure the product quality and process stability. The Chinese automotive suppliers have recognized the importance of quality demand from their customers. In order to improve business opportunity they have adopted international recognized quality standards like ISO 9001 and ISO/TS 16949. In 2010 China accounts to a quarter of all ISO 9001 certifications due to its rapid growth.[96]

ISO/TS 16949 is the only standard recognized worldwide related to quality management and it applies to any organization active in the automotive supply chain. It acts as a voluntary assurance of the product and service quality for the customer.[97] All OEMs (Original Equipment Manufacturer) have declared this technical specification as standard. If implemented correctly, then we should expect a declining number of recalls. However this should be eyed with caution:

In cooperation with the Chinese customer, the AVL team performed onsite visits at their tier 1 suppliers due to quality related issues. Some recurrences reflect common problems residing at Chinese supplier:

Discovery of bad storage conditions has been made at most of the suppliers. This is especially crucial for the machined surfaces as this could lead to the damage of the sealing during the storage phase (Fig. 11).

[96] Vgl. International Organization for Standardization: ISO 9001 Survey, 2013
[97] Vgl. URL: http://www.bureauveritas.com/services%20sheet/iso-ts-16949-certification_1502 (15.11.2015)

Figure 11: Inappropriate storage conditions observed during the supplier audit (2013).

Another common issue is the traceability of parts which led to inaccurate storage time at one supplier for engine hoses systems during the heat treatment (Fig. 12). Due to the missing documentation, the affected parts have undergone a longer heat treatment than originally intended, which led to hose damage during the pressure test. The reason of the damage was the delamination of the connection tissue.

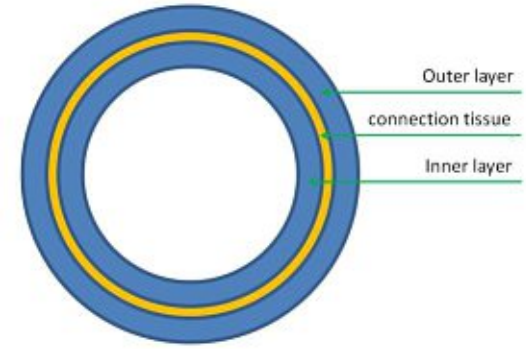

Figure 12: Cross sectional view of an engine water hose (simplified).

According to Roland Berger consulting from 2008 to 2009, OEMs put less price pressure on the suppliers because of the low supply volume. Since mid-2010 however an extreme high increase on price pressure can be seen.[98]

Besides maintaining current profitability and expanding global delivery capability, suppliers must focus even more on product innovation in the future. Only suppliers that

[98] Vgl. Roland Berger Strategy Consulting: Global Automotive Supplier Study, 2011, S.10

can differentiate themselves from the competition via superior products will be able to sustain in the business.[99] The customer satisfaction rate is a measure of how products and services supplied by a company meet or surpasses customer expectation.[100] All customer expectations are not created equal. It is worthwhile to discover which attributes of a product or services are more important to the customer. Products and service attributes behave differently in terms of how they affect customer satisfaction. Therefore It is important to understand both dimensions, the relative importance and its correlation with satisfaction to deliver the attributes in order to attract customers to the brand.[101]

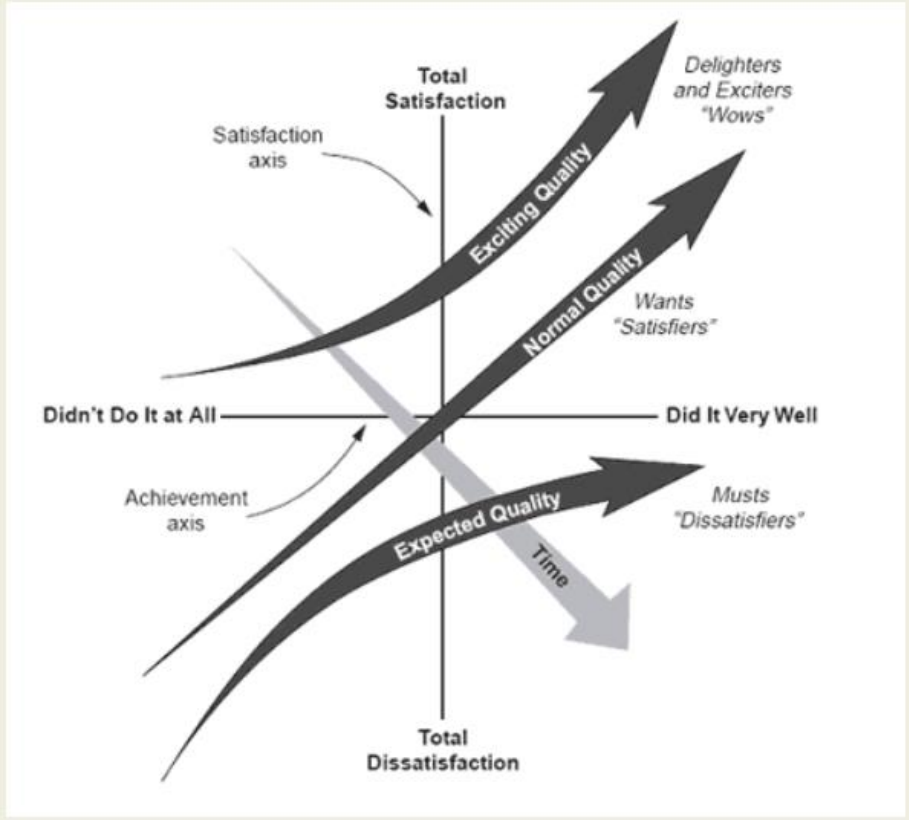

Figure 13: Cano model.[102]

Delighters are bonus features. They are represented as a concave relationship with Customer Satisfaction. The customer satisfaction increases logarithmically with the fulfillment level on these attributes according to the Cano model (Fig. 13). In the case of the automotive transmission a better fuel economy and the fulfillment of a better emission standard could influence the customer in a positive manner.[103]

[99] Vgl. Roland Berger Strategy Consulting: Global Automotive Supplier Study, 2011, S.10
[100] Vgl. P. W. Farris; N. T. Bendle,2014, S.58f
[101] Vgl. Dodson, 2015,S.1
[102] URL: http://asq.org/learn-about-quality/qfd-quality-function-deployment/overview/kano-model.html (15.11.2015)
[103] Vgl. A. Singh; M. Srivatava, 2013, S.866ff (http://www.ijarcsse.com/docs/papers/Volume_3/5_May2013/V3I5-0336.pdf)

Linear Satisfiers are represented in a straight line. Fulfillment and Satisfaction are correlating linearly. This includes features such as Comfort, costs, performance and NVH (Noise Vibration Harshness).[104]

Must-Haves, such as durability are represented by the lower convex curve. Not providing those attributes will have a negative impact on the product and it is most likely to lose out against the competition.[105] According to ETE Reman, an automatic transmission with minimum care can last up to 160,000 km.[106] Neglecting this requirement will result in a negative impact on the final product.

A company is only as strong as its weakest link. It makes a huge difference whether one is dealing with a reactive or a reliable supplier. Large suppliers are generally reliable because they have enough resources and systems in place to make sure they can still deliver if anything goes wrong. When dealing with smaller supplier, the target should be to develop a closer relationship with them while maintaining the position as a main customer. It is generally hard to obtain information about delivery reliability when dealing with new supplier since no business records are available. The perfect order rate measures how many orders are shipped without incidents. Those incidents could be damaged goods, inaccurate orders or late shipments.[107]

[104] Vgl. J. Dodson, 2001, S.1
[105] Vgl. K. Matzler and F. Bailom, 2004, S.273
[106] Vgl. URL: http://etereman.com/blog/transmission-care/from-a-transmission-expert-three-easy-ways-to-extend-the-life-of-your-automatic-transmission (15.11.2015)
[107] Vgl. Hoffmann, 2002, S.1

6.1.2 Technology and development

When talking about technology and development capacity, it usually refers to scientific knowledge that can be applied to design a new product or to improve an existing product.[108]

Technology assets must be seen as an investment to support its mission rather than expenses. Suitable infrastructure has to be provided, including a reliable connectivity between sites as well as the replacement of outdated equipment. An extensive evaluation of the current technology level usually requires a lot of data. By using the 5 steps method a rough evaluation can be made:[109]

Step One: Identify stages of added value

Step Two: Identify required technological capabilities
Each activity needs a certain level of technological capability. The required capability will be assessed during this step.

Step Three: Determine technological capability indices
A set of indices has to be identified to measure the technological capabilities.

Step Four: Comparative technological potential
This serves as a benchmark against the competitors in terms of technology.

Step Five: Gap Analysis
This step provides useful insights regarding the firm's strength and weaknesses.

When talking about the production capabilities, it usually refers to the expertise of certain production process and the ability to apply this process to a variety of applications. The following points directly contribute to the production capability:[110]

- Expertise in the production processes
- Example of past projects
- Age of equipment, In-House or Off-Site
- Expertise of Operators
- Quality assurance

[108] Vgl. Gordon, 2008, S.93
[109] Vgl. Moradnia; Nezhadesm; Navran; Shirvandehi; Alipour; Dehghan, 2013, S.608
[110] Vgl. URL: http://www.gmnaerospace.com/selecting-the-right-supplier-part-1-evaluating-capabilities/ (15.11.2015)

6.1.3 Finance / Risk

Quantitative data regarding risk can be given despite of the uncertainty of the analysis. The result of a study done in March 2007 by the Aberdeen Group uncovered the top risk indicator for the 210 surveyed companies:[111]

- Supplier financial viability
- Supplier credit ratings
- Supply disruptions
- Availability of supplier
- Supplier dependency
- Financial impact of disruptions

A direct connection between risk and the financial situation of the supplier can be identified. There is an increasing trend for large companies to monitor the credit scores of their suppliers for fear that some of the smaller businesses may be at risk of collapsing. They realized that it is to their interest to look after their supply chain and refrain from squeezing their supplier through delayed payment.[112]

Financial information can be obtained through the balance sheet of a company. By using financial ratio, better insight can be gained about a company's financial condition.[113]

Current ratio for liquidity analysis

The current ratio is used to test a company's liquidity by deriving the proportion of current assets available to cover current liabilities. This ratio shows whether the company has the ability to ascertain that his short term assets are readily available to pay off its short-term liabilities. A higher ratio signifies a better liquidity. Acceptable current ratios vary depending on the industry. In most cases if it is less than 1, the company may have trouble paying of its short term obligations. While this means that the company is not in good financial health, it does not mean it will go bankrupt, as there are many different ways to access financing. If the current ratio is too high, it may suggest an inefficient use of assets.[114]

$$Current\ ratio = \frac{Current\ Assets}{Current\ Liabilities}\ ^{115} \qquad (1)$$

[111] Vgl. Aberdeen Group: Supply risk increasing while the market stands still, 2007, S.10
[112] Vgl. Capgemini Consulting: Supplier Relationship Management (SRM) Research 2012-2013, 2013, S.4
[113] Vgl. URL: http://www.investopedia.com/university/ratios/ (03.03.2015)
[114] Vgl. ebenda
[115] Vgl. ebenda

Gross Profit Margin for profitability analysis

The Gross Profit Margin is the ratio of Gross Profit to Net Sales. The gross profit margin is used to analyze how efficiently a company is using its raw materials, labor and manufacturing-related fixed assets to generate profits. It has to be emphasized that the Gross Profit Margin is only significant for producer-type Company. Companies without a production process don't have a cost of sales and can therefore not be rated with this value.[116]

$$Gross\ Profit\ Margin = \frac{Gross\ Profit}{Net\ Sales\ (Revenue)}$$ [117] (2)

This metric can be used to compare a company with its competitors. A higher margin percentage is a favorable profit indicator. It is also useful when comparing against the margin of previous years to identify an increase in efficiency.

Debt ratio for risk analysis

The debt ratio compares a company's total debt to its total assets, which is used to gain a general idea as to the amount of leverage being used by a company. The debt ratio gives users a quick measure of the amount of debt that the company has on its balance sheets compared to its assets.[118]

$$Debt\ ratio = \frac{Total\ debt}{Total\ Assets}$$ [119] (3)

In general, the higher the ratio, the more risk that company is considered to have taken on. The acceptable debt ratio varies by industry. Businesses that require a lot of capital tend to have a high debt ratio compared to technology companies.

[116] Vgl. URL: http://www.investopedia.com/terms/g/gross_profit_margin.asp (15.11.2015)
[117] Vgl. ebenda
[118] Vgl. URL: http://www.investopedia.com/university/ratios/debt/ratio2.asp (15.11.2015)
[119] Vgl. ebenda

6.1.4 Certification and standards

Automotive customers often rely on third party certifications such as ISO 9001 or ISO/TS 16949. This has grown in the recent years due to an increase in low-cost country sourcing and the need to ensure the reliability of the supplier.[120]

When a customer contracts an ISO certified supplier they are expecting that their product is manufactured under the ISO conditions. However this has to be dealt with caution. If the supplier outsources some of his production processes to a non ISO certified sub-contractor, then there is a certain risk for the product to deviate from the expected condition. This is due to the fact that the supplier is not obliged to tell his customer about the outsourced processes even though they are required to define those processes according to the ISO standard.[121]

In order to face this problem, the following demand should be made to avoid any inconvenient disagreements. A request should be attached within the purchasing documents with the objective of obtaining a confirmation that the products are especially produced through the organizations ISO 9001 quality management systems. A notification should be send if this is not the case.[122]

[120] Vgl. Bardhan, 2015, S.71 (http://automotivemegatrends.com/automotive-megatrends-magazine-q1-2015/)
[121] Vgl. URL: http://www.cavendishscott.com/articles-news/iso-9001-articles/in-scope-or-outsourced-is-your-suppliers-iso-certificate-applicable/ (15.11.2015)
[122] Vgl. ebenda

6.1.5 Suppliers reputation / Reliable customers references

Reputation remains the top criteria when selecting preferred suppliers. Applied to the automotive business it is essential to look into this aspect during the supplier selection process. A supplier with good reputation and history of successful projects is more appealing to work with than a supplier with no reputation.[123]

A reliable source of information can be obtained from customer references. Some OEMs have a high requirement for their suppliers. The Volkswagen Group has one of the strictest demand for product quality in the automotive industry. A supplier that received an A-class certification from the Volkswagen Group for example must pass the required quality standard which even exceeds that of the common quality certification.[124]

The Delphi cable harnesses plan in Shanghai for example has already established their cooperate standard on all production and process flows. This earned them the reputation of best practice supplier for the Volkswagen group. This was observed during a plant visit by the author in 2013. Hence customer references could also be taken into account when assessing the supplier.

[123] Vgl. Suh; Houston, 2010, S.744
[124] Vgl. Luo, 2001, S.149

6.2 Definition of performance expectations

In order to establish long term working relationship and to ensure continuous progress to improve performances, a clear set of performance expectation has to be defined. According to Jeff Gary, General Manager of Magna electronics: “Automotive market expectations for Quality, Cost, Service, Technology and Delivery require supreme business efficiency and resourcefulness for profitable growth and long term survival.” There are some common criteria that have established within the automotive industry (Table 3).[125]

Product quality	Documented quality system Proactive failure detection Continuous improvement in the entire operation
Product pricing	Provide transparent information Proactive productivity improvement
Delivery reliability	Comply with contract requirement
Research and development	Provide with technical / process oriented innovation
Responsiveness	Prompt response to request for information Timely technical assistance / corrective action
Financial position	Guarantee financial stability and flexibility
Supplier reputation	Maintain a good reputation
Certification and standards	Comply with the required quality standard

Table 3: Key performance criteria of the automotive industry.

The usual supplier development process will undergo separate stages before entering serial production. Therefore it is important to finalize the framework before entering the next stage in the development process (design validation).[126] Figure 14 shows a simplified version of the supplier development process. Starting from the initiation of the program to the launch of production.

[125] Gary, 2014, S.2
[126] Vgl. ebenda, S.5

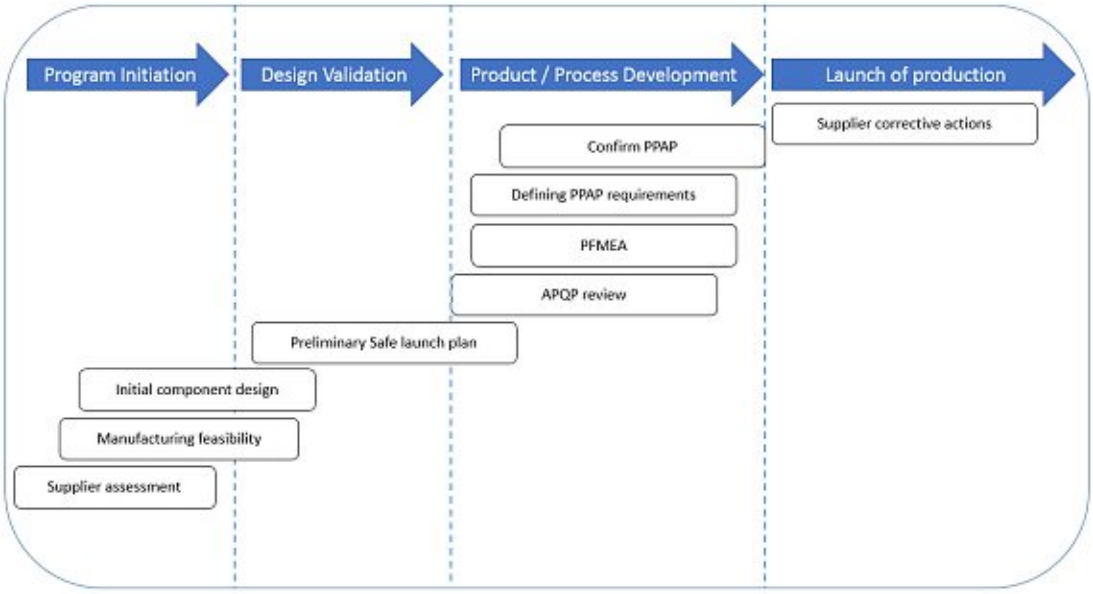

Figure 14: Supplier development process.[127]

Using the method of pairwise comparison, allows for a more precise weight distribution amount a multiple quantitative properties. Figure 15 shows the application of a pairwise comparison in order to determine the weightings for the eight criteria mentioned above. The following weighting has been done in cooperation with an experienced AVL employee with background in transmission technology.[128]

Pairwise comparison of the key performance criteria	Product quality	product pricing	Delivery reliability	Research and development	Responsiveness	Financial position	Certification and standards	Reputation / customer	Σ	%
Product quality		1	1	1	1	1	1	1	7	25.00%
product pricing	0		1	1	1	0	0	1	4	14.29%
Delivery reliability	0	0		1	1	1	1	1	5	17.86%
Research and development	0	0	0		1	0	0	0	1	3.57%
Responsiveness	0	0	0	0		0	0	1	1	3.57%
Financial position	0	1	0	1	1		1	1	5	17.86%
Certification and standards	0	1	0	1	1	0		0	3	10.71%
Reputation / customer references	0	0	0	1	0	0	1		2	7.14%

Figure 15: pairwise comparison.

[127] Vgl. Gary, 2014, S.2
[128] Interview anonymized according to the request of the interviewed person

6.3 Transmission component requirement definition

Each costumer has its own individual set of requirements and expectations toward their supplier. Nonetheless common interest such as achieving superior quality, service excellence, cost and technology leadership are the pillars upon which the supplier development strategy rest on.

Volvo for example places great emphasis on global partners with local supplying capability. The supplier has to provide Volvo with access to innovation as a preferred customer and also offer full transparency in terms of cost and strategy. Toyotas philosophy for the selection process can be summarized into four points. They are looking for supplier with competitiveness in terms of quality, cost, delivery and technological capabilities. As mandatory requirement GM demands that all suppliers must have been certified according to the ISO/TS 16949 quality standard. Some OEMs even implemented additional standard to further improve the internal supplier development process.[129] In addition to these requirements many OEMs have already implemented the Just-In-Time logistics system. Another trend is the promotion of lean manufacturing, the production of durable goods with a minimum consumption of capital investment, floor space, labor, material, time and distance.[130] The question of what kind of requirements a supplier has to fulfil in order for it to be considered a potential supplier needs to be stated at the beginning of the sourcing process. It is also recommended to modify the supplier requirements for different components. This is due to the variation of materials, machining processes as well as technological requirements. One of the frequently discussed issues of this century is regarding the depletion of natural resources. This further accentuates the need for every human to purchase more fuel efficient cars. Having an automobile with good fuel economy is not only helpful in saving money, but it is also an integral part of repairing the environment. Engineers are constantly working to find ways to increase the fuel efficiency of vehicles. Several factors affect fuel economy, so it is a matter of altering those factors to produce better efficiency. The weight of a car is one of the biggest factors in fuel economy, so engineers are always trying to make cars lighter.[131]

Better fuel economy can be achieved through the optimization of the automotive powertrain. This optimization process is directly targeting the engine and the transmission.[132]

In order to archive better fuel economy, the friction within the transmission has to be reduced.[133]

[129] Vgl. General Motors: Selling to General Motors, 2010, S.8
[130] Vgl. ebenda
[131] Vgl. Heus; Müller, 2012, S.10
[132] Vgl. United States Environmental Protection Agency: MPG CO2 Report, 2013, S.42ff
[133] Vgl. Goenka; Brunner; Nissen, 2013, S.15

Even though an accurate prediction of friction losses cannot be given, existing simulation software can be used in order to identify the friction sources within the transmission. AVL is currently developing a software called the transmission friction tool. It identifies the energy losses within the transmission and its components. In order to minimize those losses, an improved transmission design as well as an optimized set of transmission components are required. By looking at the simulation results in figure 16, the main contributors for the energy losses could be identified:[134]

- The churning losses due to the **pumps** and **gears**.
- Direct losses due to the friction of the **gears**, **shafts**, **synchronization unit**, **bearing**, **lubricants** and **sealings**
- Energy management due to design related losses

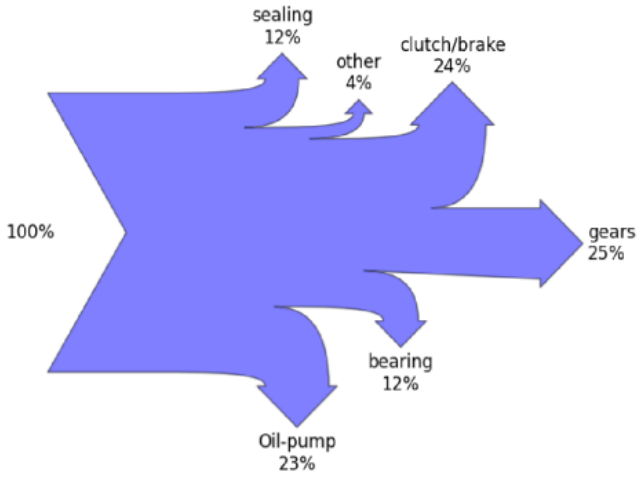

Figure 16: Transmission energy losses.[135]

Another type of transmission that needs to be discussed are the automatic transmissions. Its market share has reached 29% and is the second largest group of automotive transmission beside the manual transmission which makes up to 59% in 2012. An automatic transmission changes the gear ratios automatically, thus relieving the driver from having to shift gears manually and stepping on the clutch while shifting.[136] Taking both transmission types into consideration, a list of components can be identified whose performance directly influences the energy efficiency level of the transmission. Thus it is reasonable to say that these components as listed in table 4, play an essential role during the selection process.

[134] Vgl. Goenka; Brunner; Nissen, 2013, S.15
[135] ebenda
[136] Vgl. URL: http://www.marketsandmarkets.com/ResearchInsight/automotive-transmission-systems-market.asp (22.12.2015)

Transmission components	Manual transmission	Automatic transmission
Shafts and Gears	x	x
Planetary Gear Sets (AT)		x
Synchromesh Unit	x	
Seals and Gaskets	x	x
Torque converter (AT)		x
Oil pump	x	x
Clutch	x	x
Bearing	x	x

Table 4: Automotive transmission components (automatic and manual).

6.3.1 Shafts and Gears

According to the AVL simulation results, one fourth of the losses come from the gears. The efficiency of a gear system is simply calculated by dividing the output shaft power through the input shaft power. Figure 17 shows the efficiency range for various gear types.

Type	Normal Ratio Range	Pitch Line Velocity (m/s)	Efficiency Range
Spur	1:1 to 6:1	25	98-99%
Helical	1:1 to 10:1	50	98-99%
Double Helical	1:1 to 15:1	150	98-99%
Bevel	1:1 to 4:1	20	98-99%
Worm	5:1 to 75:1	30	20-98%
Crossed Helical	1:1 to 6:1	30	70-98%

Figure 17: Efficiency of various gear types.[137]

The power losses in gear systems can be calculated by adding up the tooth friction losses and lubrication churning losses. The churning losses are hard to calculate and are often estimated through experience. It is due to the peripheral speed of the gears passing through the fluid. Beside arrangements of the meshing gear and the power flow inside the planetary gear, the tooth friction loss is also influenced by the applied load, the entraining speed, the geometry of gears, the roughness of mating surfaces and the viscosity of lubricant. There are some models for calculating the tooth friction losses of gears.[138] Most of these factors are design related. However the roughness of the mating surface as well as the geometric tolerances are useful criteria for the supplier evaluation.

This has to be discussed since it is often the reason for different types of gear failures. A cause of failure can range from excessive wear to catastrophic breakage,

[137] URL: http://www.roymech.co.uk/Useful_Tables/Drive/Gear_Efficiency.html (03.03.2015)
[138] Vgl. ebenda

compromising the safety of the system as a whole.[139] To insure that all gear products are manufactured to industry quality standards, the geometrical and material tolerances used for the supplier component evaluation will be based on the standards created by the American Gear and Manufacturers Association AGMA, who has been accredited for the development of all US national gearing standards (Fig. 18). A higher quality number correlates with a smaller tolerance. The engineering requirement set during the design stages guides the choice of material as well as the gear quality standard. Different parts often requires their own definite treatment due to a variety of mechanical load and purposes.

Comparison of National Gear Quality Standards						
Reliance Quality Class	American AGMA 390.03 (1980)	British BS. 4582 (pt.1 : 1970)	German DIN. 867 & 3963	International ISO	Japan JIS	Admiralty BR.6001
AQ10	Q 10	Class B	Q 7	7	3	Class 2
AQ11	Q 11	Class A	Q 6	6	2	Class 1
AQ12	Q 12	Class A	Q 5	5	1	†
AQ14	Q 14	†	Q 3	3	0	†

Figure 18: Comparison of National Gear Quality Standards. Table applies to gears up to 50 mm diameter.

Component requirement:

According to PIC Design the quality of spur gears series production should be held to AGMA 10 standards, with AGMA 12-14 available for applications where accuracy is paramount.[140] By meshing the gear to be tested against a master gear of know properties, a plot can be produced showing the variances in the center distance paramount.[141] By meshing the gear to be tested against a master gear of known properties, a plot can be produced showing the variances in the center distance caused

[139] Vgl. Shipley,1967, S.2
[140] Vgl. URL: http://www.pic-design.com/PDF/PIC%20Design%20Training%20Issue%205%20-%20Gear%20Quality.pdf (15.11.2015)
[141] Vgl. ebenda

by the teeth engaging and disengaging as the gear rotates against the master (Fig. 19 and Fig. 20).

AGMA 390.03 FINE-PITCH GEAR TOLERANCES					
PIC Quality Number	AGMA Quality Number	Number of Teeth and Pitch Diameter	Diametral Pitch Range	Tooth-to-Tooth Tolerance	Total Composite Tolerance
Standard	10	Up to 20 Teeth Incl.	20 to 200	.0007	.0010
		Up to 1.999"		.0005	.0010
		2" to 3.999"		.0005	.0012
		4" and over		.0005	.0014

Figure 19: Extract from AGMA 10 quality standard. Highlighted in red are the required tolerances[142]

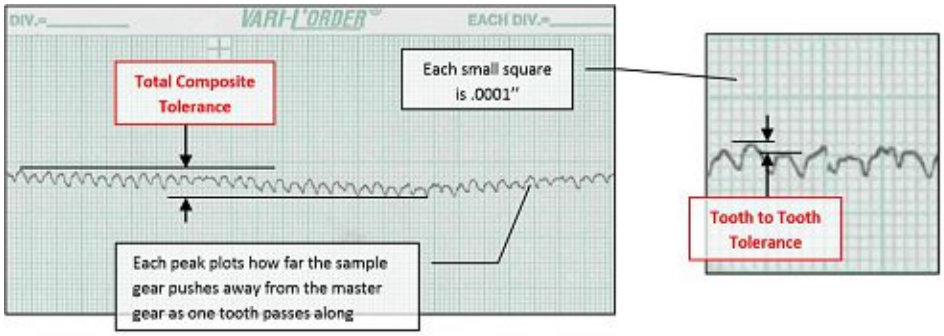

Figure 20: Quality level verification test by using a master gear.[143]

The gear manufacturing supplier must possess the capability to conduct extensive testing operations in order to verify the gearing quality standard.

[142] Vgl. URL: http://www.pic-design.com/PDF/PIC%20Design%20Training%20Issue%205%20-%20Gear%20Quality.pdf (15.11.2015)
[143] Vgl. ebenda

6.3.2 Planetary Gear Sets

Usually casted, the planetary gear set consists of three main parts- Ring Gear, Sun Gear, and Planetary carrier. The Ring gear, also known as Annulus has internal teeth and cover up the assembly completely. The Sun gear is fixed in the middle of the assembly. Planetary pinions revolve around the sun gear and is connected to the planetary carrier.

The sources of energy losses of a simple planetary gear drives are the followings:

- Friction loss between the mating teeth
- Friction loss in the bearings
- Friction loss at the seals
- Energy losses owing to lubricant churning
- Energy loss of air-drag

The main energy loss is in the tooth friction of gears depending on the arrangements of the meshing gears and the power flow inside the planetary gear drives. Besides these factors the tooth friction loss is influenced by the applied load, the entraining speed, the geometry of gears, the roughness of mating surfaces and the viscosity of lubricant. From these parameters the designer of the planetary gear drives can modify the geometry of the tooth profile in order to reach a beneficial high efficiency while decreasing the tooth friction loss.[144]

Component requirement:

The supplier requirement for the components are similar to that of the spur gears. The supplier has to comply with certain tolerance standards depending on the application.

[144] Vgl. Kozma, 2007, S.154

6.3.3 Synchromesh Unit

Synchronizers are the central component of the transmission featuring interfaces to the output, the clutch and, by way of the gear shift, to the driver. The layout and design of the synchronizer plays an essential role in how the driver experiences the gear shift (Fig. 21).

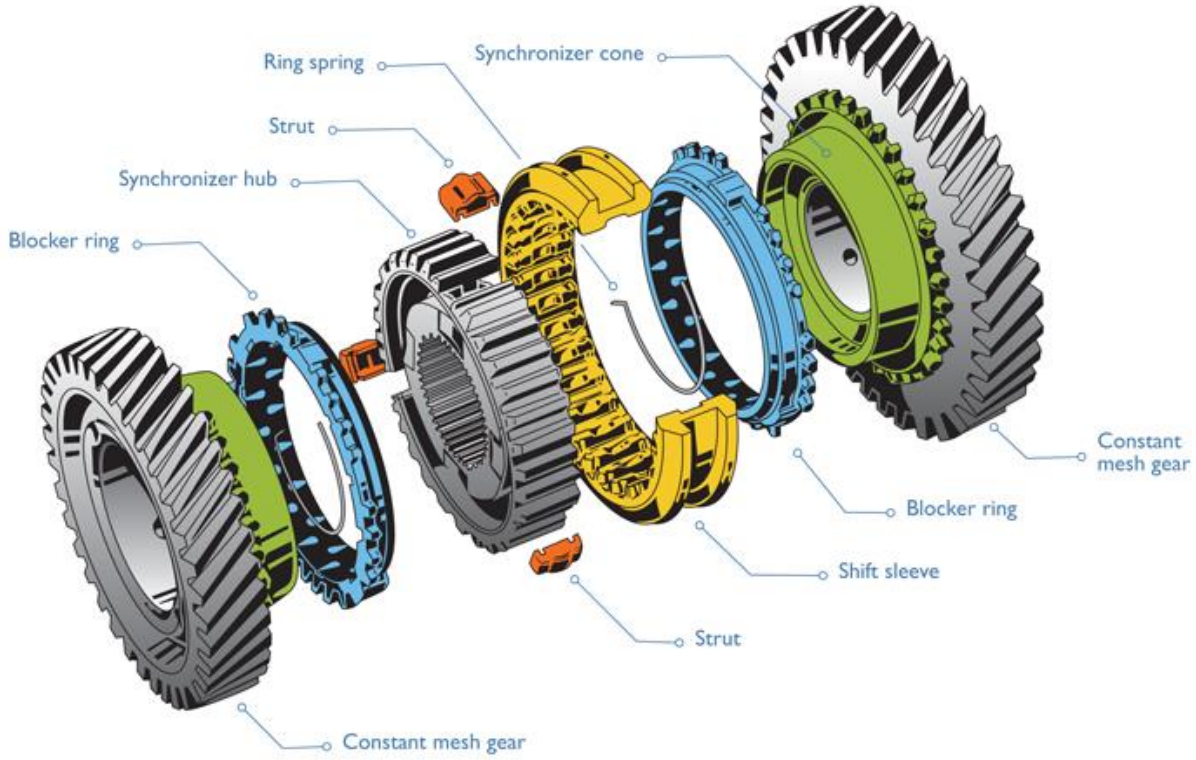

Figure 21: exploded view Synchromesh Unit.[145]

The capacity of the synchronizer is limited by:

- The torque capacity of Sleeve/Hub-System and Engagement Ring
- Capacity of Friction Material (Sliding speed, surface pressure, friction power, friction work)
- Heat dissipation through the oil, the synchronizer rings and the gear cone
- The transmission oil (viscosity and thermal stability)

Significant parameters such as pitch and position error and the conicity angle error determines the load that individual components have to bear.

[145] URL: http://www.gboxweb.com/synchronizer.html. (16.04.2015)

Component requirement:

Tests have to be carried out with load profiles using vehicle measurements. Input data such as shifting effort, shifting time, oil temperature and frequency of shifting have to be fed into the simulation and test bench runs. The test bench result includes information such as friction coefficient, gearshift effort, friction torque, frictional power rating, rotational speed and state of wear. Those values have to fit within an acceptable framework in order to fulfill the component requirements. Different requirements corresponds to different vehicle load profiles.[146] An abusive test has to be conducted in order to investigate the performance margin of synchronizers for the overload condition.[147]

[146] Vgl. Naunheimer; Bertsche; Ryborz; Novak, 2011, S. 343
[147] Vgl. Ebenda, S.344

6.3.4 Seals and Gaskets

The input shaft of the transmission typically has the highest speed of any shaft in the driveline. Thus the input shaft sealing has to withstand the high mechanical, thermal and chemical strain within the system.

Transmission seals and gaskets are made of flexible material that are used for making a pressure-tight connection between the transmission components.

Current automatic transmission designs produce very high internal fluid pressures. It tends to push out the gasket material in area of low flange pressure and high internal pressure.

Depending on the operating temperature and pressure, a pre selection of suitable materials can be done. The supplier should be able to provide a comprehensive technical data sheet with material information through technical examination.[148] One example of a pressure–temperature diagram is shown in figure 22 for the material NASB6 according to DIN 28091. Figure 23 shows the corresponding technical data sheet.

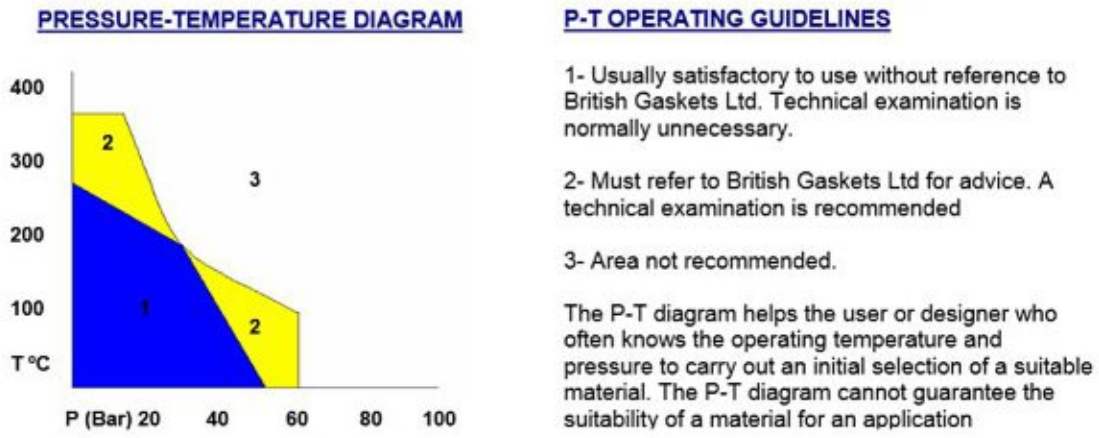

Figure 22: Pressure- Temperature Diagram: NASB6 (DIN 28091).[149]

[148] Vgl. The British Gaskets Group: NASB6 Technical Specification, S.1
[149] ebenda

COLOUR	Orange
Standard sizes (mm) Other upon request	1500 x 1500
Standard thickness (mm). Other upon request	0,5, 0,8, 1, 1,5, 2, 3
Density (±10%)	1.6 g/cm^3
Compressibility ASTM F-36 A	7% - 15%
Recovery ASTM F-36 A	>40%
Transverse tensile strength ASTM F-152	7 Mpa
Gas permeability DIN 3535/4	<1cm^3/min
THICKNESS INCREASE ASTM F-146	
ASTM oil Nº1 5h 150ºC	<8 - 12%
ASTM oil Nº3 5h 150ºC	<20 - 25%
ASTM fuel B 5h RT	<10%

Figure 23: Technical Data Sheet (typical properties for 2mm thickness).[150]

Component requirement:

- Technical examination to determine the basic material properties.
- Supplier must provide with information regarding chemical compatibility of the material either through laboratory testing or through recommendations supplied by prime producers of basic materials.

[150] The British Gaskets Group: NASB6 Technical Specification, S.1

6.3.5 Torque converter

Taking the place of a mechanical coupling, the torque converter is an essential part of the automatic transmission. The main function of the torque converter is to transport the rotational power of the engine to the downstream components of the automatic transmission (Fig. 24).

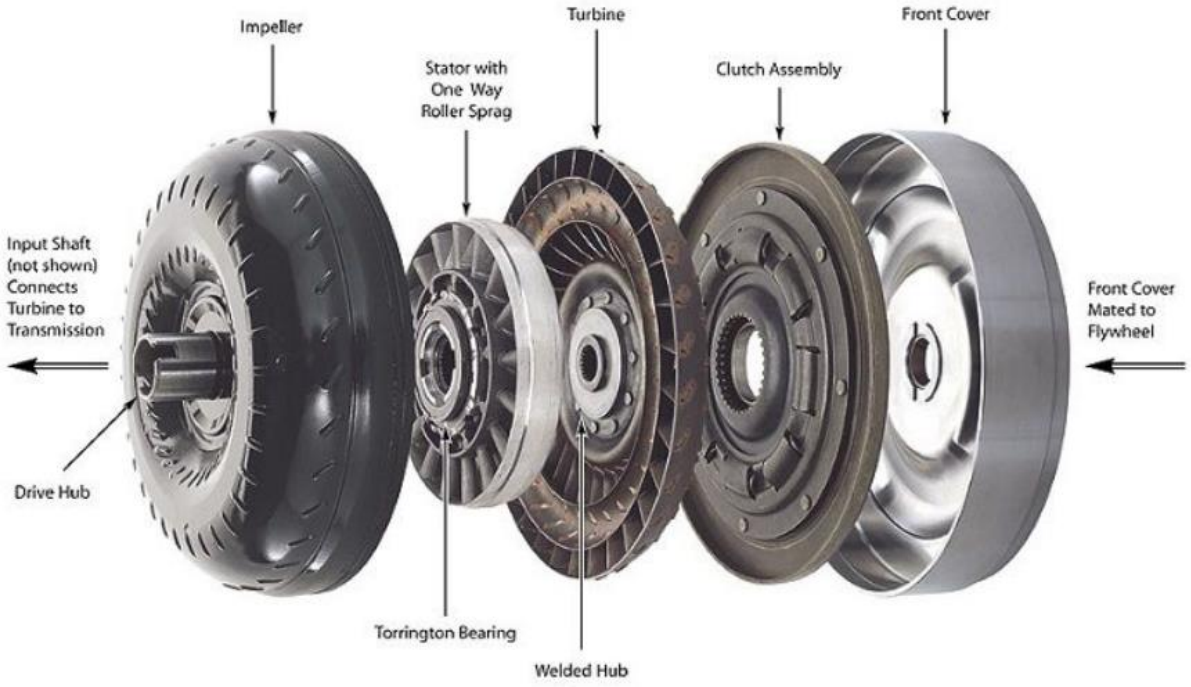

Figure 24: Exploded view automatic transmission torque converter.[151]

There are several common issues caused by component malfunction that will disrupt the normal operation of the torque converter:

The torque converter seal could be damaged as the converter overheats. This allows fluid to leak out of the converter which then could cause a number of problems, such as overheating, slippage and shifting malfunction. An overheated torque converter can be caused by several problems. A worn or stuck torque converter check valve for example could cause an excess heat buildup. In case of a malfunction of the torque converter clutch solenoid, the irregular behavior of the fluid pressure will lead to poor fuel economy and stalling.[152]

The most crucial torque converter failure occurs when the clutch elements become permanently fixed. This is usually caused by a severe distortion of the clutch

[151] URL: http://transmissionrepairguy.com/torque-converter-problems/ (04.04.2015)
[152] Vgl. ebenda

components. Stress due to shock could also completely break the clutch.[153] Issues regarding the clutch component will be discussed in chapter 6.3.7.

Needle bearing is used to separate the stator, impeller, turbine and the converter housing. Due to the driving noise caused by the metal to metal contact, this problem is usually easy to detect and thus less critical. It creates metal cuttings that will blend into the converter fluid.[154] Bearing related issues will be discussed in chapter 6.3.8.

Component requirement:

- ABEC rated needle bearing for optimum lifespan.
- Hydraulic component requirement.
- Clutch related requirement

6.3.6 Oil pump

The **transmission oil pump** is attached to the front of the transmission case. It is connected to the torque converter housing in case of an automatic transmission and supplies the transmission with the oil it needs using power generated from the torque converter and the engine. The oil comes into the pump via a filter on the bottom of the transmission oil pan. From there it travels through a tube into the oil pump. It also feeds the transmission cooler and the torque converter.

In addition to the gear pump, an additional electric pump could provide with extra flow as for gear shift operations.

Common causes for transmission pump failure are:[155]

- Low fluid
  Without a sufficient amount of transmission fluid, the transmission oil pump will not have anything to pump and can overheat or burn up.
- Contaminated Fluids
  If the transmission fluid has been contaminated with another substance, It can cause serious problems for the transmission oil pump. This contamination is often caused by water. Fluids that do not have the correct lubrication or cannot withstand the amount of heat generated by the transmission will break down and may cause various components to corrode or be otherwise damaged.
- Worn Components
  The transmission oil pump is composed of a variety of components and parts that work together in order to perform the function. If the drive gears, stator shaft

[153] Vgl. URL: http://transmissionrepairguy.com/torque-converter-problems/ (04.04.2015)
[154] Vgl. ebenda
[155] Vgl. URL: http://www.ehow.com/list_7770439_causes-transmission-pump-failure.html (15.11.2015)

or bushings are worn, breaking down or have developed other problems, the transmission oil pump will not be able to perform its job properly or maintain the correct fluid pressure.

The latter failure can be minimized through a systematic component testing during the manufacturing process, in order to detect any quality issues in the early stages.[156]

Component requirement:

- By using the SAE recommended practice to determine the performance characteristics of the hydraulic oil pumps used in automatic transmissions. This test describes the performance characteristics over a range of operating conditions. The supplier should be able to present the test data.[157]

According to Goodheart-Willcox: “Pressurized oil from the pump must be regulated in order not to influence the transmission shifting quality. The pressure regulator controls the overall transmission pressure and may be installed in the pump housing or in the valve body. Transmission operating pressures are regulated based on engine speed, throttle angle and engine load.”[158]

[156] Vgl. URL: http://www.ehow.com/list_7770439_causes-transmission-pump-failure.html (15.11.2015)
[157] Vgl. SAE International, Automatic Transmission Hydraulic Pump Test Procedure, 2015, S.1ff
[158] The Goodheart-Willcox Co., Inc.: Introduction to Automatic Transmissions and Transaxles, S.24

6.3.7 Clutch

Wet friction clutches enables the power transmission from the input shaft to the output shaft based on the friction occurring on lubricated surfaces. The contacting surfaces consist of several friction discs and the opposing separator discs. The system is lubricated in order to ensure an optimum cooling. The oil that is used during the lubrication process is also used for the actuation of the clutch pack. An electro hydraulic actuator is commonly used to control the engagement and the disengagement of the clutch discs. To compensate the friction loss due to the lubrication, several friction discs are positioned in consecutive order to increase the effective friction surface. Friction discs are mounted to the clutch hub by splines and the separator discs are mounted to the drum by lugs. (Fig. 25 and 26) Since an unexpected failure occurring in the clutch can lead to a total breakdown of the vehicle, the components have to fulfill certain quality standard in order to prevent a premature failure.[159]

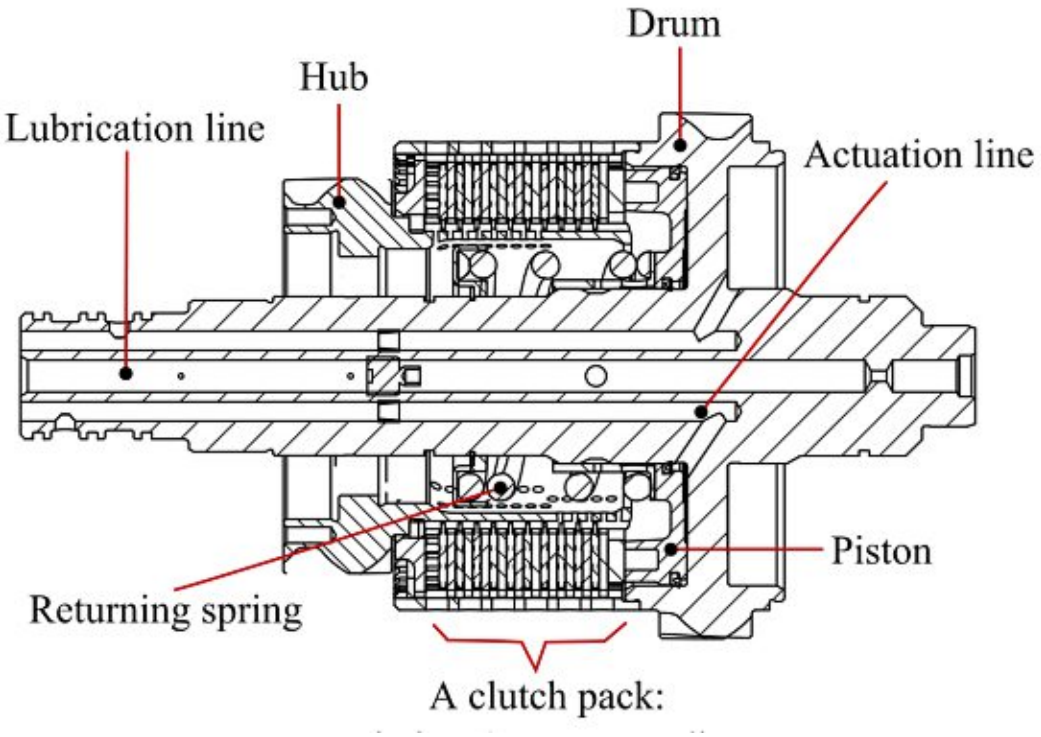

Figure 25: The clutch assembly for an automatic transmission cross-sectional view.[160]

[159] Vgl. Ompusunggu, 2012, S.2
[160] ebenda

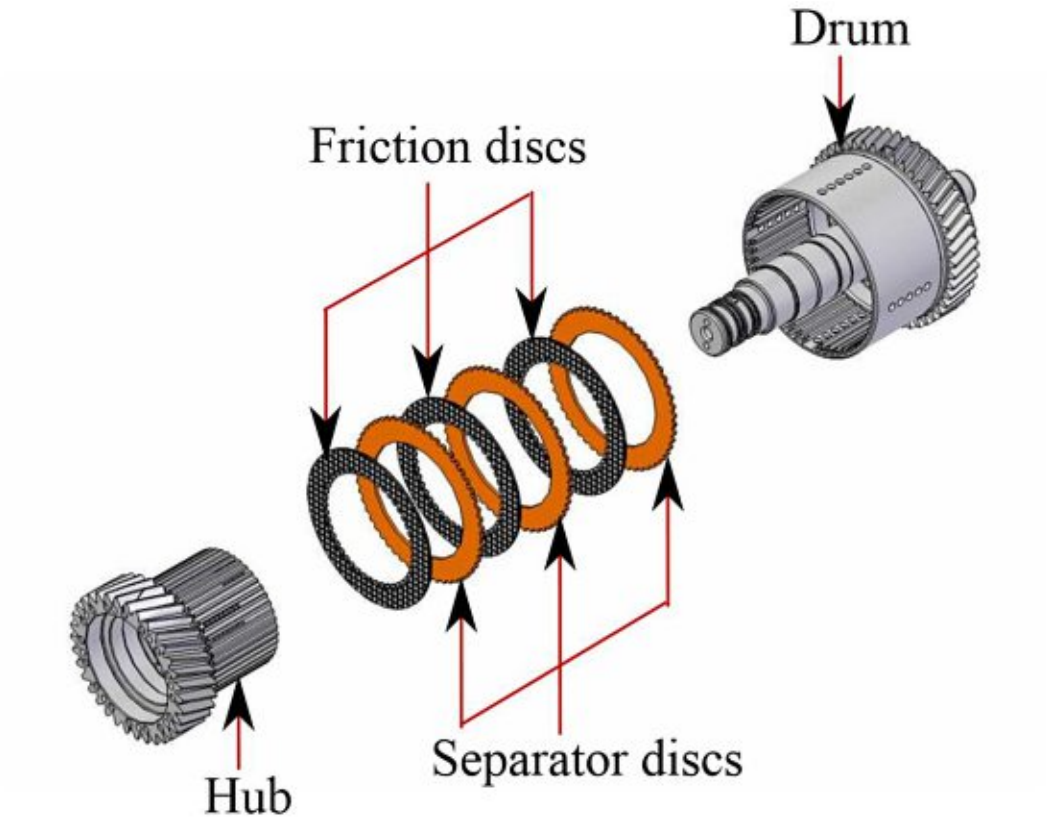

Figure 26: The clutch assembly for an automatic transmission exploded view.[161]

The type of material used for the clutch discs shall be decided by the manufacturer in agreement with the purchaser so as to withstand the service conditions.

The formation of hot spots in localized pressure zones due to non-uniformity in the contact pressure distribution across the surface can cause the cellulose to decompose leading to a degradation of the friction material. Test have shown that the wear rate will be severe in the first 200 cycles and decrease after this run-in period.[162]

The following testing methods derives from the JIS B 1401-1976 Mechanical multiple disc clutches (wet type) published by the Japanese Industrial Standards Committee:[163]

- **Static torque test** to determine the maximum torque that is transmissible from the driving side to the driven side, in case the clutch is fully engaged.
- **Dynamic torque test** to determine the torque that is transmissible from the driving side to the driven side, in case the clutch is engaged and in the presence of a certain relative velocity in the slipping state.

[161] Ompusunggu, 2012, S.2
[162] Vgl. Gustafsson, 2014, S.8
[163] Vgl. URL: https://law.resource.org/pub/in/bis/S01/is.10686.1983.pdf (15.11.2015)

- **Engaging test** to determine the force needed to apply surface pressure to the inner and outer discs.
- **Drag Torque test** to determine the torque that is transmissible from the driving side to the driven side, in case the clutch runs idle.

The drum clutch hub is one of the key components in the clutch assembly and directly linked to the efficiency of the power transmission and to the level of vibration noises. The most common technology used to process the raw material to cut the teeth of the hub is by using the cutting technology of Grob, inc. This represents the state of the art drum clutch hub manufacturing technology.[164]

Component requirement:

- As for the **clutch hub**, the supplier should possess the necessary tools to process the material using either the Grob technology or the Taguchi Method.[165]
- The **friction disc** supplier should provide with similar tests to ensure the component quality. This includes testing of the thermo elastic instability (TEI) to prevent critical thermal expansions. Torque tests to guarantee the mechanical capability of the component.[166]

[164] Vgl. Song; Park, Lee, 2010, S.141f
[165] Vgl. ebenda
[166] Vgl. Lee, Barber, 1994, S.1

6.3.8 Bearing

The Chinese bearing market experiences a significant disorder in its price and quality definition. The possible price range for standard parts can range from 12 to 21 RMB for a deep grove ball bearing.[167]

In the Chinese market, the quality of bearings is usually differentiated by its' manufacturer. As quoted by Tengen bearings: "Larger manufacturers with relatively advanced machineries produce better quality bearings, whilst lower quality bearings are produced by smaller factories with less advanced machineries. The differences of quality are greatly relied on the production engineering. These may encompass material of bearings, machines that produce the bearings, as well as finishing of material such as heat treatment that will make a different in material hardness, and surface finishing such as surface roughness that will make another different in bearings appearance."[168]

Furthermore the Chinese bearings can be divided into 3 quality level. In order to differentiate the bearings, life span, max. Speed ratings, max. Load ratings and mass are taken into consideration. No significant deviation in tolerance level could be found (Fig. 27).[169]

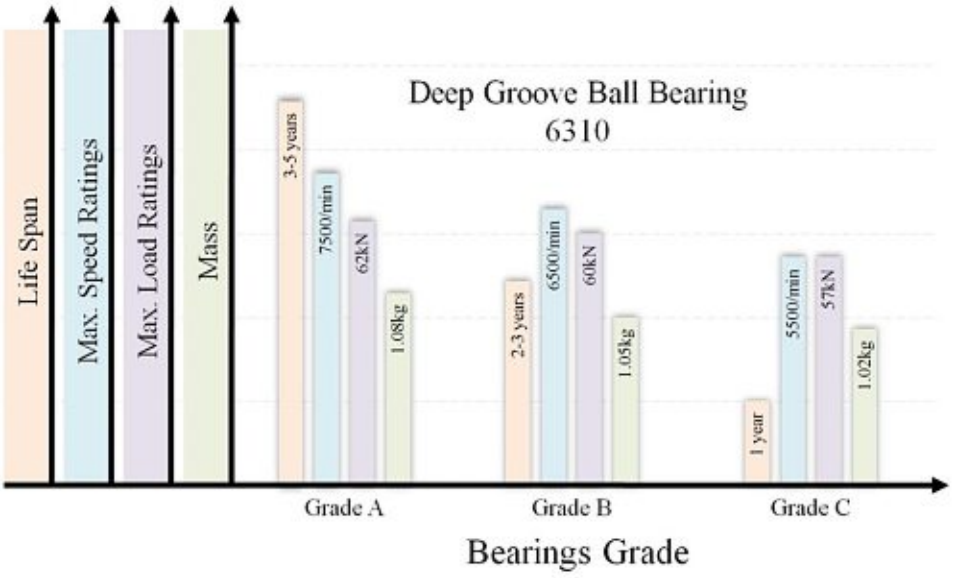

Figure 27: Quality level of Chinese Bearing Supplier (only for reference).[170]

The Annular Bearing Engineers' Committee scale, which is also often referred to as the ABEC scale, is an industry-accepted standard for the dimensional control and

[167] URL: http://www.tengenbearing.com/Introduction.asp?id=68 (02.04.2014)
[168] Vgl. ebenda
[169] Vgl. ebenda
[170] ebenda

manufacturing tolerances of ball bearings.[171] Bearings rated with the ABEC rating system typically have five ratings in the class scale that range from the widest tolerances to the tightest tolerances of the bearings with rating numbers of 1, 3, 5, 7, and 9. Each number corresponds to a degree of roundness in the outer and inner races of a bearing. Apart from the Annular Bearing Engineers Committee rating system, other standards could also be used to measure the tolerance of a ball bearing, including The International Standards Organization (ISO), the Japan Industrial Standard (JIS) and the Deutsches Institut für Normung (DIN), as shown in table 5.[172]

ABEC	ISO	DIN	JIS B 1514
ABEC -1	Normal	P0	Class 0
ABEC - 3	Class 6	P6	Class 6
ABEC - 5	Class 5	P5	Class 5
ABEC - 7	Class 4	P4	Class 4
ABEC - 9	Class 2	P2	Class 2

Table 5: International Bearing Standards.[173]

Apart from the Annular Bearing Engineers Committee rating system, other standards could also be used to measure the tolerance of a ball bearing, including The International Standards Organization (ISO), the Japan Industrial Standard (JIS) and the Deutsches Institut für Normung (DIN).[174]

Component requirement:

Higher rated bearings are intended for high precision applications usually common in the aerospace and medical industry. In case of the automotive transmission the supplier should at least be able to archive ABEC – 3 rating.

[171] Vgl. URL: http://www.nmbtc.com/bearings/abec-bearings-information/ (15.11.2015)
[172] Vgl. AST Bearings: Technical Information Bearing Tolerances, 2010, S1f
[173] Vgl. URL: http://www.ahrinternational.com/tolerance_interchange_table.htm (15.11.2015)
[174] Vgl. ebenda

6.4 Creating a supplier rating and questionnaire form

To evaluate the supplier a performance dependent rating system will be used. A total score of 100 can be archived for each of the following five categories before applying the weighting. The score is relative and should provide an objective comparison between the suppliers. A lower score does not necessary mean a poor performance. This should be communicated accordingly in order to avoid any misinterpretation.

6.4.1 General information

This section will focus on basic cooperate information as well as financial statements that will be used to evaluate the financial stability of the company. Through the inquiry of contact information regarding the responsible personnel for different key functions within the company, the effect of “grade inflation” can be minimized.

Most suppliers view the questionnaires as a tool that may have an important impact on their relationship with their customers. Naturally they want to show themselves in the most positive light as possible. Whether deliberately or due to the lack of knowledge, the results of the supplier questionnaires could be affected by non-accurate information. This is more likely to happen in case of new suppliers without previous business relationship and that are physically and culturally far from the customer. This “grade inflation” can be adjusted by the customer through knowledge of the local supplier and through experienced interpreter.

Since this work will mainly focus on new suppliers without previous business records, a certain level of “grade inflation” can be expected from each supplier. The results will be a relative comparison of those suppliers. The statement becomes more precise as more suppliers are added into the data pool.[175]

6.4.2 Production capability

This part includes information such as transmission related products as well as the current production volume. Competitive companies have to provide a dependable, predictable and consistent operating system that satisfies the customer’s needs.

The ability to develop prototype components will affect the capability of product development. Thus previous experience in prototyping will have a positive impact on the product development process. The usual approach after signing the non-disclosure agreement is to discuss the goals of the product development in order to determine the capability match of the requirements set by the customer. This avoids misinterpretations and overestimation of the development capability by the supplier.

[175] Vgl. S. R. Gordon, 2005, S.20

6.4.3 Product pricing

To assess the supplier pricing, factors such as competiveness, price stability, volume discounts have to be considered. Since key information are not available during the pre-selection process, a simplified approach will be proposed. The product pricing assessment will be conducted by the supplier.[176] In case the price quotation is on a higher level than the current market price, an explanation has to be given in order to justify this decision (E.g. superior quality, environmental commitments).

6.4.4 Request for references and quality certificates

The production and management process have to be optimized in order to fulfill the requirements of the automotive industry. Therefore quality certificates like the ISO 9001:2015 and the ISO/TS 16949:2009 have to be established. A sound reputation through previous projects with known customers is also a common criteria for the supplier selection. Usually the supplier will willingly provide this kind of information.[177]

The questionnaire form has been translated into Chinese in order to avoid any possible miscommunication with the supplier. The content of the questionnaire is designed to provide feedback for the evaluation criteria according to Chapter 6.1.

It is to be expected that the supplier will not give away all the requested information. Missing data occur in survey research due to different reasons and often causes problems for the survey analysis. A considerable amount of research has been conducted in the past years developing and refining methods for compensating for missing information.[178]

The most relevant source of missing survey data is item nonresponse, which occurs when a sampled element participates in the survey but fails to provide acceptable responses to one or more of the survey items. The reason for not complying with providing with the requested information can be due to different reasons such as availability, confidentiality, or motivation.[179]

The rating system can be deployed by using the weighting from the supplier performance expectation in Chapter 6.2. In most sample surveys, weights are attached to each respondent record and then used in analyses for a final supplier scorecard. Weighting can also be used for handling missing information.[180]

[176] Vgl. Queensland government Procurement Transformation Division: Procurement guidance, 2014, S.15
[177] Sarangapani, 2010, S.3
[178] Vgl. Brick; Kalton, 1996, S. 215
[179] Vgl. Leew; Hox; Huisman, 2003, S.163
[180] Vgl. Brick; Kalton, 1996, S.233f

Weighting class adjustment can be used as an attempt to reduce nonresponse bias by allocating the base weights of non-respondents to the respondents.[181]

6.4.5 Delivery reliability

Delivery reliability cannot be measured if the supplier is new and no previous business records are available. In this case the score for delivery reliability should be marked as unassigned. The following factors needs to be considered for the delivery measurement:

- The measurement of total order as well as the lead time orders.[182]
- According to Stapf: "The Supplier-On Time Delivery Performance formula can be used for the calculation of the supplier performance. It is the comparison of the required delivery date in the purchase order to the actual goods receipt entry date per supplier."[183]

Since this work focuses primarily on new supplier without previous business records this part will not be covered.

6.4.6 Weightings

In order to evaluate the results from the information provided by the supplier through the questionnaire, a weighting system will be introduced. Using the method of pairwise comparison, allows for a more precise weight distribution amount a multiple quantitative properties.[184] Based on this scientific principle, the eight criteria as described in Chapter 6.2 were weighted in cooperation with AVL.

Those eight independent criteria will then be distributed amount the five sections of the questionnaire except for the delivery reliability, which cannot be evaluated due to insufficient business records.

- The general information will include the information of responsiveness as well as the financial position. This contributes to a total of 21.43% to the final scoring.
- Information regarding the production capability are difficult to obtain. Without direct contact with the supplier, only limited information can be acquired through technical conversations. The ability to conduct prototype development and different aspects that affects the product quality will contribute 28.5% to the final scoring.

[181] Vgl. Brick; Kalton, 1996, S.233f
[182] Vgl. Shah, 2009, S.26
[183] Stapf, 2011, S.1
[184] Vgl. J. Feldhusen, 2013, S.388

- In terms of competiveness the product price will attribute to the scoring with 14.29%. In case of a pricing level above the market average, a good score can also be obtained through product quality leadership or other meaningful efforts.
- Good customer references and a sound international business record will increase the reliability of the supplier. Together with the availability of quality certificates, this will attribute for 17.85% of the total scoring.

As mentioned above, the delivery reliability cannot be evaluated in case of new suppliers. Due to this reason the total score of this supplier evaluation method will not reach the maximum score of 100, even for an exemplary supplier

6.5 Implementation

In order to validate the evaluation strategy a case example has been conducted. In the first step eight local transmission component suppliers were selected under consideration of their strategic localization according to Chapter 5 (Table 6). The suppliers were chosen from a pool of over 60 suppliers that have been identified using the five methods as described in chapter 2.2. Furthermore only suppliers of gears and shaft systems, as well as synchronizer assembly systems were selected for the evaluation as those parts offer the least complexity within the automotive transmission unit. This also offers a better comparison of the evaluation result due to the similarity of supplied components. The general idea can then be carried over to other components.

Supplier	Product	Point of entrance
永跃齿轮 Yongyue gear Co., Ltd	Gears & Shafts Synchronizer ring Bearings	CBU Directory
浙江耐力轴承有限公司 Zhejiang Naili Bearings Co., Ltd	Bearings	China Auto Supplier Database
十堰同创传动技术有限公司 Shiyan Tongchuang Drive Technology Co., Ltd	Synchronizer ring Synchronizer hub	China Auto Supplier Database
金华汤齿齿轮箱有限公司 Jinhua Tangchi Gearbox Co., Ltd	Gears & Shafts	China Auto Supplier Database
江苏驰翔精密齿轮股份有限公司 Jiansu Chixiang Precision gear Co., Ltd.	Gears & Shafts Oil pump gear	China Auto Supplier Database
安徽明雁齿轮有限公司 AnHui MingYan Mechanical Co., Ltd.	Gears & Shafts	China Auto Supplier Database
兴化东华齿轮有限公司 Xinhua Donghua Gear Co., Ltd	Gears & Shafts	China Auto Supplier Database
贺尔碧格传动技术 （常州）有限公司 Hoerbiger Drive Technology (Changzhou) Co,. Ltd	Synchronizer assembly Gears	CTI Symposium Berlin

Table 6: Selected transmission component suppliers.

The suppliers have been contacted through phone call. In addition to that, an electronic questionnaire form has been sent to them via mail. The questionnaire form should deliver the information of each of the 5 sectors mentioned in chapter 6.4. After

processing those information a score will be given to each of those sectors and weightings will be applied to it in order to obtain the final score.

The supplier questionnaire has been prepared in Chinese as well as English and has been sent to the supplier as well as a company introduction and an invitation to participate in the AVL SRM sourcing process. (Appendix 8.1 and 8.2) suppliers then have been given a period of two weeks to turn in the completed form. As an incentive for their cooperation, cooperative suppliers will be added into the AVL supplier relationship database and will therefore become a part of AVLs future sourcing process.

Out of the eight suppliers, two of them have turned in the questionnaire form according to the instruction given. The explanation for the low return of 25% could be due to the following reason:

- As a technology consultant and powertrain design company AVL is not directly involved in any kind of sourcing process. Suppliers who are not willing to share corporate information could misinterpret the intention of the survey.
- Due to the business model of AVL that lacks any kind of production activity, the supplier sees no direct benefit in a cooperation with AVL.
- The supplier cannot offer the presumably most desired information for the questioner and fears that the survey could negatively influence their business opportunities in the future.
- Lack of experience or expertise to work with oversea companies. During the phone calls some responding counterparts have exposed a lack of English skills. In those cases the conversation has to be switched to Chinese. A lack of working experience with oversea companies can be derived if no English support could be offered.

In the next step the results of the survey will be evaluated. After the application of the weightings, the final score can be determined according to Chapter 6.4.

6.5.1 Shiyan Tongchuang Drive Technology Co., Ltd

This chapter shows the evaluation scoring for Shiyan Tongchuang Drive Technology Co., Ltd based on the available information. The superscript numbers will further explain the given scores by explaining the decision process at the end of this chapter. The tables and figures used were created in order to provide with an overview of the evaluation result. Table 7 generates a scoring for the general information. It also uses the information from table 8 and figure 28 during the evaluation of the financial statements. Table 9 to table 12 will each separately evaluate the categories production capability, product pricing, the request for references and quality certificates as well as the delivery reliability. The results will then be finalized in table 13 to generate the total scoring for Shiyan Tongchuang Drive Technology Co., Ltd.

Section 1: General information			
Main category	**Detailed sub category**	**Maximum reachablescore**	**Actual score**
Contact information	technical manager	5,00	5,00
	sales manager	5,00	5,00
	production manager	5,00	2,50(1)
	logistics manager	5,00	2,50(1)
online presence	corporate email address	5,00	0,00(2)
	corporate webpage	5,00	5,00
financial statements	Structure of turnover	10,00	10,00(3)
	Development of turnover	5,00	5,00(3)
	Current ratio	10,00	10,00(4)
	Gross profit margin	10,00	10,00(5)
	Debt ratio	10,00	10,00(6)
Supplier audit willingness		25,00	25,00
Total		100,00	90,00
Total score with weighting (21.43%)		21,43	19,29

Table 7: General Information - Shiyan Tongchuang Drive Technology Co., Ltd.

(1) The corresponding sales and logistics manager are not able to communicate in English, therefore they only receive 50% of the score.

(2) A missing corporate email address indicates a lack of IT proficiency. In this case no score will be given.

(3) The analysis of the turnover will be done in two separate sub categories. The structure of the turnover is an indicator for the scale of business. The development of turnover evaluates the improvement or deterioration over the last three years.

(4) The current ratio of Volkswagen AG in 2011 is 1.13.[185] After calculation the current ratio of Shiyan Tongchuang Drive Technology Co., Ltd amount to 1.03, which is an acceptable value for the automotive industry.
(5) According to CSImarket the gross margin of the auto and truck manufacturers industry has improved to 16.41% in the second quarter of 2015.[186] As for Shiyan Tongchuang Drive Technology Co., Ltd, the value amounts to 17%.
(6) In 2009 the debt ratio for the motor vehicle parts manufacturing sector add up to 0.379.[187]

毛收入 Gross Profit	33 million RMB
短期负债 Current Liabilities	65 million RMB
重负债 Total Liabilities	65 million RMB
流动资产 Current Assets	67 million RMB
重部资产 Total Assets	180 million RMB
Current ratio	1,030769231
Gross Porfit margin	0,171875
Debt ratio	0,361111111

Table 8: Financial structure - Shiyan Tongchuang Drive Technology Co., Ltd.

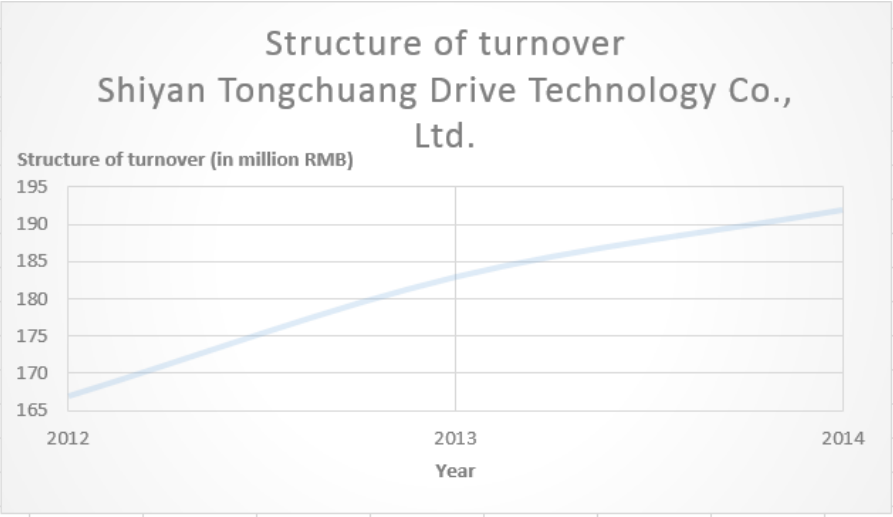

Figure 28: Structure of turnover Shiyan Tongchuang Drive Technology Co., Ltd.[188]

[185] Vgl. URL: http://de.slideshare.net/ArundhatiPoshattiwar/automobile-industry-analysis-16714550 (13.09.2015)
[186] Vgl. URL: http://csimarket.com/Industry/Industry_Profitability.php?ind=404 (13.09.2015)
[187] Vgl. Statistics Canada, Financial and Taxation Statistics for Enterprises, Statistics Canada, 2012.
[188] Appendix 8.1, S.2

Section 2: Production capability		
Main category	Maximum reachablescore	Actual score
Prototype production	5	5
Serial production	5	5
Component & Volume	40	40(1)
Product quality	50	25±25(2)
Total	100	100
Total score with weighting (28.5%)	28,5	21,38±7,125

Table 9: Production capability - Shiyan Tongchuang Drive Technology Co., Ltd.

(1) In terms of the production volume for the synchronizer assembly, the supplier has declared a value of 1.000.000 pieces per year. According to the supplier during the interview, all of those pieces will be distributed to local Chinese OEMs such as Dongfeng Motor transmission Co., Ltd.

(2) According to the supplier they have implemented some state of the art testing procedures in order to insure compliance with the product tolerance. It has to be mentioned that only limited information has been provided regarding the specific testing and simulation procedures. Therefore no precise statement can be given and the production quality scoring will be marked as an uncertain value.

Section 3: Product pricing		
Main category	Maximum reachablescore	Actual score
Price level	100	50
Total	100	50
Total score with weighting (14.29%)	14,29	7,15

Table 10: Product pricing - Shiyan Tongchuang Drive Technology Co., Ltd.

Section 4: Request for references and quality certificates		
Main category	Maximum reachable score	Actual score
ISO TS 16949	25	25
ISO 9001	25	25
ISO 14001	10	10
Customer references	40	30(1)
Total	100	80
Total score with weighting (17.85%)	17,85	14,28

Table 11: Request for references and quality certificates - Shiyan Tongchuang Drive Technology Co., Ltd.

(1) Shiyan Tongchuang Drive Technology Co., Ltd will receive 75% of the score due to the lack of international customer reference. Their main customers include FAW Jiefang Automotive Company as well as Dongfeng Motor

Corporation, both of which are well established Chinese OEMs each with over 2.7 million vehicle sold in 2014.[189]

Section 5: Delivery reliability		
Main category	**Maximum reachablescore**	**Actual score**
Delivery reliability	100	50±50(1)
Total	100	50±50
Total score with weighting (17.93%)	17,93	8,965±8,965

Table 12: Delivery reliability - Shiyan Tongchuang Drive Technology Co., Ltd.

(1) This section contains information regarding the delivery reliability of the supplier. Since no information could be obtained in this section the delivery reliability will be taken into consideration with an uncertain value.

Total score	
Main categories	**Score**
General information	19,29
Production capability	21,38±7,125
Product pricing	7,15
Request for references and quality certificates	14,28
Delivery reliability	8,965±8,965
Total score	71,065±16,09

Table 13: Total score - Shiyan Tongchuang Drive Technology Co., Ltd.

[189] Vgl. D. M. G. C. Limited: Annual Report 2014, 2014, S.3

6.5.2 Hoerbiger Drive Technology (Changzhou) Co,.Ltd

This chapter shows the evaluation scoring for Hoerbiger Drive Technology Co., Ltd based on the available information. As stated in chapter 5.5.1 the superscript numbers will be further explain the given scores by explaining the decision process at the end of this chapter. The tables and figures used were created in order to provide with an overview of the evaluation result. Table 14 generates a scoring for the general information. It also uses the information from figure 29 during the evaluation of the financial statements. Table 15 to table 18 will each separately evaluate the categories production capability, product pricing, the request for references and quality certificates as well as the delivery reliability. The results will then be finalized in table 19 to generate the total scoring for Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

Section 1: General information			
Main category	**Detailed sub category**	**Maximum reachablescore**	**Actual score**
Contact information	technical manager	5,00	5,00
	sales manager	5,00	5,00
	production manager	5,00	0
	logistics manager	5,00	5,00
online presence	corporate email address	5,00	0
	corporate webpage	5,00	5,00
financial statements	Structure of turnover	10,00	10,00
	Development of turnover	5,00	5,00
	Current ratio	10,00	5,00±5,00
	Gross profit margin	10,00	5,00±5,00
	Debt ratio	10,00	5,00±5,00
Supplier audit willingness		25,00	25,00
Total		100,00	75,00±15,00
Total score with weighting (21.43%)		21,43	16,07±3,21

Table 14: General Information – Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

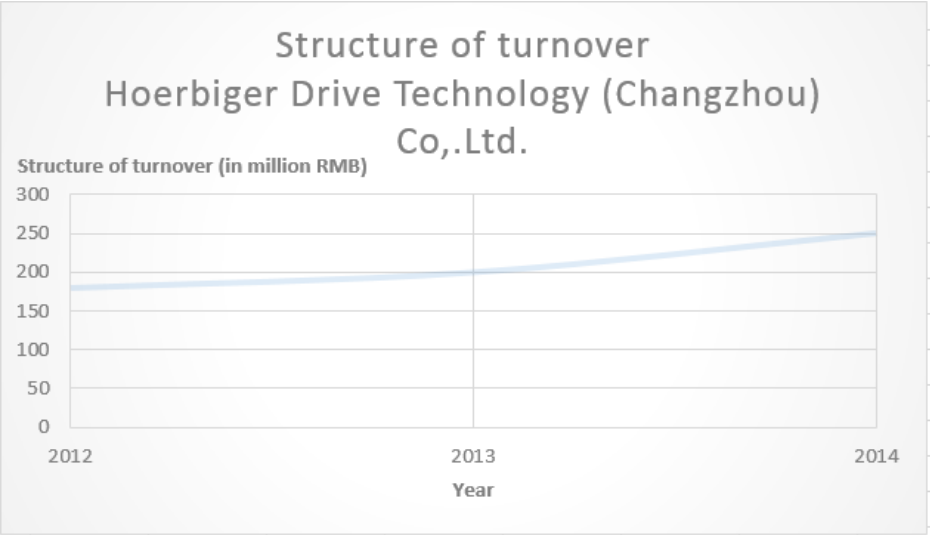

Figure 29: Structure of turnover Hoerbiger Drive Technology (Changzhou) Co,.Ltd.[190]

Section 2: Production capability		
Main category	**Maximum reachablescore**	**Actual score**
Prototype production	5	5
Serial production	5	5
Component & Volume	40	40
Product quality	50	50(1)
Total	100	100
Total score with weighting (28.5%)	28,5	28,5

Table 15: Production capability – Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

(1) As one of the world's largest specialist in synchronizer systems, Hoerbiger sets the benchmark in terms of product and production quality. With the same global standard introduced to the Chinese plant, they also offer a comprehensive analysis and testing procedure to insure the product meets the required standard.[191] Thus explaining the high score in this section.

Section 3: Product pricing		
Main category	**Maximum reachablescore**	**Actual score**
Price level	100	50
Total	100	50
Total score with weighting (14.29%)	14,29	7,15

Table 16: Product pricing – Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

[190] Appendix 8.2, S.2
[191] Vgl. HOERBIGER: HOERBIGER Drive Technology Asia Pacific Portfolio, 2015, S.1

Section 4: Request for references and quality certificates		
Main category	Maximum reachablescore	Actual score
ISO TS 16949	25	25
ISO 9001	25	25
ISO 14001	10	10
Customer references	40	40
Total	100	100
Total score with weighting (17.85%)	17,85	17,85

Table 17: Request for references and quality certificates – Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

Section 5: Delivery reliability		
Main category	Maximum reachablescore	Actual score
Delivery reliability	100	80±10(1)
Total	100	80±10
Total score with weighting (17.93%)	17,93	14,34±1,8

Table 18: Delivery reliability – Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

(1) Precious experience with different subsidiaries of Hoerbiger Drive Technology (Changzhou) allows for a more precise estimation of the product delivery reliability.

Total score	
Main categories	Score
General information	16,07±3,21
Production capability	28,5
Product pricing	7,15
Request for references and quality certificates	17,85
Delivery reliability	14,34±1,8
Total score	83,91±5,01

Table 19: Total score – Hoerbiger Drive Technology (Changzhou) Co,.Ltd.

6.5.3 Interpretation

Using the given information provided by the supplier through the telephone interview and the electronic survey, the participants could be each assigned with a total score (Fig. 30). All expectations that have been elaborated through the method of pairwise comparison have been implemented into the evaluation system.

In this case, a direct comparison is practicable due to the similar product offering of both supplier. According to the results Hoerbiger Drive Technology (Changzhou) reaches a score of 83.91 with an uncertainty area of 5.01. This is a remarkably high score that could only be archived through a superior product quality standard.

Shiyan Tongchuang Drive Technology Co., Ltd. on the other hand offers great potentials to become a feasible business partner. They offer good financial stability thus minimizing the risk of a breakdown. Their previous business records with local customers as well as their associated production volume provide with a sufficient production capability for future sourcing activities. Due to the lack of information to complete an exact judgment of their product capability the uncertain area in this case is much bigger. It bears repeating that the scoring does not necessarily qualifies a certain supplier as a potential supplier. A company with a high overall scoring but poor financial performances often poses a great risk to the customer and should therefore be avoided. It often also depends on the own expectation towards the suppliers. A good example would be a cost driven sourcing decision. In this case the weighting for the cost factor has to be adjusted to this specific occasion.

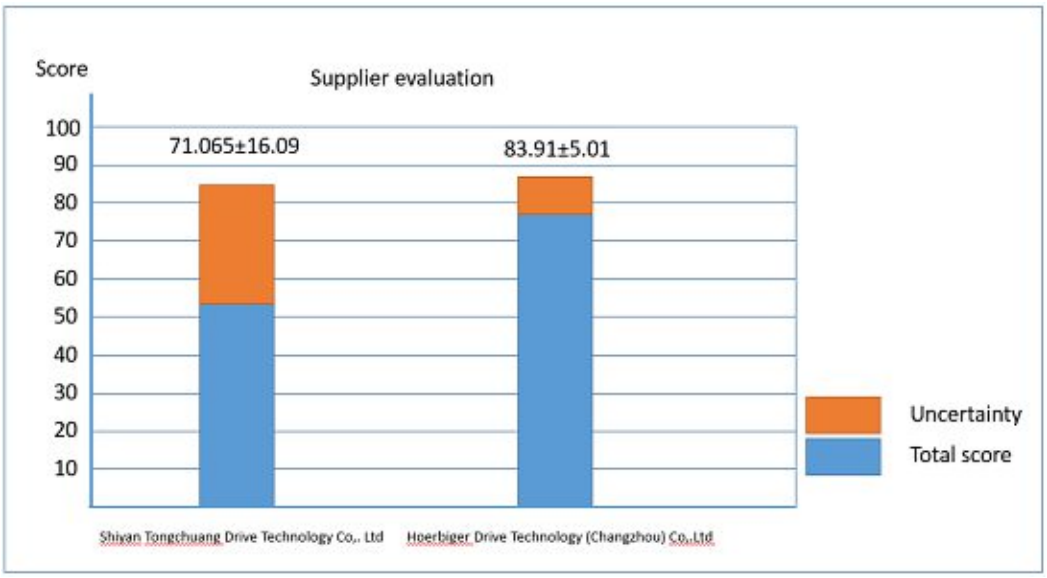

Figure 30: Comparison of evaluation result.

Following this example, this evaluation process can be expanded to a broader band of suppliers so that a direct comparison of their strength and weaknesses becomes much more apparent.

After the evaluation process a manageable amount of potential suppliers could then be identified. Further steps includes the elimination of the remaining uncertainty and further communicative approaches towards the chosen suppliers. This further includes the request for quotation (RFQ) for a specific product with detailed information regarding product quality, contract length, terms for the payment as well as the product pricing. The evaluation scoring of the pricing section is the result of a self-assessment by the supplier. Due to the lack of a comparable product specification this result remains inaccurate. Through the RFQ a more precise judgment of the supplier pricing performance can be accomplished.

It has to be said that up until this stage of the supplier evaluation process no definite statement can be given regarding the quality performance of the supplier. It is the responsibility of any business unit to give importance to quality checks and audits. Upon selecting the suitable supplier, they should be kept under surveillance through an extensive supplier audit. This can help to tackle some of the current challenges that do not reflect into the previous supplier evaluation (Table 20).[192] That been said only an extensive supplier audit can determine the precise product quality condition.

Labor	- Excessive labor - Insufficient training - Unnecessary handling - Lack of employee involvement - Poor attendance
Cost	- Downtime - Cost rising - Excessive capacity - Unplanned equipment
Delivery	- Poor response - Missed shipment deliveries - Inconsistent schedules - Inventory errors - Unrealistic forecasts
Quality	- Excessive variation - Warranty cost - Incapable processes
Communication	- Poor internal communication - Poor customer/supplier relationship
Inventory	- Additional material handling - Complex inventory management - Large Lot sizes - Long changeover

[192] Vgl. Subramaniam, 2009, S.4

	- Long lead time - Unbalanced material flow
Safety	- Accidents - Unsafe work environment
Engineering	- Poor design control - Lack of cross functional input - Uncontrolled changes - Obsolete technology - Poor prototype quality - Unexpected cost increase
Environment	- Poor working environment

Table 20: Current vendor audit challenges.

7 Conclusion

The conclusion section highlights the main findings and the fulfillment of this work as well as answering the research question. Furthermore, some additional findings and considerations which are not directly related to the research questions are presented.

With over 2000 suppliers for the regarded transmission components coming from the online databases of China Automotive Review and China auto supplier (中国汽车供应商网) as well as additional suppliers from different trade fairs and supplier workshops, an efficient evaluation method is needed to identify the potential suppliers for future sourcing activities. The aim of this work has been to create a supplier evaluation strategy in order to reduce the amount of potential candidates to a manageable amount for further analysis. One important factor that has to be considered during the supplier selection process is the strategic localization of the supplier. The concentration of automotive transmission component suppliers at the eastern coast of China suggests that industrial clusters have formed around specific regions. Those are mostly the regions with the presence of big players in the Chinese Automotive market and their overseas joint venture partners. Four reasons have been identified that supports this theory:

- Infrastructural advantages
- Customer intimacy
- Regional government incentives
- Qualified labor through better education

The measurement strategy that has been chosen is a request for information through an electronically conveyed survey and a personal conversation through a telephone interview. The reason for choosing the survey option for information gathering is due to its scoreboard compatibility. It enables the possibility to compare the results for each supplier since the questions are stated uniformly. In order to fulfil the basic expectations of the OEMs in terms of financial stability, Development capability, Technology and Service certain specific measuring criteria have been chosen to be included into the evaluation process. These criteria have to be aligned with the performance expectation of the customer. The performance expectations were identified by using the method of pairwise comparison.

It is to be expected that the target for future development will further push in the direction of fuel efficiency. In order to archive this target, certain transmission components have to comply with component specific quality requirements. Those requirements have been worked out for eight different key components of the transmission system.

The implementation of this evaluation method in the case of the two suppliers of transmission synchronizer assembly systems provided with a comparison in different sections such as product and production capability. The evaluation shows that both supplier deliver good results. However Hoerbiger Drive Technology (Changzhou) Co., Ltd. has a slight edge over his competitor Shiyan Tongchuang Drive Technology Co., Ltd. Specific statements regarding the quality performance of the supplier cannot be determined at this stage of the evaluation process. The main findings of this work can be summarized as follows:

Given the limitation of instrumentation available, a precise evaluation of supplier performance is neither a feasible option nor is it required at this stage of the evaluation process. The available information strongly depends on the supplier's willingness to cooperate. Through the evaluation strategy that has been developed in this thesis, the list of potential supplier can be reduced to a manageable amount for further inspection. In the case of AVL, this approach can assist future sourcing activities by providing an initial solution to reduce data overflow. In combination with the existing IT oriented SRM (Supplier relationship management) system, it can increase the efficiency of the future sourcing process.

There are also some influences that may distort the results of this evaluation method. The lack of product information could lead to an unreliable scoring result, due to the importance of the product quality and its importance in the weighting system. Also the limited knowledge of the technical quality requirements for some specific transmission components could lead to the evaluation result become more conservative. This work would by far exceed the scope of a master thesis if all automotive transmission components would be taken into consideration. Therefore only a selection of transmission components could be evaluated within this work. The general idea can then be carried over to other components.

Further research would require a request for quotation to be sent out to the supplier. This would provide additional insight regarding supplier performance in terms of cost, engineering capability and product quality. By expanding to a broader band of suppliers, a direct comparison of their strength and weaknesses will become much more apparent. In addition to this, an automated manipulation of the supplier data would improve the operating efficiency of the evaluation process.

8 Appendix

This appendix presents the supplier self-assessment questionnaire as well as the response from the selected supplier according to chapter 7.5.

8.1 Questionaire result for Shiyan Tongchuang Drive Technology Co., Ltd

Supplier Self-Assessment Questionnaire (1/3)	AVL

公司名称 Company name	十堰同创传动技术有限公司		
联系电话 Phone number	+86-27-84956903	传真号 Fax number	+86-27-84472672
公司官方网页 Homepage	http://www.tcsync.com.cn/	电子邮箱 Email	sytcjyb_66@263.net

联系人 Contact information	名称 Name	联系电话 Phone number	电子邮箱 Email	英文交流 English
技术经理 Technical manager	唐忠杰	+86-27-84472671	tang.zhongjie@163.com	yes
产品经理 Production manager	刘剑	+86-27-84956903	ljosf@163.com	no
销售经理 Sales manager	项星	+86-27-84956903	pac1no@126.com	yes
物流经理 Logistics manager	叶发明	+86-719-8797203	sytcyfm@163.com	no

中国生产地点 Production facilities in China
1、湖北省十堰市东风大道 78 号/N0.78 Dongfeng Ave. Shiyan City Hubei P.R. China 2、武汉市经济技术开发区珠山湖大道 129 号/No. 129 Zhushanhu Ave. Wuhan Economic &Technological Development Zone, Wuhan,Hubei, P.R.China

公司是否供应产品样板? Does your company supply prototype production?	yes
公司是否供应批量生产? Does your company supply serial production?	yes

Supplier Self-Assessment Questionnaire (2/3)	AVL

主要客户 Main customers	重营份额 Share of turnover
中国重汽集团大同齿轮有限公司	25[%]
一汽解放汽车有限公司变速箱分公司	20[%]
綦江齿轮传动有限公司	15[%]
东风汽车变速箱有限公司	15[%]

营业额 Structure of turnover	2012	2013	2014
	1.67 亿元	1.83 亿元	1.92 亿元

毛收入 Gross Profit	0.33 亿元
短期负债 Current Liabilities	0.65 亿元
重负债 Total Liabilities	0.65 亿元
流动资产 Current Assets	0.67 亿元
重部资产 Total Assets	1.80 亿元

国际质量体系认证 Do you run a certified Quality Management system?	TS16949 ISO 14001 ISO18001
ISO/TS 16949	☒
ISO 9001	☐
ISO 14001	☒

Supplier Self-Assessment Questionnaire (3/3)	AVL

公司生产发动机的零件吗？YES Does your company produce engine components?		
零件称呼 Component	产量 Volume	主要客户 Main customers
康明斯发动机齿轮毛坯	12 万件/年	中国重汽集团大同齿轮有限公司
公司生产变速箱的零件吗？YES Does your company produce transmission components?		
零件称呼 Component	产量 Volume	主要客户 Main customers
同步器总成	100 万件/年	中国重汽集团大同齿轮有限公司、 一汽解放汽车有限公司变速箱分公司 东风汽车变速箱有限公司 綦江齿轮传动有限公司
钢制同步环	150 万件/年	中国重汽集团大同齿轮有限公司、 一汽解放汽车有限公司变速箱分公司 东风汽车变速箱有限公司 綦江齿轮传动有限公司
粉末冶金齿毂、同步环	100 万件/年	安徽星瑞齿轮传动有限公司、 格特拉克（江西）传动技术有限公司、 上海汽车变速器有限公司 欧瑞康美科便面技术（意大利）有限公司
铜质同步环	90 万件/年	一汽解放汽车有限公司变速箱分公司 东风汽车变速箱有限公司 安徽星瑞齿轮传动有限公司、 上海汽车变速器有限公司
同步环摩擦材料（喷钼、碳纤维、碳基、覆碳、烧结青铜）	200 万件/年	中国重汽集团大同齿轮有限公司、 一汽解放汽车有限公司变速箱分公司 东风汽车变速箱有限公司 綦江齿轮传动有限公司 代傲同步技术(无锡)制造有限公司

请您评估公司产品价格 How do you assess your current price level?	
高于市场价 Above market price level	☐
市场价格 On market price level	☒
低于市场价格 Below market price level	☐
如果产品价格高于市场价，请解释原因。 If the price is above market price level why?	
Click here to enter text.	

是否同意客户审核？ Are you willing to accept a supplier audit?	yes

8.2 Questionaire result for Hoerbiger Drive Technology (Changzhou) Co., Ltd

Supplier Self-Assessment Questionnaire (1/3)	AVL

公司名称 Company name	HOERBIGER Drive Technology (Changzhou) Co., Ltd. 贺尔碧格传动技术（常州）有限公司		
联系电话 Phone number	0519-85603636	传真号 Fax number	0519-85602525
公司官方网页 Homepage	www.hoerbiger.com	电子邮箱 Email	Info-hdc@hoerbiger.com

联系人 Contact information	名称 Name	联系电话 Phone number	电子邮箱 Email	英文交流 English
技术经理 Technical manager	戴志云	0519-85603636	Zhiyun.Dai@hoerbiger.com	yes
产品经理 Production manager				yes
销售经理 Sales manager	冯超华	0519-85603636	Leo.Feng@hoerbiger.com	yes
物流经理 Logistics manager				yes

中国生产地点 Production facilities in China
江苏省常州市新北区创业东路 16 号粤海工业园 7 号厂房

公司是否供应产品样板？ Does your company supply prototype production?	yes
公司是否供应批量生产？ Does your company supply serial production?	yes

Supplier Self-Assessment Questionnaire (2/3)	AVL

主要客户 Main customers	重营份额 Share of turnover
VWATD	35[%]
ChangAn	30[%]
JAC	15[%]
SAGW	15[%]

营业额 Structure of turnover	2012	2013	2014
	180 Mio.	200 Mio.	250 Mio.

毛收入 Gross Profit	Click here to enter text.
短期负债 Current Liabilities	Click here to enter text.
重负债 Total Liabilities	Click here to enter text.
流动资产 Current Assets	Click here to enter text.
重部资产 Total Assets	Click here to enter text.
国际质量体系认证 Do you run a certified Quality Management system?	
ISO/TS 16949	☒
ISO 9001	☒
ISO 14001	☒

Supplier Self-Assessment Questionnaire (3/3)

AVL

公司生产发动机的零件吗？No Does your company produce engine components?		
零件称呼 Component	产量 Volume	主要客户 Main customers

公司生产变速箱的零件吗？Yes Does your company produce transmission components?		
零件称呼 Component	产量 Volume	主要客户 Main customers
同步器系统	400,000	JAC, SAGW, ChangAn
齿套	3,000,000	VWATD,JAC, SAGW, ChangAn
摩擦系统	2,000,000	JAC, SAGW, ChangAn
结合齿单元	500,000	SAGW, ChangAn

请您评估公司产品价格 How do you assess your current price level?	
高于市场价 Above market price level	☐
市场价格 On market price level	☒
低于市场价格 Below market price level	☐

如果产品价格高于市场价，请解释原因。 If the price is above market price level why?

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11 List of table

12 List of abbreviation

ABEC	Annular Bearing Engineering Commitee
AG	Arbeitsgemeinschaft
AGMA	American Gear Manufacturers Association
AVL	Anstalt für Verbrennungskraftmaschinen
BGNASB	British Gaskets – specific material labeling
BMW	Bayerische Motoren Werke
BYD	Build your dreams
C	Celsius
CAAM	China Association of Automobile Manufacturers
CBU	China Business Update
Cm^3	Cubic meter
Co., Ltd	Company limited
Dipl. –Ing.	Diplomingenieur / Master of Science
DIN	Deutsches Institut für Normung
Dr.	Doctor
e.g.	Example given
FAW	First automobile works
g	Gramm
GM	General Motors
GmbH	Gesellschaft mit beschränkter Haftung
Html	Hypertext markup language
http	Hypertext transfer protocol
ICE	Internal combustion engine
ISO	International Organization for Standardization
ISO/TS	International Organization for Standardization/Technical Specification
JAC	Jianghuai Automobile Cooperation
JIS	Japanese Industrial Standard
km	Kilometer
max	Maximum
MG	Morris Garages
min	Minimum
mm	Millimeter
mpa	Mega pascal
NVH	Noise Vibration Harshness
OEM	Original Equipment Manufacturer
p.	page

pdf	Portable document format
PFMEA	Process failure mode and effect analysis
PPAP	Production part approval process
Prof	Professor
P-T	Pressure-Temperature
RFI	Request for Information
RFQ	Request for quotation
RMB	Renminbi
R&D	Research and Development
SAIC	Shanghai Automotive Industry
SAE	Society of automotive engineers
SRM	Supplier relationship management
TEI	Thermo elastic instability
UK	United kingdom
USA	United States of America
US	United States
VW	Volkswagen
www	World wide web

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Financial ratios

$Current\ ratio = \frac{Current\ Assets}{Current\ Liabilities}$	Page 37
$Gross\ Profit\ Margin = \frac{Gross\ Profit}{Net\ Sales\ (Revenue)}$	Page 38
$Debt\ ratio = \frac{Total\ debt}{Total\ Assets}$	Page 38