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Product Differentiation

A step towards entry level products at Anton Paar GmbH

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Dominik Santner

Kurzfassung

Ein Kostenvorteil gegenüber dem oder eine Differenzierung vom Wettbewerb sind, die richtige Umsetzung vorausgesetzt, zwei Strategien eine Unternehmung erfolgreich zu betreiben. Unabhängig von Industrie, Sparte oder Geschäftsfeld wird die erfolgreiche Umsetzung einer der beiden Strategien mit der wachsenden internationalen Verflechtung von Wirtschaftssystemen zunehmend schwieriger.

Wendet man eine der beiden beschriebenen Strategien auf ein Unternehmen in der Messtechnikbranche an, bedeutet dies dem Kunden entweder eine Messung zum bestmöglichen Preis anzubieten, oder zu versuchen sich von seiner Konkurrenz zu differenzieren. Eine Differenzierung durch stetigen technischen Fortschritt in Form der Erreichung immer höherer Messgenauigkeiten ist genauso lange erfolgreich, so lange der Kunde durch ebendiese Messgenauigkeit einen Vorteil hat und bereit ist für diesen Vorteil entsprechende Mehrkosten in Kauf zu nehmen. Ist dieser Punkt erreicht, ist die Möglichkeit der Differenzierung für das Unternehmen plötzlich beschränkt und die Suche nach alternativen Differenzierungsmöglichkeiten scheint unumgänglich. Der Wandel vom Hersteller von Messinstrumenten bestmöglicher Genauigkeit zum Komplettanbieter von Messlösungen verschiedener Messgenauigkeiten und Preisklassen scheint ebenso komplex wie langwierig. Für die Herstellung von Produkten im Entry Level Segment, dies ist das Marktsegment mit niedrigen Produktpreisen, müssen zuerst entsprechende Marktpotentiale identifiziert und in weiterer Folge Produkte, wie auch alle damit verbunden Leistungen wie zum Beispiel Vertrieb oder Service, neu überlegt werden. Die Identifizierung eines konkreten Marktpotentiales und die entsprechende Konzeptionierung eines Messinstrumentes stellen, in Form dieser Arbeit, den ersten Schritt einer derartigen Entwicklung dar.

Abstract

When appropriately implemented, cost advantage over or differentiation from the competition are two strategies for operating a business successfully. With the growth of interdependencies of economies, the implementation of both strategies becomes challenging regardless of industry or business segment.

A company that manufactures measuring instruments could apply one of the two strategies by either offering the customer a measurement at the lowest possible price or by differentiating from the competition. A differentiation by continuous improvement in terms of constantly achieving higher accuracies remains crucial as customers notice advantages through this higher accuracy and are also willing to accept the additional cost for this advantage. As soon as this point is reached, the company's possibility for differentiation is limited all of a sudden and alternatives must be found. To change from a manufacturer of high level measurement instruments to a provider of instruments of all segments in terms of accuracy and price is complex and requires lengthy time investment. Generally, market potentials in entry level segments must be identified and in a next step products as well as appropriate sales channels and service possibilities must be developed. With the identification of such a market potential and the elaboration of an adequate product concept, this thesis represents the first step towards such a development.

Table of content

1 Introduction

The development and production of high-precision measuring instruments are the main reason for remarkable growth at Anton Paar GmbH. The constant pursuit for precision and measuring quality is firmly seated in the minds of the company's employees. When developing new products, developers placed importance on the highest possible measurement accuracy than on customer needs.

The deliberate development of instruments for simple applications with low accuracies with the aim to simply fulfil customers' needs and offering them the best possible price occurred rarely in the past. When the growth of the company product groups were added and existing product portfolios were extended, new challenges such as new competitors arose. Managers asked themselves whether it would yield favourable production if they were to enter the market using entry level products. This would be made possible by using the development of simple measuring instruments or with the acquisition of an established manufacturer of entry level products. However, without establishing a working concept, the decision would not be favourable. On the following pages, the overview of the company Anton Paar GmbH is presented. Second, the objective of this thesis is defined and finally the detailed approach to achieve the objective is described.

1.1 Anton Paar GmbH

The company Anton Paar GmbH was founded in 1922 by the locksmith Anton Paar himself as a one man workshop. In 2014, Anton Paar GmbH is a globally acting high tech company in the field of precision measurement instrumentation with its headquarters in Graz. In 2003, the Santner Foundation became the new owner of the Anton Paar group as shown in Figure 1. The foundation is exclusively aimed at charitable causes which are the promotion of scientific work in the field of natural science and technology and the addiction prevention.

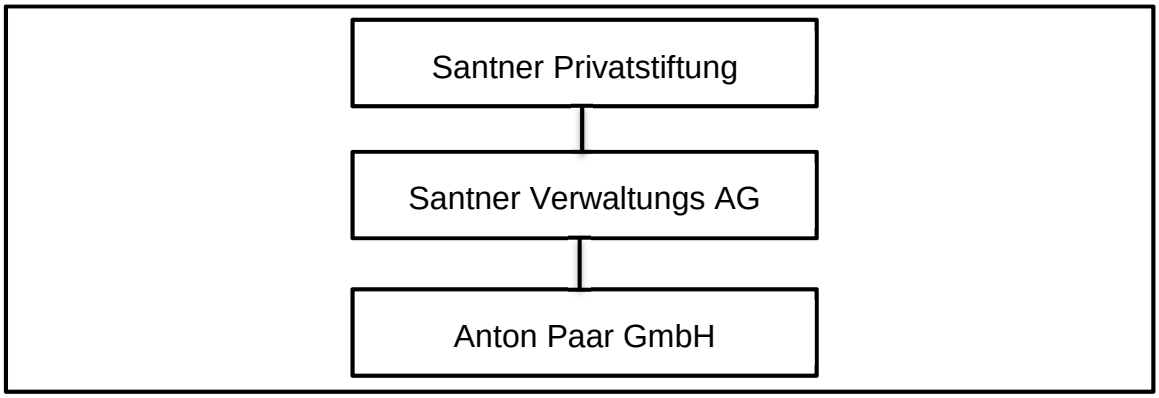

Figure 1; Ownership of Anton Paar[1]

In the headquarters in Graz as well as in Stuttgart (Germany), Hannover (Germany), Berlin (Germany) and Peseux (Switzerland) measurement devices are developed and produced. Furthermore, the products are distributed using 17 distribution subsidiaries, which are spread all over the world. Additional sales partners and joint ventures sell products from Anton Paar GmbH in 110 countries. An overview of the Anton Paar group, its subsidiaries, branch offices, and joint ventures is shown in Table 1. In May of 2014, the company hired its 2000th employee. From those 2000 employees, 900 work in the headquarters in Graz and approximately 28% are women. In 2013, the turnover of Anton Paar group was € 202.000.000 from which € 38.000.000 (19%) were spent in research and development. In the year 2008, the company's turnover was €112.000.000 which means that in just five years until 2013 it nearly doubled.

[1] Intranet Anton Paar GmbH (2014), date of access 08.07.2014

Headquarters	Founded	Based in
Anton Paar GmbH	1922	Graz, Austria
Subsidiary	**Founded**	**Based in**
Anton Paar (UK) Limited	1982	London, United Kingdom
Anton Paar USA Inc.	1986	Ashland, USA
Anton Paar Germany GmbH	1989	Ostfildern, Germany
Anton Paar Hungary Kft	1991	Veszprém, Hungary
Anton Paar Benelux BVBA	2001	Gentbrugge, Belgium
Anton Paar France SAS	2001	Courtaboef Cedex, France
Anton Paar Mexico S.A. de C.V.	2004	Mexico D.F., Mexico
Anton Paar (Shanghai) Trading Co. Ltd.	2006	Shanghai, China
Anton Paar ShapeTec GmbH	2006	Wundschuh, Austria
Anton Paar ShapeTec BA d.o.o.	2012	Derventa, Bosnia & Herzegovina
Anton Paar OptoTec GmbH	2007	Seelze-Letter, Germany
Anton Paar Japan K.K.	2008	Tokyo, Japan
Anton Paar India Private Limited	2008	Gurgaon, India
Anton Paar Switzerland AG	2009	Zofingen, Switzerland
Anton Paar Nordic AB	2011	Malmö, Sweden
Anton Paar Italia S.r.l.	2011	Rivoli, Italy
Anton Paar Ölçüm Aletleri Ticaret Ltd. Sirketi	2011	Istanbul, Turkey
Anton Paar ProveTec GmbH	2012	Dahlewitz, Germany
Anton Paar Southern Africa	2014	Midrand, South Africa
Anton Paar Poland Sp. z o.o.	2013	Warsaw, Poland
Anton Paar Brasil Importação,	2014	Sao Paulo, Brasil
Anton Paar TriTec SA	2013	Peseux, Switzerland
Branch Offices	**Founded**	**Based in**
Anton Paar Representación America Latina (LAM)	2001	Buenes Aires, Argentina
Anton Paar Hulpkantoor Nederland	2001	Oosterhout, the Netherlands
Austrian Anton Paar GmbH Shanghai	2003	Shanghai, China
Anton Paar Posredništvo Podružnica Ljubljana	2005	Ljubljana, Slovenia
Anton Paar GmbH organizační složka	2006	Praha, Czech Republic
Anton Paar Canada	2006	Saint Laurent, Canada
Anton Paar GmbH Podružnica Zagreb	2010	Zagreb, Croatia
Anton Paar Ireland	2011	Dublin, Ireland
Anton Paar Nordic AB, Suomen sivuliike	2011	Helsinki, Finland
Anton Paar Danmark, Sverige	2011	Ballerup, Denmark
Joint Ventures	**Founded**	**Based in**
MEP Instruments Pty. Limited	1998	Gladesville, Australia
MEP Instruments (NZ) Limited	1998	North Shore City, New Zealand
Metrohm Siam Limited	2001	Bangkok, Thailand

Table 1; Structure - Anton Paar group[2]

Due to fast growth in all areas of the company there was a need to expand and reorganize. Therefore, in April 2014, the company was divided into three business units.

[2] Intranet Anton Paar GmbH (2014), date of access 08.07.2014

The following list indicates Anton Paar's fields of business and how it was divided into three business units Measurement, Characterization, -and Solutions;

Business Unit Measurement has the following five product groups;

- Density and concentration measurement
- Viscometry: measurement of viscosity
- Refractometry: measurement of refractive indexes
- Polarimetry: measurement of polarization of waves
- Test equipment for petroleum properties

Business Unit Characterization has the following two product groups;

- Rheometry: measurement of rheological properties
- Tribometry: measurement of friction upon a surface

Business Unit Solutions has the following three product groups;

- Material characterization
- Density and concentration measurement in process
- Analytical and synthetic chemistry

This thesis deals with the product line Density and concentration measurement (short "LDC" for lab density and concentration) and the product line Viscometry. The product line LDC includes the measurement of dissolved carbon dioxide in liquids. The following sections describe these products out of these product lines in detail. Furthermore, as part of the literature review, basic measurement principles of these products are described.

Products of the product line density and concentration measurement are portable measuring instruments for the laboratory. They are highly precise bench top

instruments and systems for automated analysis which can measure the density, concentration, specific gravity, temperature and dissolved gas content of and in liquids.[3]

The product Anton Paar GmbH sells the most of its kind (approximately 5000 devices in 2013[4]) is the portable Density Meter DMA-35 (shown in Figure 2). It measures density of samples on site with an accuracy of 0.001 g/cm³ and gives results of density and concentration, such as °Bx which is degrees brix an d stands for the content of sugar in a liquid water-based solution. One gram of sucrose in 100 grams of the solution corresponds to one degree Brix; therefor it is comparable with the percentage by weight.

Figure 2; DMA - 35[5]

The device shown in Figure 3, is the second most selling instrument in Anton Paar GmbH (approximately 1500 devices in 2013[6]). It measures the density and concentration of liquids with a maximum accuracy of 0.000005 g/cm³ and provides integrated conversion tables for many applications.[7]

[3] Portfolio catalogue (2013) provided by Anton Paar, p.2
[4] Data from SAP-application – Business Warehouse, date of access 08.07.2014
[5] General catalogue (2014) provided by Anton Paar, p.7
[6] Data from SAP-application – Business Warehouse, date of access 08.07.2014
[7] General catalogue (2014) provided by Anton Paar, p.7

Figure 3; DMA - Generation M[8]

Measurement instruments that are used to analyse dissolved gases in liquids, such as carbon dioxide in soft drinks, are part of the second product group that is investigated throughout this thesis. As previously described, this product group is also apart of the product line density and concentration measurement.

The so-called CboxQC (shown in Figure 4) combines the measurement of CO_2 and O_2. In this thesis, only the measurement of CO_2 was taken into consideration.

[8] General catalogue (2014) provided by Anton Paar, p.8

Figure 4; CboxQC

The second product line, investigated throughout this thesis, is the product line Viscometry (short “Visco”). Anton Paar’s Viscometers determine the viscosity of liquids and there are two different types. The SVM 3000 viscometer (shown in Figure 5), measures the dynamic viscosity and density of oils and fuels and calculates the kinematic viscosity automatically. The second Viscometer, called Lovis 2000 M/ME, determines the dynamic and kinematic viscosity of liquids. Due to the small size of its measuring capillaries this viscometer requires only small sample volumes – starting from 100 µL – to deliver results with high precision.[9]

[9] General catalogue (2014) provided by Anton Paar, p.20

Figure 5; SVM-3000[10]

1.2 Objective

The main question of this thesis is to find out whether there is a profitable opportunity for Anton Paar GmbH investing in the development of an entry level product for one of the investigated product lines. The objective is therefore defined as a recommendation for the implementation of a two brand strategy for one product group out of Anton Paar's business unit "Measurement" including;

- the selection of a product group for launch,
- an economic evaluation for a selected product to start with and
- a recommendation for a distribution channel.

The selection of a product group for launch is based on quantitative information. Therefore, an overview of selected markets in order to identify market sizes and prove the basic entitlement of the development of entry level products is required. Economic evaluation as well as recommendation for distribution channel is then all be related to the one product group selected.

[10] General catalogue (2014) provided by Anton Paar, p.20

1.3 Approach

As a demarcation of the observation, two product lines of the "Business Unit Measurement" are selected. These are the product lines density and concentration measurement, which also includes the measurement of carbon dioxide in liquids and the product line viscometry as previously described. In the first six months of 2014, these two product lines were responsible for 87% of revenue at Anton Paar's Business Unit Measurment and for 37% of revenue at Anton Paar GmbH.[11]

Following the Manual for scientific work from the Institute of Industrial Management and Innovation Research, the expression of this master thesis will be marked by the central topic[12] which is the search for the answer to the fundamental question whether it pays off to introduce entry level products at Anton Paar GmbH. This happens within two stages.

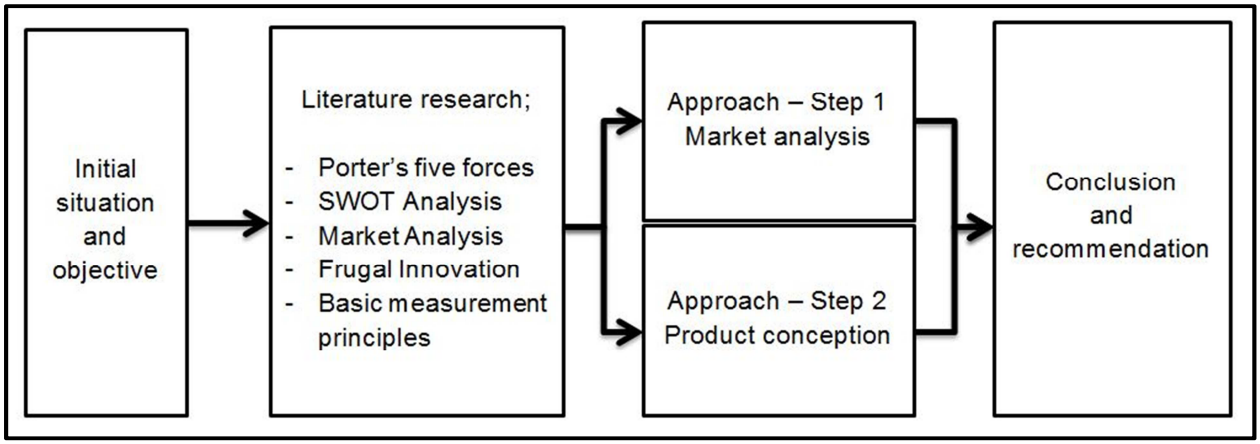

Figure 6; Organizational steps[13]

At the initial stage, the global market of three product groups previously defined is analysed in the context of a two brand strategy; the total markets size are found out and the markets are divided in segments of entry, medium and high level products. This segmentation is done by a classification depending on products prices wherefore products prices are found out. Products, currently offered from Anton Paar GmbH are then also assigned to defined market segments. Finally the market coverage by those

[11] Data from Anton Paar's CRM - System, date of access: 10.07.2014
[12] Cf. Ramsauer (2014), Industriewissenschaftliches Forschungsmanual, p.10
[13] Own illustration

products is found out and vice versa to this market coverage, market potentials are then identified.

In the second stage, on the base of the market analysis, one out of the three investigated product groups is selected for further analysis in the context of an entry level product. This selected product group, a concept for an entry level product is created for. The concept is based on Anton Paar's guideline for product concepts including a description of the product idea, an estimation of development costs, a detailed market analysis, and all together resulting in an economic evaluation in form of a net present value calculation. In Figure 6, the iterative organizational steps of the thesis are demonstrated.

2 Literature review

In this literature review, selected topics related to product differentiation and different methods of market analysis are studied; with Porter's generic strategies, the fundamentals of strategy are examined at the very beginning. Next, different approaches with regard to product politics are taken into consideration. In this context the term product differentiation in contrast to product diversification is investigated as well as Ansoff's product market matrix. Furthermore, Porter five forces as external forces on a firm are examined as well as interrelationships between these external forces and firms' internal strengths and weaknesses in form of the Swot analysis. Additionally, Bruhn's process for market analysis is studied.

The second practical part of this thesis is the product conception of an entry level product. Therefore, Frugal Innovation, the most recent research topic, is researched more in depth. Moreover, the basic measurement principles for the different product groups previously described are investigated.

2.1 Principles of Strategy

Strategy is "the fundamental, long-term behaviour (combination of policies) of a company and relevant parts of it to their environment towards achieving the long-term goals."[14] Under the consideration of Porter's five forces, as described in chapter 2.4, an infinite variety of different strategies can be formulated always dependent from the focus and the prerequisites of the strategist. Within a strategy, the long term behaviour is important; as to remain flexible in terms of strategy ruins the competitive advantage. The abrupt change from one strategy to another makes it difficult to be successful in either one of them. The continuous implementation of new ideas is important to ensure operatively effectiveness, but this is certainly compatible with a consistent strategic position.[15]

In the context of this thesis, a fundamental question is how far two brands, in terms of strategy, must be separated from each other; are common research and development and production departments a barrier for the development of each brand itself or are

[14] Webpage Gabler Wirtschaftslexikon, date of access 26.06.2014
[15] Cf. Porter (2013), Wettbewerbsstrategie, p.19

advantages in terms of knowhow transfer and efficiency predominant and must therefore be a separate strategy for an entry level brand, clearly differentiated as well internal as towards the customer? Considering this question, a closer look is taken on strategies predetermined in the literature;

Porter illustrates three generic strategies, shown in Figure 7, as examples of successful approaches. Each of them can work on its own but also take place in any combination. For the design of a future strategy, a closer look at the individual product areas and mapping in the single generic strategies seems necessary.[16]

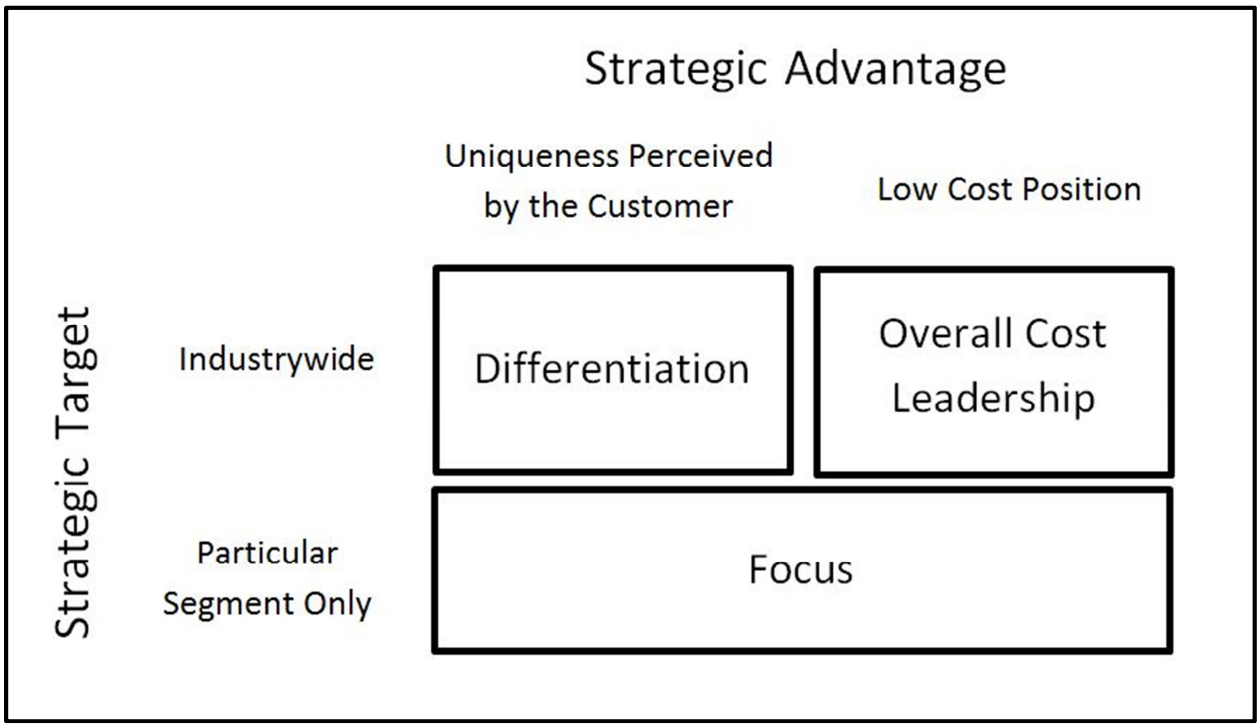

Figure 7; Three generic strategies[17]

On first inspection of its products, Anton Paar GmbH does not follow just a single strategy out of the three generic strategies which are shown in Figure 7. On the one hand they focus on segments of measurement instruments and therefore on a certain group of buyers by offering only a few product groups and on the other hand they try to differentiate from competition within these particular segments. Nevertheless, it can be

[16] Cf. Porter (2004), Competitive Strategy, p.35
[17] Cf. Porter (2004), Competitive Strategy, p.39

excluded that Anton Paar GmbH tries to achieve cost leadership on any of its nowadays business fields. Under consideration, the parallel application of previously described strategies has no negative impact on the prevailing business; there is no indication against the establishment of a second brand within the same company.

2.1.1 Overall cost leadership

Based on the experience curve concept in the 1970s, cost leadership describes a set of functional policies with the intention to produce a product at the smallest price possible in order to create profitability. Porter names efficient facilities, cost reductions from experience, tight cost control and cost minimization in areas like research and development, service, sales force and advertising as possibilities.[18]

Among management, the question arises whether cost leadership is relevant for a possible second brand of Anton Paar GmbH or not? A meeting with Mister Goud from Elico Ltd. (Hyderabad, India) shows the price sensitiveness of customers from developing countries. Elico Ltd. offeres two entry level spectrophotometers with the same specifications, one with a segment display, the other with a LCD touch screen. The price difference is below 10%, still about 90% of all customers buy the cheaper devices.[19] This example illustrates the importance of price in the entry level segment but the conclusion must not be that one has to be cost leader to be successful in an entry level segment. It can also be assumed that the grade of differentiation was too low as the LCD touch screen did not significantly add value to the customer.

2.1.2 Differentiation

Instead of the ability to offer a better price in order to hold cost leadership, differentiation is about offering different and unique features to the customer. In some of its core businesses Anton Paar GmbH follows a differentiation strategy offering for example the best accuracy in the field of density measurement or the best variability of its products in the field of Rheometry. Furthermore, differentiation creates “brand loyalty by customers […], increases margins […], and need for a competitor to overcome

[18] Cf. Porter (2004), Competitive Strategy, p.35
[19] Goud, G.C., Asst. Manager of Elico Ltd., oral information at 13.06.2014

uniqueness provide entry barriers"[20]. Assuming that differentiation in the basic function of an entry level product is hardly possible, other options for differentiation from competitors could contribute product design, the distribution channel, service and maintenance or pricing.

2.1.3 Focus

Focusing can have many forms; a firm can focus on a particular buyer group, a segment of a product line, or a geographic market. The development of each functional policy happens with the special focus in mind. The main principle of a focusing firm is to be able to serve a strategic target more effectively or efficiently than broadly acting competitors. Focussing does not exclude differentiation or overall cost-leadership. You can follow all three strategies at the same time; any combination is as possible as the application of only one strategy.[21]

2.2 Product politics

Product lines and programs are often developed within product politics. The term "product" is commonly regarded to illustrate not only the physical product itself or a sum of products, but also services or the sum of products and services to fulfil a particular requirement. This thesis deals with the expansion of the assortment, which is a part of assortment planning. It is important to decide which product groups should be expanded in future. In terms of expansion of existing product lines there are two options to choose from; the variation of existing products and the product diversification. While the variation is only the change of certain properties of a product, differentiation is the creation of an additional product. There are two possible directions for these options;[22]

- Differentiation / Trading down is the development of low-price segments done by firms who are acting in high-price and high-quality segments. Bruhn describes that firms protect themselves and their brand from getting a low-quality image by creating a second brand name.

[20] Porter (2004), Competitive Strategy, p.38
[21] Cf. Porter (2004), Competitive Strategy, p.38 ff.
[22] Cf. Bruhn (2012), Marketing, p.157 ff.

- Vice versa, differentiation / Trading up; is the development of high-price and high-quality segment, done by firms which act in a low-end segment.

According to Bruhn, on the one hand product differentiation enables better exploitation of customer groups, improves the assortment attractiveness, attracts new customer groups and defences the competition. Conversely, differentiation could cause a loose of image and reactions of competitors which already serve market segments the differentiating company is starting to develop. [23]

For completeness, it is also important to describe the diversification process. There are three possibilities of diversifying;

- Horizontal Diversification; is the development of products in a similar field, for instance if Anton Paar GmbH develops scales.
- Vertical Diversification; is the forward or backward integration of an economy level, e.g. if Anton Paar GmbH starts to produce displays for their measurement devices.
- Lateral Diversification; is the entry into a completely new business, for example if Anton Paar GmbH starts to trade pickles.

All three ways of diversification bring a company a bit further away from acting within their field of core competences and therefor are connected with a major risk.[24] For better overview, various possibilities for expanding an assortment are shown in Figure 8.

[23] Cf. Bruhn (2012), Marketing, p.157 ff.
[24] Cf. Bruhn (2012), Marketing, p.157 ff.

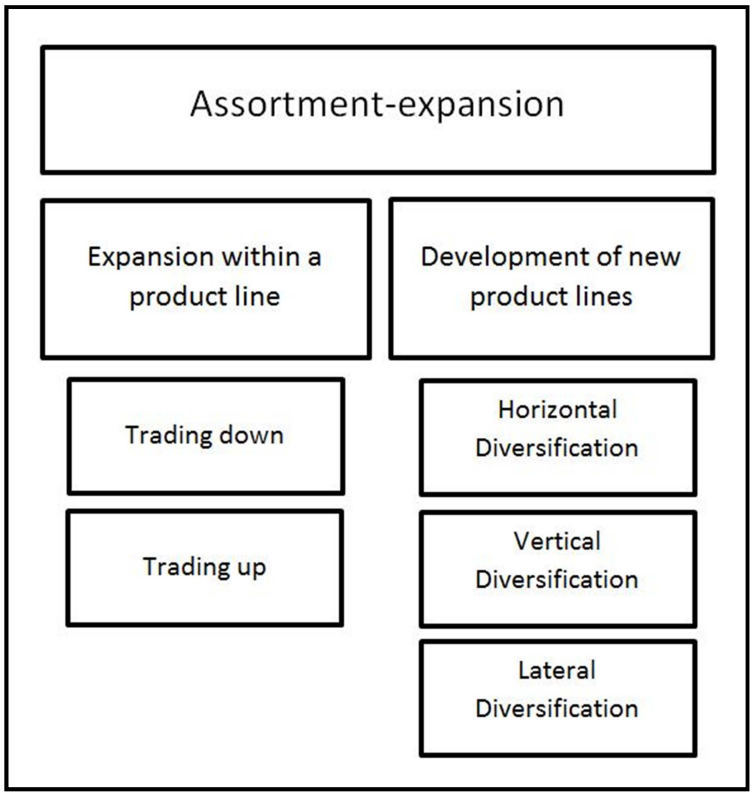

Figure 8; Assortment-expansion[25]

Further illustration (Figure 9) of the relationships of products and markets demonstrates Ansoff's product market matrix. It divides growth strategies in market penetration, product development, market development and diversification.[26] The introduction of a second brand, following the principle of trading down as previously described, would be classified in the product development segment of the product-market matrix.

The development of new products for existing markets is assigned to the segment of product development. Such a development goes often hand in hand with a huge effort on research and development-work. As this effort is often associated with a high risk, a systematic plan for research and development activities is necessary.[27]

[25] Cf. Bruhn (2012), Marketing, p.157 ff.
[26] Cf. Ansoff (1988), The New Corporate Strategy, p.108 ff.
[27] Cf. Welge et al., (2012), Strategisches Management, p.591 ff.

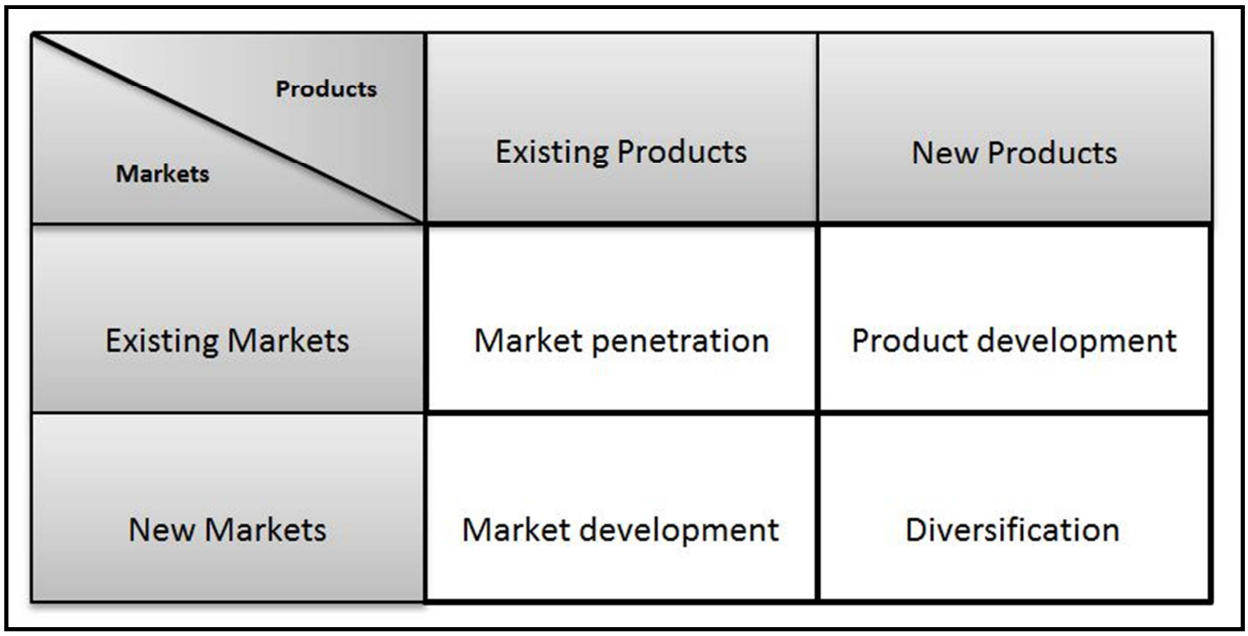

Figure 9; Product-Market-Matrix[28]

2.3 Process of market analysis

In this thesis, market analysis as part of marketing analysis forms the basis for further considerations in terms of a two brand strategy. The analysis of several product lines provides information about which of these product lines are the most appropriate for the start of a two-brand strategy. In the following paragraphs the processes, as shown in Figure 10, and single steps of the market analysis process are described as a basis for being able to subsequently find the right modus operandi.

[28] Cf. Ansoff (1988), The New Corporate Strategy, p.109

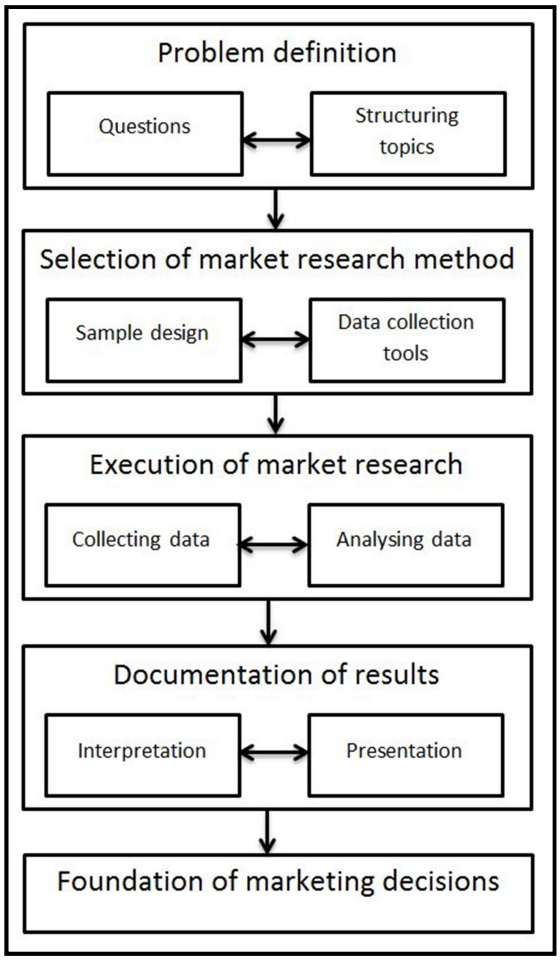

Figure 10; Process of market analysis[29]

The problem definition phase, the initial phase of market analysis, starts with the clear formulation of the questions, typically with the decision makers of a company. After listing up all relevant questions, they are structured into themes with the target to establish objectives as well as objects of the market analysis. It is about what to ask. The next step is to select the market research method. The main question is whether secondary research is sufficient or additional primary research is necessary or not. If primary research is required, sample designs and methods such as survey or observational designs need to be conducted. It is about whom to ask. After selecting the method, data has to be collected and subsequently analysed using appropriate tool. If, for example, a survey of customers using questionnaires is chosen in the second phase, it is necessary to design the questionnaire while considering and evaluating the

[29] Cf. Bruhn (2012), Marketing, p.93

collection method. Finally, the results need to be analysed, documented and prepared for the subsequent decision.[30]

2.4 Porter's five forces

External Forces on one market or branch influence mostly all competitors. Therefore, it is relevant to consider how the different competitors are able to deal with these external forces.[31]

The competitive situation in a branch depends on five forces shown in Figure 11. These five forces describe the different influences on a company acting in a specific branch concerning existing competition, potential future competition, customer, substitutes, and suppliers.

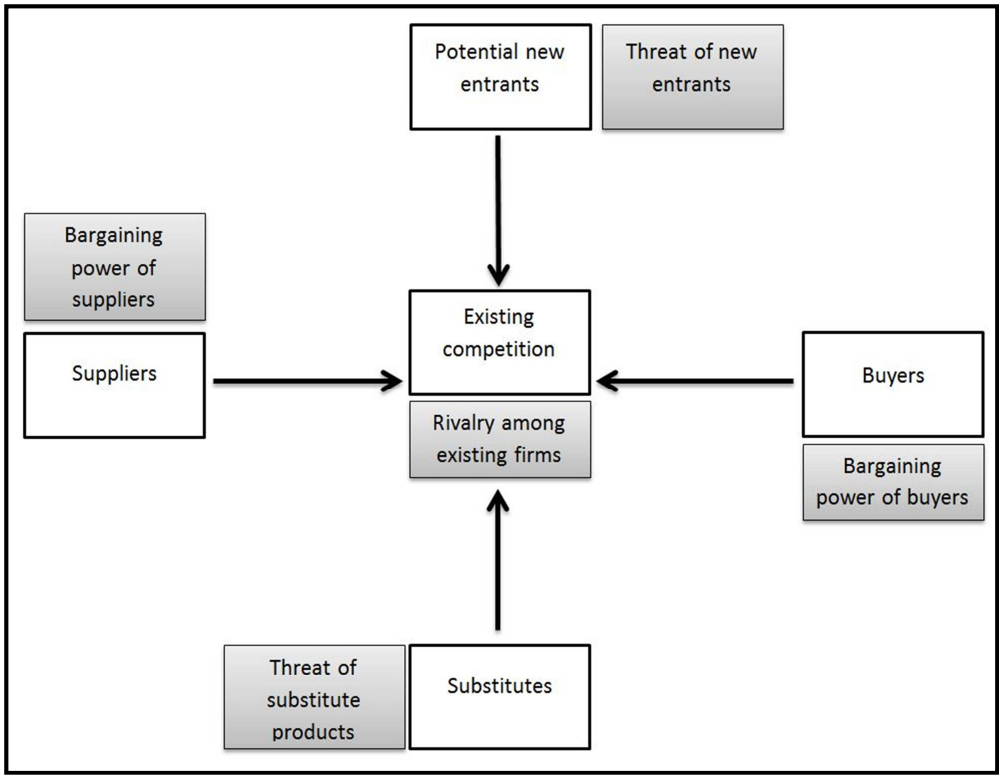

Figure 11; Porter's five forces[32]

[30] Cf. Bruhn (2012), Marketing, p.92 ff.
[31] Cf. Porter (2013), Wettbewerbsstrategie, p.37
[32] Cf. Porter (2013), Wettbewerbsstrategie, p.38

The key of developing a strategy is to look for the sources of these five forces. The relevant strengths and weaknesses of a company and the opportunities and threats of the branch the company is acting on are shown by the knowledge of these sources. The understanding of these forces will additionally aid in identifying potentials for diversification. The profitability of a specific branch as well as the intensity of competition is determined by the combination of all five forces.[33] The different forces are described in detail on the following paragraphs.

2.4.1 Threat of new entrants

As this thesis is about entering new market segments in the field of entry level products, the following threats for new entrants are investigated and described from the entrants' point of view.

First Threat for new entrants, the seven entry barriers;

1. The first entry barrier is referred to as Economies of scale. In special economic effects in production, research and development, marketing, and service are important as entry barriers.[34] They can on the one hand be a disadvantage for a small sized entrant, but an advantage for experienced companies from a similar branch. Anton Paar GmbH has a lot of know-how experience in terms of measurement principles and measurement methods; the economies of scale in the field of research and development should rather be a small barrier. As economy of scale in production, marketing and service are named as relevant barriers, the questions of where the production is located and the distribution channels that are used have to be taken into consideration.
2. The second entry barrier is referred to as Product differentiation, which means that "established firms have brand identification and customer loyalties, which stem from past advertising, customer service, product differences, or simply being first into the industry. Differentiation creates a barrier to entry by forcing entrants to spend heavily to overcome existing customer loyalties. This effort usually involves start-up losses and often takes an extended period of time. Such investments in building a brand name are particularly risky since they have no

[33] Cf. Porter (2013), Wettbewerbsstrategie, p.38 ff.
[34] Cf. Porter (2013), Wettbewerbsstrategie, p.42

salvage value if entry fails."[35] As we adress about a business in which customers are relatively rarely in contact with their suppliers, the importance of a brand name seems rather low. If a second brand was to be created, the question becomes whether the well-known and high quality brand name that is Anton Paar GmbH should be brought in connection with the new name of a second brand in order to benefit from its popularity and good reputation or not.

3. The third entry barrier is Capital requirements, and will strongly depend from how the start of a second brand will look like. If Anton Paar GmbH starts producing entry level products including the initial development of a single product within the existing organisation, needed start-up capital will be low and therefor the risk will be manageable. Starting with the creation of a separate legal entity and brand is as well tantamount to higher capital requirements and risks as corporate acquisitions, albeit depending on the size of the company bought. Porter describes capital requirements as a barrier, particularly when capital is required for risky advertising or research and development. Specially, the barrier out of costs for development appears to be a small one as the idea is to use Anton Paar's well-known technologies.
4. The fourth entry barrier is Switching costs, which is seen as one-time costs for switching from one product to another. Particularly, in the field of low cost measurement devices at first glance do not seem to be a major barrier as we talk about affordable devices, easy to buy and use. Highly complex equipment, where training of the user and a lot of additional accessories is required, would definitely cause switching cost to the customer, but is part of Anton Paar GmbH's main business and has nothing to do with a possible second brand. Therefore, the first delineation of a possible second brand to the main brand can be defined as the requirement of training. The complexity of an instrument depends not only on its specifications in general and in particular on its accuracy, but also on the usability and subsequently the amount of training required.
5. The fifth entry barrier is referred to Access to distribution channels. It is considered as the best distribution channel and has already been used by established firms. Distribution using those same logical channels will probably cost at least as much as it costs the competitor. [36]

[35] Porter (2004), Competitive Strategy, p.9
[36] Cf. Porter (2004), Competitive Strategy, p.10

Furthermore, competitors enjoy immense benefits on known distribution channels through their experience and reputation, which, assuming the product is equivalent. can only be compensated by a price difference. A lower price for its products combined with the same costs for distribution could lead to a competitive disadvantage of a second brand. Anton Paar GmbH sells its products by means of its own sales organisation, mainly through their 17 Sales and Service subsidiaries.[37] These products usually require training by the sales staff. The cost for distribution is about 40% of the retail price. The idea of a second brand must include the development of simple and easy-to-use solutions; it would be optimal if Anton Paar GmbH's second brand's products would not require training. If done so, the use of the more expensive distribution network of Anton Paar GmbH would no longer be necessary. For products where training is not necessarily required, Anton Paar GmbH established a web shop in January 08, 2014. It is promoted being "the new address for browsing and conveniently ordering best-in-class measuring instruments for research and quality control in numerous industries - from beverages, food and chemicals to pharmaceuticals, and petroleum. With a few clicks only, visitors,…, can now buy several "five-star" Anton Paar solutions online, such as different versions of the renewed portable DMA 35 density meter, the compact DMA 500 density meter, …, and the MKT 50 high-precision thermometer – with more solutions to be included in the future."[38] The mentioned products DMA 35, DMA 500 and MKT 50 are entry level devices for measuring density, "DMA" stands for "Dichte-Mess-Apparatur", and temperature, "MKT" is the abbreviation for "Milli-Kelvin-Thermometer". With the establishment of the online store, the company already started to take advantage of saving costs for distribution. Assuming that Anton Paar GmbH has to offer the customer a possibility to save switching costs, it was previously said that the first delineation of a possible second brand to the main brand has to be the requirement of training. It means that the complexity of an instrument does not only depend on its specifications but also on the difficulty of use. This delineation can now be extended; measuring with a device of a low-cost brand has to be as easy, as once the customer has bought the device on the online store he or she may, without further explanation and training, be able to use the device properly.

6. The sixth entry barrier is called Cost disadvantages, which are independent of the general scale. The two cost advantages for a possible two brand strategy at

[37] Intranet Anton Paar GmbH (2014), date of access 23.06.2014
[38] Webpage Anton Paar GmbH (2014), date of access 23.06.2014

Anton Paar GmbH seem to be; proprietary product technology and knowhow and experience. At this point it is important to find out which existing technologies can be adopted and therefore only adaptations are required and where fundamental new developments are necessary. Regarding experience as a barrier to enter a market, it has to be taken into account that Anton Paar GmbH develops, produces, and distributes highly accurate measuring instruments. Assuming that a lot of experiences in each of these three areas exist, the question becomes how experience can be used in terms of creating a second brand, a low cost brand and in which fields lack of experience could be an entry barrier. The workshop production of highly complex measuring instruments in small numbers versus the production of a high number of simple measuring instruments may be mentioned by way of example.

7. Government policy, as the last entry-barrier mentioned by Porter, describes obstacles on the basis of country-specific regulations and does not seem to be relevant in the context of a two-brand strategy for Anton Paar GmbH.[39]

Second threat for new entrants, expected retaliation;

Porter named different conditions that encouraged competitors fighting against other market entrants. It is especially risky for new entrants if established firms have got substantial resources such as excess cash and productive capacity. Additional risk is given when an industry grows slowly and therefore a new firm cannot exist without depressing the sales and financial performance of established firms.

Third threat for new entrants, the Entry Deterring Price;

The concept of the entry-deterring price simply summarizes the condition of an entry in an industry. The entrant makes a forecast, calculating a potential price for his product including cost for structural entry barriers. For established market participant, pricing below this entry-deterring price creates a strong entry barrier for new entrants or competitors, but profit will subsequently be lower. If market participants price higher than the entry-deterring price, the industry becomes interesting for new entrants. [40]

[39] Cf. Porter (2004), Competitive Strategy, p.11 ff.
[40] Cf. Porter (2004), Competitive Strategy, p.14

Fourth threat for new entrants, properties of entry barriers;

Porter described mainly three properties of entry barriers. The first one is the change of entry barriers, such as expiring patents, as it was the case with Polaroid by way of example. Once the basic patents on instant photography ran out, the absolute cost entry barrier was reduced and Kodak entered the market. Secondly, Porter named the change of entry barriers for reasons outside a firm's control. The capital cost barrier was raised when companies of the car industry decided to vertically integrate parts manufacturers to save costs and increase the economies of scale. At last the possibility for some firms of entering an industry more cheaply than others due to the ability to share costs is listed.[41]

Fifth threat for new entrants, experience and size as entry barriers;

Company size and experience must not be mixed up at that point. "Although they often coincide, economies of scale and experience have very different properties as entry barriers."[42] Whereas size and associated economies of scale as an entry barrier do not seem to be critical for a second brand strategy concept at Anton Paar GmbH, experience can be a relevant factor, as Anton Paar GmbH seems to be enormous experienced in developing, producing, and selling high level measurement instruments. Again, the question would be in which areas experiences can be used in accordance to the development of entry level products. Furthermore, it will be necessary to think about those areas of a second brand's business where no experience is available and how this lack of experience can be compensated.

2.4.2 Bargaining power of buyers

Whether a new market is profitable depends on the number of acting competitors. Porter summarizes that "buyers compete with the industry by forcing down prices, bargaining for higher quality or more services, and playing competitors against each other – all at the expense of industry profitability."[43] At that point, circumstances, which make a buyer powerful, are described. In context with this thesis, a closer look at two of these circumstances is considered:

[41] Cf. Porter (2004), Competitive Strategy, p.14 ff.
[42] Porter (2004), Competitive Strategy, p.15
[43] Porter (2004), Competitive Strategy, p.24

- First, since technology made information easily accessible, buyers have full information about offered products, alternatives, and prices. This situation gives the buyer greater bargaining power than without information. For Anton Paar GmbH, if entering the field of entry-level products, this is a case that needs to be considered. Customers suddenly have a wide range of alternatives to choose from, pricing is therefore highly influenced by others. When analysing the market, a closer look has to be taken on prices of competition to be able to identify profitable opportunities.
- Second, as entry-level products in general offer fewer features, the ability to differentiate from competition is rather small. As products are more undifferentiated, customers, knowing they can find alternative suppliers, will play one company against another.[44]

2.4.3 Threat of substitute products

Substitute products are "different goods that, at least partly, satisfy the same needs of the consumers and, therefore, can be used to replace one another. Price of such goods shows positive cross-elasticity of demand. Thus, if the price of one good goes up the sales of the other rise, and vice versa."[45] From the perspective of creating a second brand and entering a new market, the first question is how to create substitutes. Thinking about substitutes in the field of entry level measurement devices, there are two possibilities. You can either create a substitute by developing a new measuring principle or by adapting exiting technologies to make them usable for other purposes and applications or affordable for other customer groups. It is clear that once you have a product, a second step would be to defend your position against other substitutes.

2.4.4 Bargaining power of suppliers

First the access to information was mentioned as something making the buyer strong (see chapter 2.4.2). "The conditions making suppliers powerful tend to mirror those making buyers powerful."[46] This would mean that withholding information from the customer would make the supplier strong. It is assumed that a customer buying an

[44] Porter (2004), Competitive Strategy, p.25 ff.
[45] Webpage Business-dictionary, date of access 26.06.2014
[46] Porter (2004), Competitive Strategy, p.27

entry level measuring device essentially wants to know the accuracy of the measurement and the price for the measuring device, as well the purchasing price as the costs for maintenance and service. The theory though does not apply in this case.

Differentiation on the other hand, could potentially make a difference to suppliers as it cuts off the options for a buyer to play one supplier against another.[47] As entry-level products in general offer basic features, creating values different from the competitors will be as difficult as crucial. In addition to the basic function of an entry-level product, other options come to mind for differentiation from competitors such as product design, the distribution channel, service and maintenance or pricing just to name a few.

2.4.5 Intensity of rivalry among existing competitors

Entering a new market, the basic question is how competition is represented. The more market players, the more intensive the rivalry and the less interesting it is the market to enter. “In most industries, competitive moves by one firm have noticeable effects on its competitors and thus may incite retaliation or efforts to counter the move; that is, firms are mutually dependent. This pattern of action and reaction may or may not leave the initiating firm and the industry as a whole better off. If moves and countermoves escalate, then all firms in the industry may suffer and be worse off than before.”[48] If rivalry is strong, firms have to work out benefits for the customer not to fall into a price war that would eventually reduce profitability.

Despite the number of competitors, the intensity of rivalry strongly depends on the growth-rate of a market. A fast growing market will enable several firms to reach an acceptable result. “Slow industry growth turns competition into a market share game for firms seeking expansion.”[49] In the context of a two-brand strategy, it is of interest if and how fast the market of entry-level measurement devices is growing.

2.5 SWOT analysis

Porter’s five forces are basically external forces, which influence some firm’s businesses from outside. Those external forces could as well represent opportunities,

[47] Cf. Porter (2004), Competitive Strategy, p.28
[48] Porter (2004), Competitive Strategy, p.17
[49] Porter (2004), Competitive Strategy, p.18

as also threats for a firm. Those forces, combined with internal strengths and weaknesses set the base for the so called SWOT analysis which was developed in the Harvard Business School. According Kotler's advices, following points have to be considered when applying the SWOT analysis in practice;[50]

- Keep statements descriptive.
- Do not interpret while you are analysing, certain points may be listed multiple times.
- Focus on the external part; try to get information from competitors because this is the information relevant for a qualitative external analysis.
- Do not mix internal and external analysis.

The idea of a strategy derived from the SWOT principle, is to use strengths and avoid weaknesses. Making a swot analysis should still not make a company acting only in those segments in which they currently operate successfully. In a long-term perspective, opportunities of the future should be considered and weaknesses of today should be avoided.[51] In the literature the SWOT-method and the TOWS-method are found, both of them correspond to each other, for simplicity from now on the term SWOT is used. As the SWOT-analysis is sometimes just a list of strengths, weaknesses, opportunities, and threats, Weihrich and Welge put those internal and external forces in context with each other (see Figure 12). For each Segment of the matrix specific strategies are then further developed.

[50] Cf. Kotler et al., (2010), The Quintessence of Strategic Management, p.32 ff.
[51] Cf. Welge et al., (2012), Strategisches Management, p.448

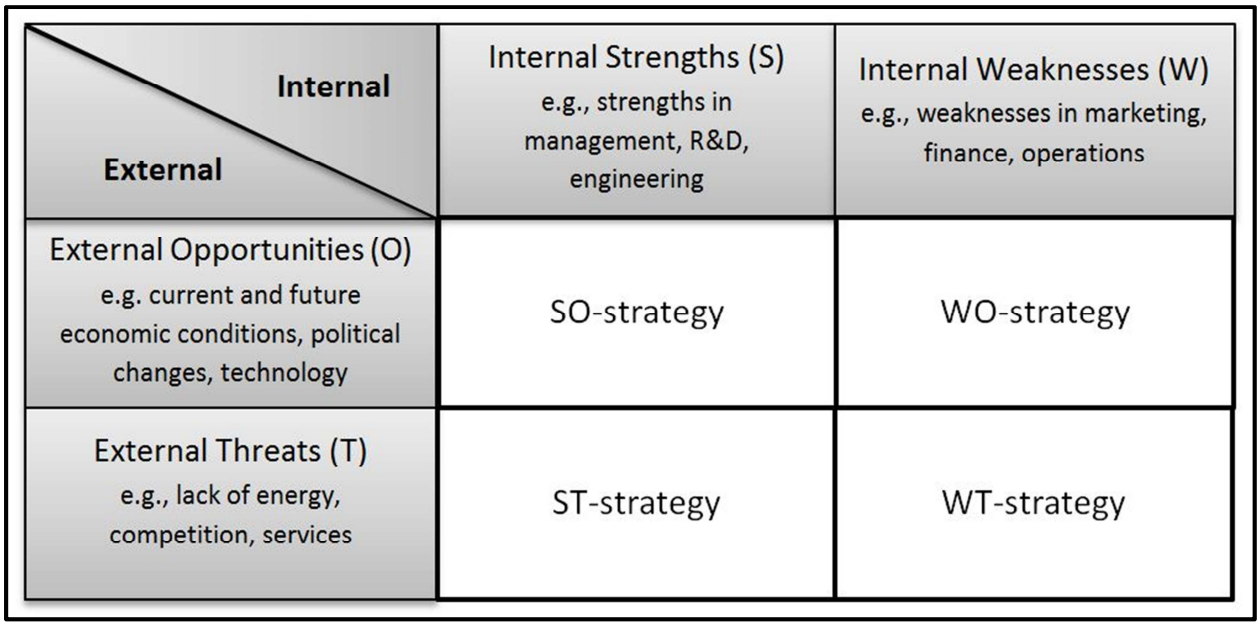

Figure 12; The SWOT-Matrix[52]

The **SO-strategy** is the ideal case of strategy formation as there are strong internal strengths combined with big external opportunities. Acting in this segment, the use of growth strategies seems appropriate. **WO-Strategies** try to eliminate internal weaknesses for being able to use opportunities. It is the target of WO-Strategies to reach the SO-Segment. If there were for example a lack of know-how; "One possible WO-Strategy would be to acquire this technology by forming a joint venture with a firm having competency in this field. Another WO-strategy would be to hire and train people with the required technical capabilities"[53]. **ST-Strategies** try to use a firm's strengths to protect from external threats. Differentiation, as described in chapter 2.2, might be used to counteract competitors who bring entry-level products to the market which are bought by customers as substitutes to some company's high-end products. **WT-Strategies** are typically defensive strategies and are trying to minimize internal weaknesses and avoid external threats.[54]

[52] Cf. Weihrich (1982), The TOWS Matrix – A tool for situational analysis, p.60
[53] David (1986), Fundamentals of Strategic Management, p.206
[54] Cf. Welge et al., (2012), Strategisches Management, p.449

2.6 Frugal innovation

The word Jugaad, originally from Punjabi, describes a makeshift vehicle such as a truck cobbled together with an engine[55], whereas frugal innovations describe "products with a strong focus on core functionalities and a radically reduced cost-structure."[56] A study reveals that frugal products reduce costs in thirteen different categories anywhere between 58% und 97% compared to standard, non-frugal, entry-level products.[57] By trying to answer the question how innovators of frugal products are able to manage this paradox, Tiwari and colleagues provide a link between the success of a frugal invention and the use of analogies and a transfer of knowledge from one area to another.[58] This link between innovation and analogies corresponds with Schumpeter's view that "development consists primarily in employing existing resources in a different way, in doing new things with them"[59].

Radjou describes that the Jugaad-way of thinking also existed in the western world (North-Amerika) and names Cyrus McCormick and Benjamin Frankling as examples. McCormick, together with his father, developed a machine, which could automate grain harvesting in the early 19th century. The new invention mainly developed with limited resources and handmade components could harvest more grain than five men using the earlier cradles. Franklin invented a new stove with a simple case in the front and an air box at the back, the redesign of the flues made the stove as more efficient as twice as much heat could be generated with 75% less wood. Franklin furthermore wanted all Americans to benefit from his stove and therefore did not patent any of his inventions. As economics expanded in the 20th century, innovation capabilities were institutionalized in R&D-departments. Standardized business processes and the management of innovation ruled the creative act of innovation. Companies that applied this structured approach were quite successful in the second half of 20th century but face three basic problems in the 21st century.[60] The problems of the structured approach are shown in the following;

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[55] Cf. Radjou et. al., (2012), Jugaad Innovation, p.4
[56] Tiwari et al., (2014), Frugal innovation and analogies, pp.15-23
[57] Cf. Rao (2013), Technology in Society, pp.65-73
[58] Cf. Tiwari et al., (2014), Frugal innovation and analogies, pp.15-23
[59] Schumpeter (1934), The Theory of Economic Development, p.68
[60] Cf. Radjou et.al., (2012), Jugaad Innovation, p.6 ff.

- At first, it is said that product development became extremely expensive and resource consuming in the western world; Radjou describes that the output of R&D does not correlate with the input in it. He gives us two examples; Big Pharma's spending on R&D ballooned from $2 billion in 1980 to $30 billion in the early 2000s. On the other hand, the average costs to successfully develop a drug rose from $320 million in the mid-1980s to $1.2 billion in the early 2000s.[61] While the input rose by 15 times, the output only fourfold. Second example is the U.S. auto sector, where the "Big Three" (Chrysler, General Motors and Ford) from 1998 to 2009 lost 25.8% of the U.S. market (from 70% to 44.2%) despite enormous development expenditure.[62]
- Secondly, the lack of flexibility is described; Radjou criticises a structured approach for innovation processes, as it seems too inflexible for a fast changing surrounding. As an example, he names Six Sigma, a management tool pioneered by Motorola in 1986 to decrease production defects and increase efficiency, to be "unfit to deliver the agility and differentiation that enterprises need in a fast-paced and volatile world."[63]
- Acting elitist and insular is blamed to be the third problem of western companies. Concerning that, Radjou claims that firms make innovation to an elite affair in the belief that the control of access to knowledge means power. Thus, only a few could be innovative and new innovations are strictly protected. This combined with the idea that only top of the line technology and the ownership of the best intellectual property enable firms to dominate markets might have been right in the earlier industrial area but is far less valid now. [64] By way of example, he cites Bob McDonald, CEO of Procter and Gamble;

  "For us, innovation is not invention. It's the conversion of a new idea into consumer delight and, ultimately, into revenues and profits. If an idea or technology cannot be successfully commercialized, it's not an innovation."[65]

[61] Webpage Key Industry and Pharma Facts, date of access 15.07.2014
[62] Cf. Radjou et.al., (2012), Jugaad Innovation, p.9 ff.
[63] Radjou et. al., (2012), Jugaad Innovation, p.10
[64] Cf. Radjou et.al., (2012), Jugaad Innovation, p.11 ff.
[65] Webpage Procter and Gamble, date of access 15.07.2014

2.7 Basic measurement principles

In the following chapter, the technical basics of different measurement principles of the three product groups investigated in the second practical part of this thesis are described. As the number of different measurement methods is extensive, only the most commonly used are described in detail.

2.7.1 Measuring the density of liquids

There are basically two different common methods for measuring the density of liquids, the gravimetric measurement method and the measurement method using an oscillating u-tube with a constant volume and a variable mass due to different densities of the measured liquids inside the tube. Both methods are to be described in more detail;

The gravimetric measurement method is based on Archimedes' principle. It says that the force F on a body, as shown in Figure 13, is as big as the weight G of the fluid, with its density ρ, which is displaced by the body with its area size A, the depth of immersion h.

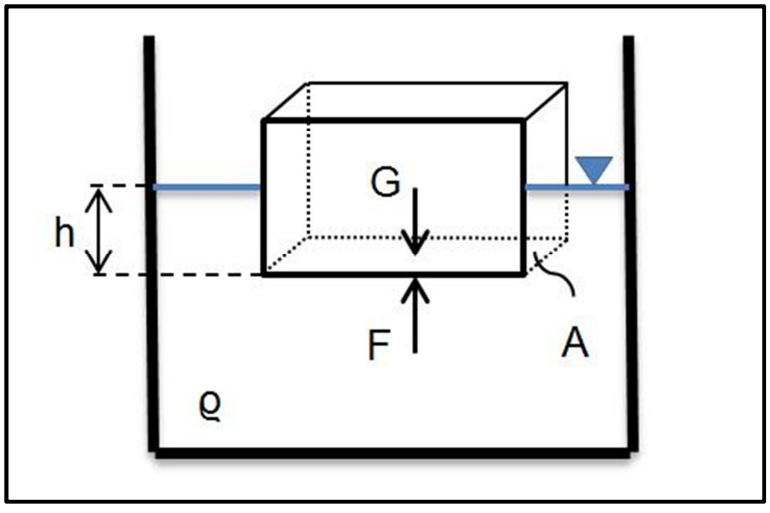


Figure 13; Archimedes' principle[66]

[66] Own illustration

Consequently, the system can be described by the following equation;

$$G = F = A * h * g * \rho \quad .$$ **(Equation 1)**

If weight G, the area A and the gravitational acceleration g are known, the density ρ can be derived directly dependent on the penetration depth of the body;

$$\rho = C1 * \frac{1}{h}$$ with **(Equation 2)**

$$C1 = \frac{G}{A * h}$$ **.** **(Equation 3)**

The measurement using an oscillating U-tube with a constant volume and a variable mass due to different densities of the measured liquids inside the tube was developed in the late 1970s. The development is based on the relation between the natural frequency of a harmonic oscillation system and its mass. A cantilevered U-tube is then filled with the liquid to be measured; the total mass of the oscillating system is thus dependent on the density of the filled liquid. The development of this principle can be traced back to Technical University Graz, Dr. Otto Kratky be mentioned here in the first place. The oscillating U-tube principle is based on a simple model of the undamped spring-mass system as shown in Figure 14.[67]

[67] Cf. Laznickova (1995), Biegeschwinger für Gasdichtemessungen, p.5 ff.

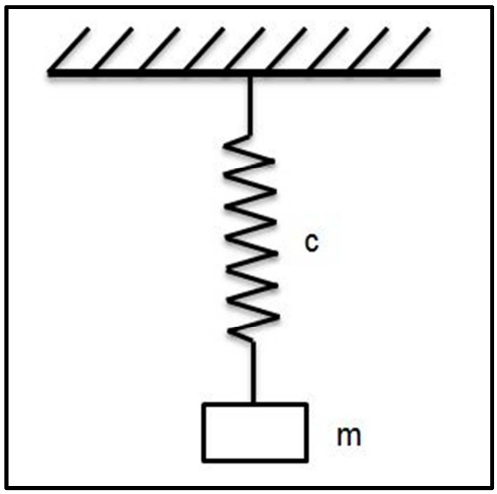


Figure 14; Undamped spring-mass system[68]

The natural frequency f of this system with the mass m and the spring rate c is;

$$f = \frac{1}{2*\pi} * \sqrt{\frac{c}{m}} \quad . \qquad \textbf{(Equation 4)}$$

If the mass m is composed of m_0, the mass of the U-Tube and V*ϱ, the mass of the filled liquid with the Volume V and the density ϱ, the equation becomes;

$$\boldsymbol{f = \frac{1}{2*\pi} * \sqrt{\frac{c}{(m0+V*\rho)}}} \quad . \qquad \textbf{(Equation 5)}$$

As the mass of the U-Tube m_0 and the volume of the filled liquid are constant, the density ϱ of the filled liquid can further be expressed;

$$\boldsymbol{\rho = C2 * \left(\frac{1}{f^2}\right) - C3} \quad \text{with} \qquad \textbf{(Equation 6)}$$

[68] Own illustration

$$C2 = \frac{c}{4 * \pi^2 * V}$$ and **(Equation 7)**

$$C3 = \frac{m0}{V}$$. **(Equation 8)**

2.7.2 Measuring carbon dioxide in liquids

The measurement of carbon dioxide in liquids is mainly required in the beverage industry. “In the beer and beverage industries, the content of dissolved carbon dioxide is a determining factor in the quality and taste of beer and carbonated beverages. Breweries as well as soft drink manufacturers continuously control and measure the CO_2 quantity during production.”[69] There are two common principles for measuring the concentration of carbon dioxide in liquids.

Within the first principle, typically, the pressure and the temperature are measured in a container in which both the liquid to be measured and a gas portion is located. Based on Henry's law, the partial pressure in the gas phase is directly proportional to the concentration of the gas dissolved in the liquid. Basically, simply measuring pressure and temperature by a manometer and a thermometer is sufficient as the concentration of dissolved CO_2 can then be read of from concentration tables which exist in various variants. Within this simple measurement method, also gas fractions of other gases than CO_2, such as nitrogen, are measured. Therefore, by using this method, these additional gas fractions could not be measured separately and a measurement error occurs. As this measurement error is in a single digit percentage range, most measuring customers accept it or even ignore it.[70]

The second method is based on laser absorption. Within this method, a beam is send through the headspace of a container by a laser transmitter. The CO_2 molecules in the headspace absorb then parts of the light of the laser; the rest of the light reaches a receiver at the opposite of the container. From the degree of absorption, the CO_2 concentration is derived. The two big advantages of this method, compared to the previously described method measuring pressure and temperature, are;

[69] Webpage Haffmans, date of access 15.09.2014
[70] Schölnberger, M., Product management CO_2 at Anton Paar, oral information at 12.09.2014

- the container to be measured must not be opened and
- additional gases in the headspace, such as nitrogen, do not impact the measurement result.[71]

2.7.3 Measuring the viscosity of liquids

For measuring viscosity of liquids, there is on the one hand the measurement of kinematic viscosity and on the other hand the measurement of dynamic viscosity. The dynamic viscosity is defined by the “Two plates model” whereas the lower plate stands still and the upper plate moves parallel as shown in Figure 15.

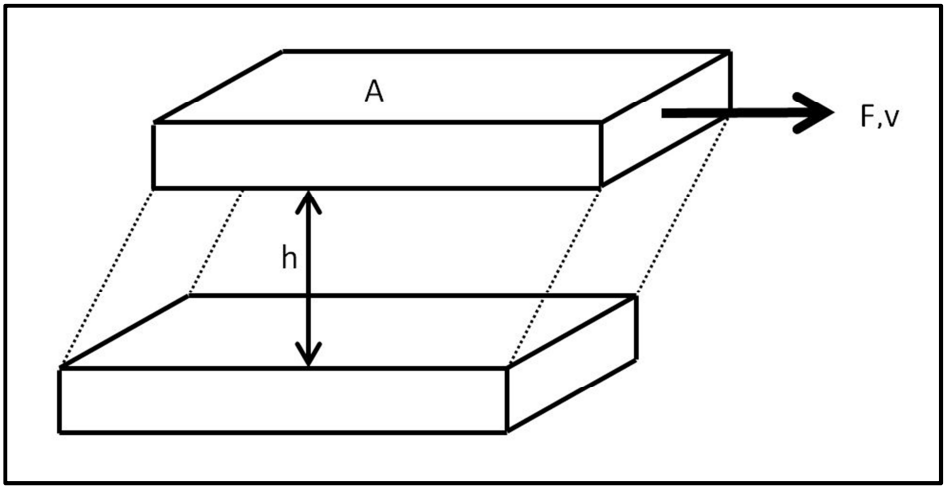


Figure 15; Two plates model[72]

Within this model the shears stress τ and the shear rate γ̇ within a liquid in between the two plates are defined with the force F and the area size A;

$\boldsymbol{\tau = F/A}$	and	**(Equation 9)**

$\boldsymbol{\dot{\gamma} = v/h}$	.	**(Equation 10)**

[71] Cf. Webpage Haffmans, date of access 15.09.2014
[72] Cf. Mezger (2014), Angewandte Rheologie, p.22 ff.

With the shear stress τ and the shear rate $\dot{\gamma}$ the dynamic viscosity η is defined as;

$$\eta = \frac{\tau}{\dot{\gamma}} \quad . \qquad \textbf{(Equation 11)}$$

The two measures of kinematic viscosity v and dynamic viscosity η are directly related by density ρ;

$$\eta = \nu * \rho \quad . \qquad \textbf{(Equation 12)}$$

The kinematic viscosity is the flow behaviour of a fluid under the influence of gravity; "it is mostly used in the petrochemical industry as it has set as a standard by the historical use of simple glass capillaries. The reason is that the driving force, gravity, does not require any technical equipment, it is simple available everywhere."[73] The simplest and cheapest method for measuring the kinematic viscosity is the measurement using a so called flow cup. Within this method, the time is measured a liquid needs to run out a defined cup through a defined, usually small, opening. The more accurate and most common principle to measure the kinematic viscosity is the gravimetric capillary principle. The fluid to be measured flows through a glass capillary with a defined geometry and the time t is measured the fluid needs to pass a defined section of the capillary.[74] With a system depending capillary factor C4, the kinematic viscosity can then easily be calculated[75];

$$\nu = C4 * t \qquad \textbf{(Equation 13)}$$

Different applications require different geometries of the glass capillaries, typical ones are shown in Figure 16. As an example, the "Houillon" capillary (Nr. 4) allows the use of a very small amount of sample and therefore a fast measurement.

[73] Feischl, T., REA KAM PetroChem Employee of Anton Paar, oral information at 09.09.2014
[74] Cf. Mezger (2014), Angewandte Rheologie, p.12 ff.
[75] Cf. Webpage Viscopedia, date of access 09.09.2014

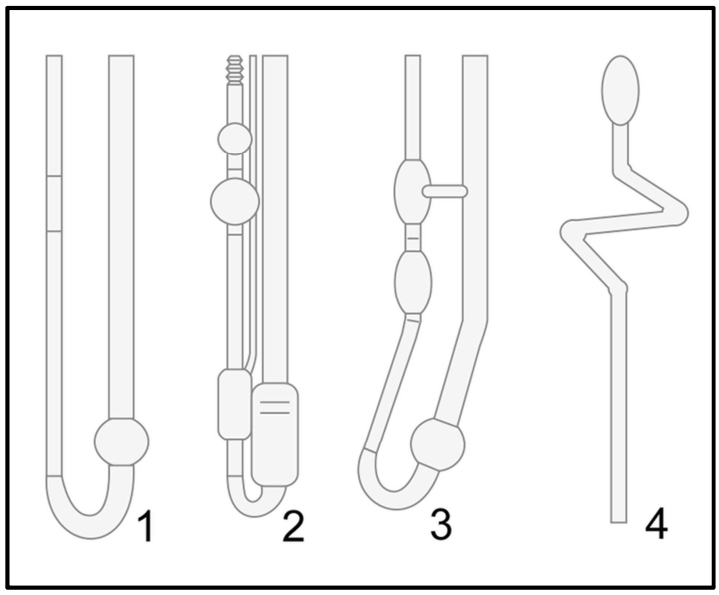


Figure 16; Typical geometries of glass capillaries[76]

For the measurement of dynamic viscosity η, the two most common used methods are the rotational measurement and the measurement using a rolling ball or falling ball. In rotational viscometers the required torque M is measured to rotate a spindle immersed in the liquid to be measured at a predetermined rotational speed n as shown in Figure 17. With the help of these simple and mostly inaccurate systems only relative values of torque are measured, they therefore often serve simple quality controls.[77]

[76] Webpage Viscopedia, date of access 10.09.2014
[77] Cf. Mezger (2014), Angewandte Rheologie, p.13 ff.

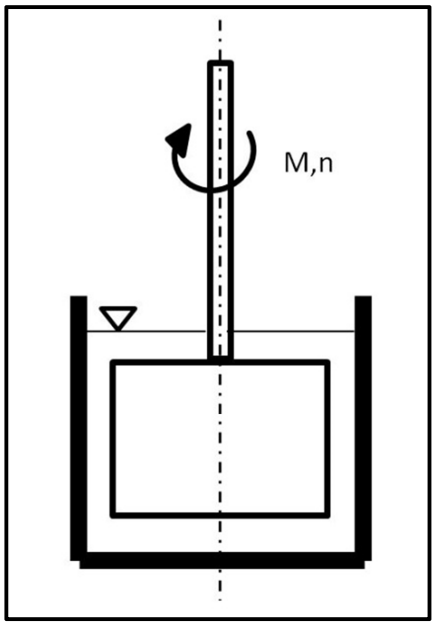


Figure 17; Rotational measurement of viscosity[78]

Within the method of a rolling or falling ball, a “ball rolls through a closed capillary filled with sample fluid which is inclined at a defined angle. The time it takes the ball to travel a defined measuring distance is a measure for the fluid’s viscosity. The inclination angle of the capillary permits the user to vary the driving force. If the angle is too steep, the rolling speed causes turbulent flow. For calculating the viscosity from the measured time, the fluid’s density and the ball density need to be known. Instruments that perform at inclination angles between 10° and 80° are rolli ng-ball viscometers. If the inclination angle α is 80° or greater, the instrument is referred to a s a falling-ball viscometer.”[79] In both cases, thus with the rolling-ball and the falling-ball viscometer, three forces acting on the ball as shown in Figure 18. The weight force F_g and the lifting force F_b depend on the density of the ball ϱ_b and the liquid to be measured ϱ_s. The viscosity force F_v depends on the viscosity of the fluid to be measured.

[78] Own illustration
[79] Webpage Viscopedia, date of access 10.09.2014

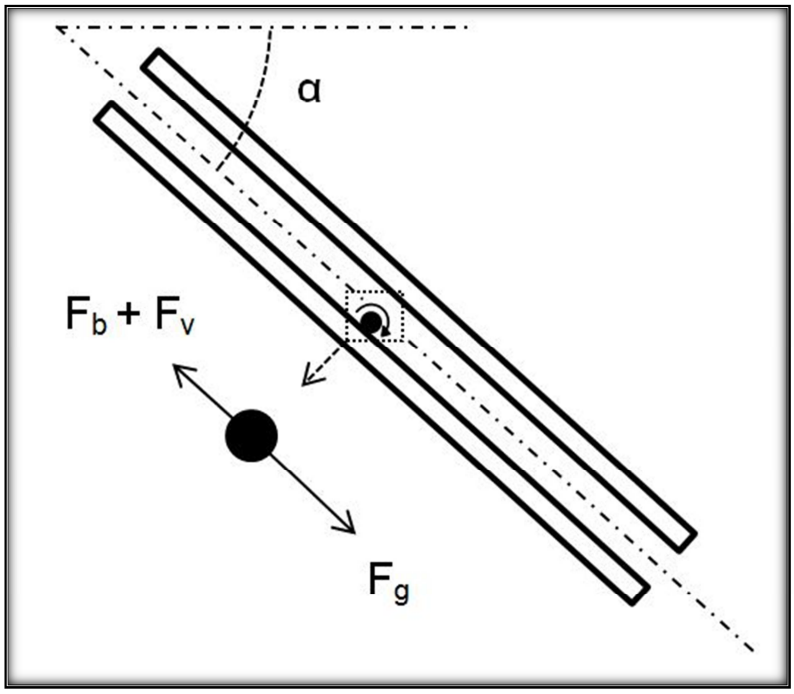


Figure 18; The Rolling-ball principle[80]

Within the method, the time t is measured the rolling or falling ball needs to pass a predefined distance. The dynamic viscosity η of the fluid is further derived from the measured time t as it can be seen below;

$$\eta = C5 * (\varrho b - \varrho s) * t \quad . \qquad \textbf{(Equation 14)}$$

[80] Own illustration

3 Practical part

For synthesis purposes, it is decided to divide the practical part into two steps, first step is the market analysis and second step is the development of a concept for an entry level product. This concept is for the product group most relevant for entry level products. It is the goal of the market analysis to identify this product group out of the three investigated. Within the literature review, different methods for market analysis are studied. Whereas Porter's five forces analysis and the Swot analysis take into account qualitative information, Bruhn's process of market analysis describes a general method for analysing markets regardless of whether it is qualitative or quantitative. Due to this fact Bruhn's process of market analysis is followed. The second step of practical part, the development of a product concept, follows the prescribed method of Anton Paar GmbH, the so called "Rahmenvorgabe" which is compulsory and the base of each development project at Anton Paar GmbH, in order to be able to start with development if conclusion of this thesis is positive.

3.1 Quantitative market analysis

Within the quantitative market analysis, three different product groups are investigated. As previously described, those are products for measuring density of, CO_2 content in and the viscosity of liquids. In each of these product lines, Anton Paar GmbH offers various products. It is assumed that Anton Paar's currently offered products are mainly part of medium and high level market segments in terms of measurement accuracy and price. The objective of this first phase is to create an overview of global markets and their segments broken down to products offered during the time of the analysis. Furthermore, market sizes has to be assigned to the different segments in order to be able to make a statement on the current positioning of Anton Paar GmbH in the global market environment.

3.1.1 Problem definition

Market analysis starts with the problem definition phase according to Figure 10. Therefore the basic questions of the market analysis were formulated;

- Which products for measuring density and viscosity and the content of CO2 in liquids are currently offered on the global market?
- To which market segments, as a function of price, can offered products be assigned?
- How big is Anton Paar's share of the above mentioned market segments?

To be able to answer the formulated questions, the market analysis is divided into three phases as listed in Figure 19. In the first phase, the market-phase, at least 90% of all globally offered measurement devices for measuring density and viscosity of liquids and the content of CO_2 in liquids are listed. In the second phase, the segments-phase, listed products were classified as high level, medium level or entry level products. Products are classified only according to retail prices as it is considered that the retail price correlates with the sum of the other found out products specifications. Within the third phase, the coverage-phase, the market segments are assigned with market segment's sizes in order to get a complete picture of the markets; finally with knowing sizes of different market segments together with the knowledge of market shares of Anton Paar's currently offered products, market potentials are identified.

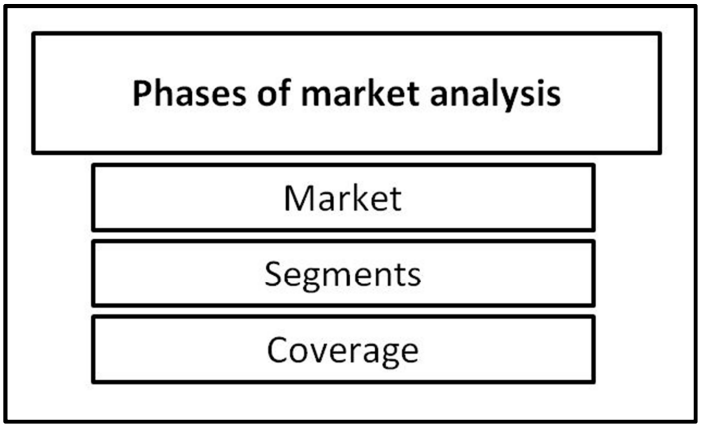


Figure 19; Phases of market analysis[81]

3.1.2 Selection of market research method

In the first phase, the market-phase, it is defined that the objective is to find at least 90% of all products offered on the global market for each product area to be examined

[81] Own illustration

without further respond to market segmentation, market sizes or coverage. An assessment of the appropriate competent product managers is used to monitor the achievement of this 90%. The developed sample design, shown and described within the following figures, includes general data such as producer, product name or country of origin and as well qualitative data such as the area of application and underlying measurement technology as quantitative data such as accuracy, repeatability or price.

General data					
Product line	Product group	Producer	Country of origin	Product name	Product picture

Figure 20; Market analysis, General data[82]

The purpose of the collection of specific data shall be described in more detail. The product pictures, as shown in Figure 20, is needed because many manufacturers sell their devices via various partners, sometimes under different names, product images enable the identification of equal products sold by different vendors.

Qualitative data			
Type of Product	Area of application	Technology	Basic unit of measurement

Figure 21; Market analysis, Qualitative data[83]

The type of product, as shown in Figure 21, contains a basic differentiation between bench top products and handheld products. The area of application describes the basic type of application and is limited to laboratory instruments and mobile instruments for measuring process parameters by taking samples. Measurement devices that are permanently installed in process plants are generally excluded from market analysis.

[82] Own illustration
[83] Own illustration

Technology shows the basic principle of measurement. The most common principles are described in chapter 2.7.

Quantitative data			
Accuracy	Repeatability	Measurement Range	Alleged Price

Figure 22; Market analysis, Quantitative data[84]

Accuracy, as shown in Figure 22 describes the accuracy of measured values and includes two types of error. The first error, the systematic error, arises for example due to lack of calibration of the measurement system. The measured value always deviates in the same direction. The second error, the statistical error, occurs randomly. By way of example, the inaccuracy starting and stopping a dial gauge may be mentioned.[85] In the course of data collection specifications given by suppliers are not further questioned.

Repeatability describes the "measurement precision under a set of repeatability conditions of measurement"[86]. The repeatability condition of measurement describes the "condition of measurement, out of a set of conditions that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time"[87].

As described in chapter 2.3, the next step is to answer the basic question whether secondary research is sufficient or additional primary research is necessary. For the different phases, defined in chapter 3.1.1, different data sources are chosen as summarized in Figure 23.

[84] Own illustration
[85] Cf. Erdmann (2011), Experimentalphysik 1, p.21
[86] Webpage International Vocabulary of Metrology, date of access 13.11.2014
[87] Webpage International Vocabulary of Metrology, date of access 13.11.2014

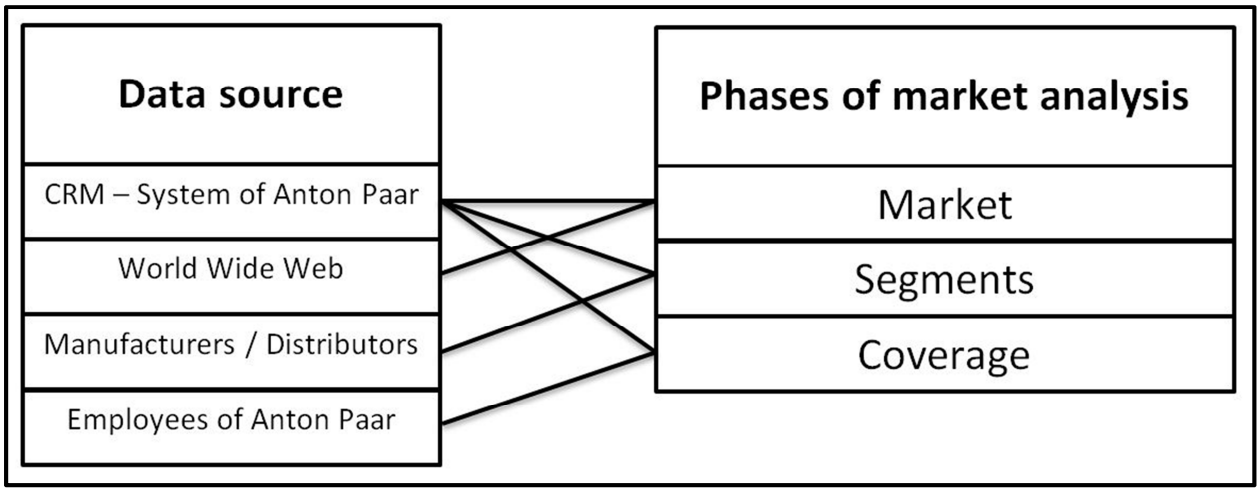


Figure 23; Data sources for market analysis[88]

Analysing defined questions from the problem definition phase, as well primary research as secondary research is necessary for being able to answer them. The single steps are described in detail in chapter 3.1.3. Basically secondary research is applied by using Anton Paar's CRM System. Within this system, information about Anton Paar's products as well as correlated competitor's products is collected.

Primary research is additionally applied by asking distributors directly trying to find out offered products prices. According to primary research and as described in chapter 2.3, the question is whom to ask; The two main sources for the market analysis are on the one hand, the internet, on the other hand product managers, responsible for relevant products at Anton Paar GmbH;

- Analysing the internet is an appropriate approach since markets are relatively small in relation to the complexity of the products themselves. Therefore products are typically sold globally and offered on the internet.
- For knowledge exchange and verification of analysis, Anton Paar's product managers are consulted. To understand why they are asked instead of employees from sales departments, the role of Anton Paar's product managers may be explained in more detail; within the Anton Paar group, a product manager has to take the role of the entrepreneur in the enterprise. He is involved in both sales and marketing, as well as in technical topics, product development decisions and portfolio strategies. Overall, he brings extensive expertise and

[88] Own illustration

market knowledge, which makes him the right person in questions of market analysis and portfolio expansion.

3.1.3 Execution of market research

Throughout the market-phase, in a first step devices of known competitors from Anton Paar's CRM database are analyzed. In the course of the described first step of this analysis, about 100 products currently offered on the market are identified.

In a next step, research expanded to unknown vendors and manufacturers. The data collection is therefore carried out by listing as far unknown devices offered on the internet. The independent search in these first two steps ensures that knowledge of the Anton Paar's product managers does not affect the market analysis itself.

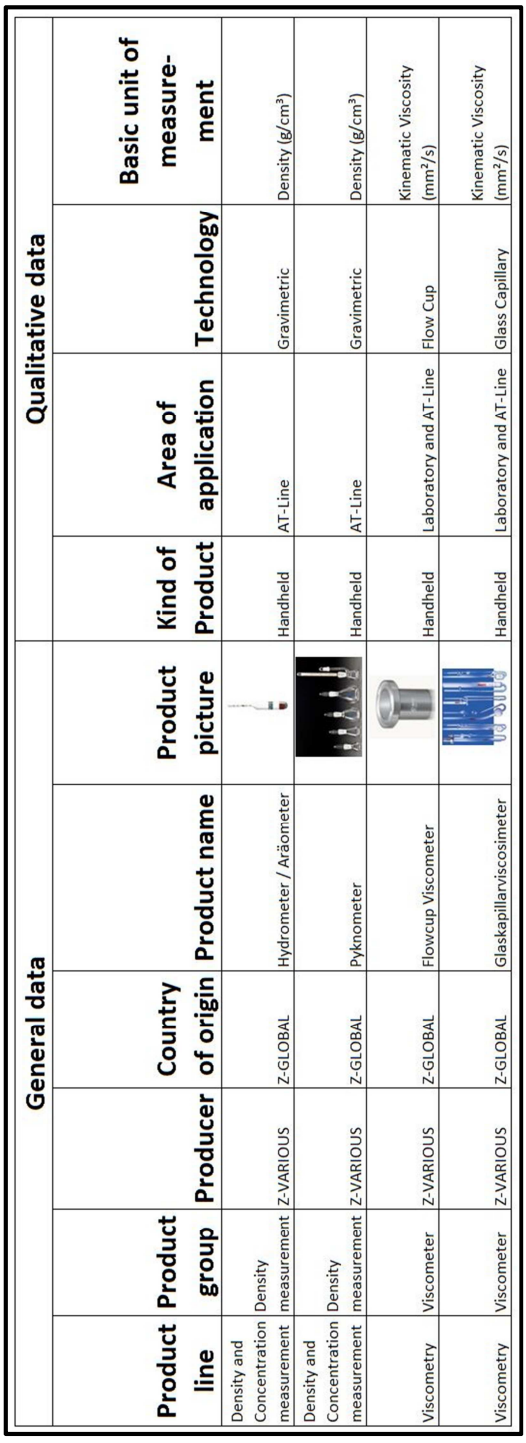
That is followed by a feedback round with product managers who are responsible for relevant products. During this feedback session, Anton Paar's product managers are attentive on products that they did not know so far. Knowledge exchange takes place and in a third step further products are identified by more precise and more comprehensive analyzes to the inputs of the product managers.

In total, at the end 152 products are found, 24 of them in the field of CO_2 measurement, 47 in the field of density measurement and 81 in the field of viscometry.

Regarding entry level products, it has to be mentioned that some of them are not further subdivided into individual product manufacturers. This seems to make sense, since there are a variety of manufacturers that offer similar to almost identical entry level products on the global market. For example, the simplest measurement of density of liquids is the measurement by hydrometers; these can be found at online trading houses such as Amazon from various manufacturers. A closer look at these online trading houses leads to the assumption that there are more than one hundred manufacturers of similar to same hydrometers worldwide. In the list of products, these are therefore collected under "Z-Various" - manufacturers.

Another example is glass capillaries. These simple measurement devises for measuring the viscosity of liquids allow a measurement which is cheap and accurate, as described in chapter 2.7.3. For the measurement of different viscosities different geometries are needed. It is believed that there are more than 50 different glass capillaries of different manufacturers worldwide. Again, in the list of products, those are therefore collected under "Z-Various" - manufacturers. Following the just described example, four types of

instruments, for measuring the density of liquids and viscosity of liquids, are summarized in Figure 24.



General data						Qualitative data				
Product line	Product group	Producer	Country of origin	Product name	Product picture	Kind of Product	Area of application	Technology	Basic unit of measure-ment
Density and Concentration measurement	Density measurement	Z-VARIOUS	Z-GLOBAL	Hydrometer / Aräometer		Handheld	AT-Line	Gravimetric	Density (g/cm³)
Density and Concentration measurement	Density measurement	Z-VARIOUS	Z-GLOBAL	Pyknometer		Handheld	AT-Line	Gravimetric	Density (g/cm³)
Viscometry	Viscometer	Z-VARIOUS	Z-GLOBAL	Flowcup Viscometer		Handheld	Laboratory and AT-Line	Flow Cup	Kinematic Viscosity (mm²/s)
Viscometry	Viscometer	Z-VARIOUS	Z-GLOBAL	Glaskapillarviscosimeter		Handheld	Laboratory and AT-Line	Glass Capillary	Kinematic Viscosity (mm²/s)

Figure 24; Products from various manufacturers[89]

[89] Own illustration

Within the second phase, called the segment phase, retail prices of measurement devices are analyzed in the following way; at first and if available price information is drawn from Anton Paar's CRM database. By this means, retail prices could be assigned to one third of all devices listed. To find out the remaining missing prices, primary research is carried out and suppliers were contacted directly. Prices, which could not be found at all by the previous explained approaches, are finally estimated. To provide a valid estimation, products are compared with each other in terms of other information analysed such as principle of measurement, measurement accuracy or repeatability and country of origin. Finally all investigated products are assigned to different segments according to following criteria;

For segmentation of found density meters, differentiation between entry level, medium level and high level products is done by the following price-levels;

- Entry level density meter: retail price lower than € 2.000
- Medium level density meter: retail price in between € 2.000 and € 10.000
- High level density meter: retail price higher than € 10.000

For segmentation of found viscometers, differentiation between entry level, medium level and high level viscometers is done by the following price-levels;

- Entry level viscometer: retail price lower than € 2.000
- Medium level viscometer: retail price in between € 2.000 and € 8.000
- High level viscometer: retail price higher than € 8.000

For segmentation of found CO_2 meters, the differentiation between entry level, medium level and high level products is done by the following price levels;

- Entry level CO_2 meter: retail price lower than € 4.000
- Medium level CO_2 meter: retail price in between € 4.000 and € 20.000
- High level CO_2 meter: retail price higher than € 20.000

Throughout the third phase, the coverage phase, it is tried to find out market sizes of defined segments and the coverage of these segments by products of Anton Paar GmbH. This happens differently for each product group investigated;

Market segment's sizes and Anton Paar's coverage in the field of density measurement;

Sizes of market segments of density meters are based on different sources. Total market sizes of oscillating U-tube systems are calculated as an average between surveys of sales subsidiaries of Anton Paar GmbH[90] and on market estimations from the department responsible for density measurement at Anton Paar GmbH.[91] For finding out markets segments sizes, again, Anton Paar's CRM database, especially sales opportunities from the year 2013, is analysed; These opportunities were created in the year 2013 by sales employees within Anton Paar's CRM database as soon as the opportunity for selling a product was recognized. Depending on the development of the sales process, the opportunity than changed into a won opportunity as the customer actually bought a product, into a lost opportunity as the customer bought a competitor's product or into a stopped opportunity as a customer did not buy any product due to various reasons not further defined. As Anton Paar GmbH offers products in all defined segments, it is assumed that in case of density measurement based on the technology of the oscillating U-tube the proportion of single segments correlate with the proportion of sales opportunities, as well won, lost and stopped opportunities, of Anton Paar's products in these different segments.

Market shares of Anton Paar GmbH are found out through analysing the products sold by Anton Paar within the year 2013.[92] Market size of density measurement devices based on the technology of gravimetric measurement is estimated after finding out potential users of hydrometers and pycnometers. The second practical part includes a detailed market analysis of hydrometers, details are shown in chapter 3.2.3Market.

Market segment's sizes and Anton Paar's coverage in the field of viscometry;

Shares and sizes of market segments of viscometers are based on an existing market analysis from 2012[93]. This existing market analysis is revised in, as sales volumes of single products have not been set in connection with product segments depending on

[90] Information provided by Anton Paar – Corporate Intelligence and Market Analysis 13.11.2014
[91] Information provided by Anton Paar – Lab Density and Concentration department 15.10.2014
[92] Data from SAP-application – Business Warehouse, date of access 08.10.2014
[93] Information provided by Anton Paar – Viscometry department 14.10.2014

product prices so far. Market shares of Anton Paar GmbH are again found out by analysing the products sold by Anton Paar GmbH within the year 2013.[94]

Market segment's sizes and Anton Paar's coverage in the field of CO_2 measurement;

Due to lack of data market sizes of instruments based on the technology of laser absorption cannot be found out. Nevertheless market segments sizes of instruments based on the technology of measuring the pressure and temperature are found out again by analysing Anton Paar's CRM database which shows that 37% of all sales opportunities for instruments measuring the content of CO_2 were won in 2013. It was assumed that the number of won opportunities correlates with the market share in this special segment of medium level CO_2 meters as all products of Anton Paar GmbH are part of this medium segment. By this means, the market size of the segment of medium level instruments using the technology of measuring pressure and temperature can be found out. In a next step the CRM Database is further analysed finding out that Anton Paar GmbH lost 37% of its sales opportunities due to the fact that the retail price was too high. The market size of entry level CO_2 meters is therefore assumed being 37% of the market size of medium level CO_2 meters. Market shares of Anton Paar within the field of instruments measuring the content of CO_2 in liquids are again found out by analysing the products sold by Anton Paar within the year 2013.[95]

3.1.4 Documentation of results

The main results of the market analysis are shown in the following chapter, separated into the measurement of density, the measurement of CO_2 content in and the measurement of viscosity of liquids. Market data always refer to the year 2013, and prices to the years 2013 and 2014. A change of prices in between that period is not taken into account. For each field of measurement, interpretation of data is shown via charts and tables beneath. For better overview information as defined in sample design such as product picture or measurement range are left out in the following tables. Starting with the field of density measurement, the results of market analysis are shown in the following charts.

[94] Data from SAP-application – Business Warehouse, date of access 08.10.2014
[95] Data from SAP-application – Business Warehouse, date of access 09.10.2014

Market analyis density measurement, technology: gravimetric measurement									
Producer	**Product name**	**Kind of Product**	**Basic unit of measurement**	**Accuracy [g/cm]**	**Repeat-ablity [g/cm³]**	**Alleged Price [€]**	**Level**	**Annual market size [€]**	**Source**
Z-VARIOUS	Hydrometer / Aräometer	Handheld	Density (g/cm³)	0,001		25	e	25.000.000	www.amazon.de, date of access: 09.09.2014
Z-VARIOUS	Pyknometer	Handheld	Density (g/cm³)	0,0001		846	e		www.waagenshop.at, date of access: 01.10.2014
AS Lemis Baltic	DenDi	Handheld	Density (g/cm³)	0,001	0,0005	2.000	e		www.lemis-process.com, date of access: 25.07.2014, Price ADS
Average / Sum						957	e	25.500.000	
AS Lemis Baltic	DenDi	Handheld	Density (g/cm³)	0,0005	0,00025	2.500	m		www.lemis-process.com, date of access: 25.07.2014, Price ADS
Gibertini	Densimat - CE	Benchtop	Density (g/cm³)	0,0005		2.500	m		www.gibertini.com, date of access: 24.07.2014
Average / Sum						2.500	m	500.000	
Sum						1.729		26.000.000	
Market analyis density measurement, technology: oszillating U-Tube									
Producer	**Product name**	**Kind of Product**	**Basic unit of measurement**	**Accuracy [g/cm]**	**Repeat-ablity [g/cm³]**	**Alleged Price [€]**	**Level**	**Annual market size [€]**	**Source**
Shijiazhuang Baiheng	Sensor	Benchtop	Density (g/cm³)	0,001		115	e		CRM Anton Paar
STM-Insturments	eDrometer	Handheld	Density (g/cm³)	0,0015		308	e		www.stm-instrument.com, date of access: 06.08.2014, Price: AP
Anton Paar	SNAP 40	Handheld	Density (g/cm³)	0,0004	0,0002	950	e	0	General Catalog Anton Paar 01.2014, Price AP
Termex	ViP - 2MP	Sensor	Density (g/cm³)	0,0001		1.308	e		CRM Anton Paar
AS Lemis Baltic	DM - 250.1/250.2	Handheld	Density (g/cm³)	0,0005	0,0003	1.500	e		www.lemis-process.com, date of access: 24.07.2014
Shijiazhuang Baiheng	BHDM YM10	Benchtop	Density (g/cm³)	0,001		1.500	e		CRM Anton Paar
Kyoto Electronics	DA - 130n	Benchtop	Density (g/cm³)	0,001		1.600	e		www.kyoto-kem.com, date of access: 24.07.2014, Price: AP
Anton Paar	DMA 35n	Handheld	Density (g/cm³)	0,001	0,0005	1.676	e	9.059.000	General Catalog Anton Paar 01.2014, Price AP
Mettler Toledo	Densito 30PX	Handheld	Density (g/cm³)	0,001		1.800	e		www.at.mt.com, date of access: 23.07.2014, Price: AP
AS Lemis Baltic	VDM300 - V1	Handheld	Density (g/cm³)	0,001		2.000	e		www.lemis-process.com, date of access: 25.07.2014
Average / Sum						1.276	e	10.929.240	
Shijiazhuang Baiheng	BHDM YM08	Benchtop	Density (g/cm³)	0,0008		2.154	m		CRM Anton Paar
AS Lemis Baltic	VDM300 - V2	Handheld	Density (g/cm³)	0,0005		2.500	m		www.lemis-process.com, date of access: 25.07.2014
Shijiazhuang Baiheng	BHDM YM05	Benchtop	Density (g/cm³)	0,0005		2.615	m		CRM Anton Paar
Anton Paar	SNAP 50	Handheld	Density (g/cm³)	0,0002	0,0001	2.640	m	0	General Catalog Anton Paar 01.2014, Price AP
AS Lemis Baltic	VDM300 - V3	Handheld	Density (g/cm³)	0,0002		3.000	m		www.lemis-process.com, date of access: 25.07.2014
Shijiazhuang Baiheng	BHDM YM04	Benchtop	Density (g/cm³)	0,0004		3.000	m		CRM Anton Paar
Shijiazhuang Baiheng	BHDM YM02	Benchtop	Density (g/cm³)	0,0002		4.154	m		CRM Anton Paar

Table 2a; Market analysis, density measurement[96]

[96] Own illustration

Centec GmbH	Rheotec L	Benchtop	Density (g/cm³)	0,001	0,0005	5.000	m		www.centec.de, date of access: 24.07.2014, Price ADS
Shijiazhuang Baiheng	BHDM YM01	Benchtop	Density (g/cm³)	0,0001		5.154	m		CRM Anton Paar
Cannon Instuments	D155	Benchtop	Density (g/cm³)	0,001	0,0005	5.308	m		www.cannoninstrument.com, date of access: 24.07.2014, Price: AP
Anton Paar	DMA 500	Benchtop	Density (g/cm³)	0,001	0,0002	5.320	m	1.313.000	General Catalog Anton Paar 01.2014, Price AP
Kyoto Electronics	DA - 100	Benchtop	Density (g/cm³)	0,001		5.500	m		www.kyoto-kem.com, date of access: 24.07.2014, Price ADS
Shijiazhuang Baiheng	BHDM YM005	Benchtop	Density (g/cm³)	0,00005		6.000	m		CRM Anton Paar
Mettler Toledo	DA - 100M	Benchtop	Density (g/cm³)	0,001	0,0005	7.000	m		www.at.mt.com, date of access: 23.07.2014, Price: AP
Kruess	DS7800	Benchtop	Density (g/cm³)	0,0001	0,0001	7.980	m		www.kruess.com, date of access: 24.07.2014, Price: AP
Rudolph Research Analytical	DDM 2909	Benchtop	Density (g/cm³)	0,0003	0,0001	8.000	m		www.rudolphresearch.com date of access: 25.07.2014, Price: ADS
Anton Paar	DMA 4100 m	Benchtop	Density (g/cm³)	0,0001	0,00005	8.760	m	3.319.000	General Catalog Anton Paar 01.2014, Price AP
Kyoto Electronics	DA - 640	Benchtop	Density (g/cm³)	0,0001	0,00005	8.900	m		www.kyoto-kem.com, date of access: 24.07.2014, Price: AP
Mettler Toledo	DM40 / DX40	Benchtop	Density (g/cm³)	0,0001	0,00005	9.000	m		www.at.mt.com, date of access: 23.07.2014, Price: AP
Average / Sum						5.368	m	11.449.680	
Kyoto Electronics	DA - 645	Benchtop	Density (g/cm³)	0,00005	0,00001	10.400	h		www.kyoto-kem.com, date of access: 24.07.2014, Price: AP
Anton Paar	DMA 4500 m	Benchtop	Density (g/cm³)	0,00005	0,00001	10.750	h	14.825.000	General Catalog Anton Paar 01.2014, Price AP
Rudolph Research Analytical	DDM 2910	Benchtop	Density (g/cm³)	0,0001	0,00005	10.937	h		www.rudolphresearch.com, date of access: 25.07.2014, Price: AP
Mettler Toledo	DM45 / DX45	Benchtop	Density (g/cm³)	0,00005	0,000005	11.000	h		www.at.mt.com, date of access: 23.07.2014; Price: AP
Schmidt und Haensch	EDM 4000	Benchtop	Density (g/cm³)	0,0001	0,00005	11.000	h		www.schmidt-haensch.com, date of access: 25.07.2014, Price ADS
Rudolph Research Analytical	DDM 2911	Benchtop	Density (g/cm³)	0,00005	0,00001	12.600	h		www.rudolphresearch.com, date of access: 25.07.2014, Price: AP
Schmidt und Haensch	EDM 5000	Benchtop	Density (g/cm³)	0,00005	0,00001	13.000	h		www.schmidt-haensch.com, date of access: 25.07.2014, Price ADS
PAC L.P.	VIDA 40	Benchtop	Density (g/cm³)	0,0001	0,00005	14.400	h		www.paclp.com, date of access: 25.07.2014, Price: AP
Kyoto Electronics	DA - 650	Benchtop	Density (g/cm³)	0,00002	0,000005	15.000	h		www.kyoto-kem.com, date of access: 24.07.2014, Price: AP
Anton Paar	DMA 5000 m	Benchtop	Density (g/cm³)	0,000005	0,0000001	15.880	h	5.399.000	General Catalog Anton Paar 01.2014, Price AP
Mettler Toledo	DM50 / DX 50	Benchtop	Density (g/cm³)	0,00002	0,000005	16.000	h		www.at.mt.com, date of access: 23.07.2014, Price: AP
PAC L.P.	VIDA 40H	Benchtop	Density (g/cm³)	0,00005	0,00001	18.000	h		www.paclp.com, date of access: 25.07.2014, Price: AP
Rudolph Research Analytical	DDM 2911 Plus	Benchtop	Density (g/cm³)	0,00001	0,000005	20.700	h		www.rudolphresearch.com, date of access: 25.07.2014, Price: AP
Average / Sum						12.453	h	29.665.080	
Average / Sum						6.365		52.044.000	
Total sum								78.044.000	

Table 2b; Market analysis, density measurement[97]

[97] Own illustration

Based on Table 2a and Table 2b, the annual sales volumes depending on the technology used are summed up in Table 3 and Figure 25.

Technology	Market size [€/a]	Sales volume competition [€]	Sales volume Anton Paar [€]
Gravimetric	26.000.000	26.000.000	0
Oscillating U-Tube	52.044.000	18.129.000	33.915.000
Sum	78.044.000	44.129.000	33.915.000

Table 3; Density measurement - Annual sales volume by technology[98]

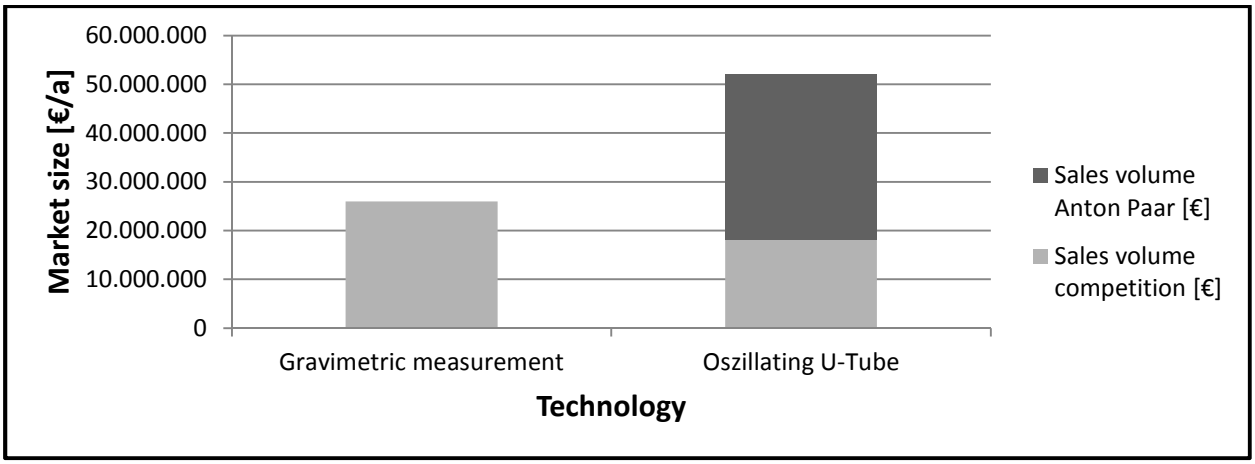


Figure 25; Density measurement - Sales volume by technology[99]

[98] Own illustration
[99] Own illustration

Annual sales volumes depending on the different product levels are shown in Table 4 and Figure 26.

Product level	Global market size [€/a]	Sales volume competition [€]	Sales volume Anton Paar [€]
Entry level	36.429.240	27.370.240	9.059.000
Medium level	11.949.680	7.317.680	4.632.000
High level	29.665.080	9.441.080	20.224.000
Sum	78.044.000	44.129.000	33.915.000

Table 4; Density measurement - Sales volume by product level[100]

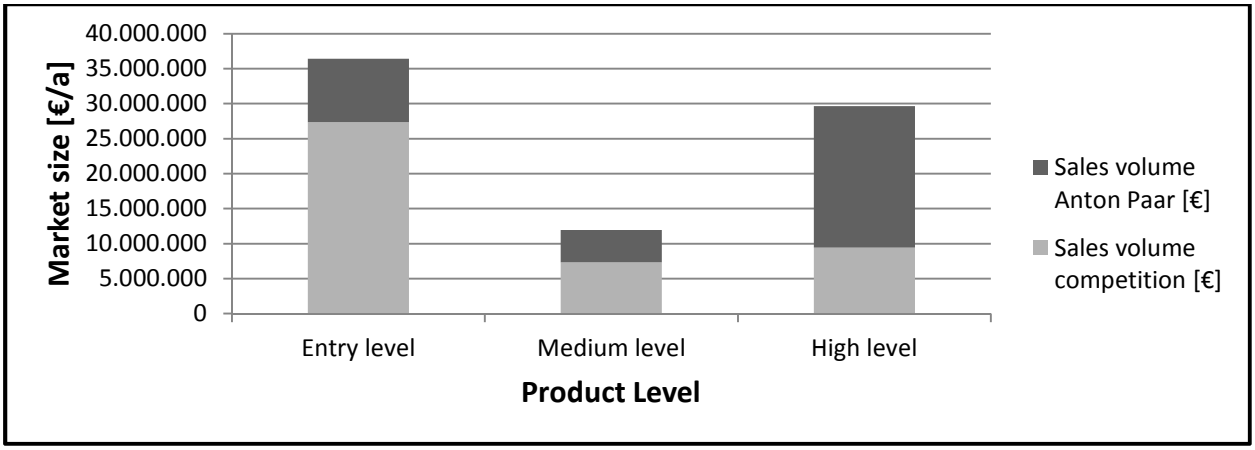


Figure 26; Density measurement - Sales volume by product level[101]

[100] Own illustration
[101] Own illustration

The average retail prices depending on the technologies used are shown in Table 5 and Figure 27.

Technology	Average retail price competition [€]	Average retail price Anton Paar [€]
Gravimetric	1.729	0
Oscillating U-Tube	6.365	8.670

Table 5; Density measurement - Average retail price[102]

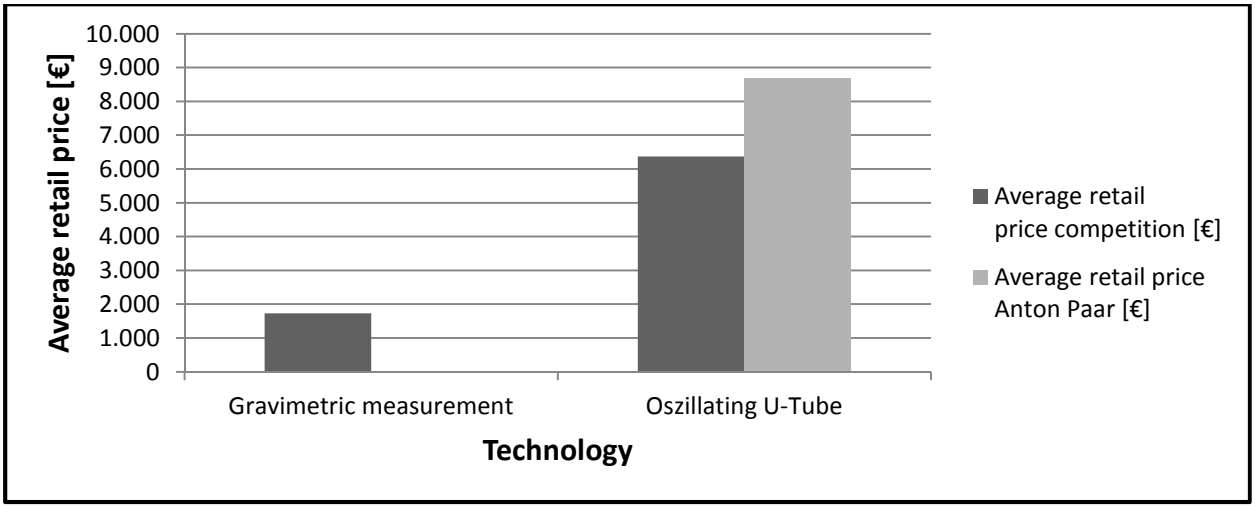


Figure 27; Density measurement - Average retail price[103]

Interpretation of market analysis of density measurement;

The annual global market of instruments for measuring density of liquids is around € 78 Mio and Anton Paar has a market share of 43%. Anton Paar GmbH does offer products only based on the technology of the Oscillating U-Tube. Entry level products, which do cost less than € 2.000, are mainly based on the technology of gravimetric measurement in which Anton Paar GmbH does not offer products at all. The market of entry level products is the biggest in the field of density measurement. In between the market of entry level products, there is a big difference between products from Anton Paar GmbH

[102] Own illustration
[103] Own illustration

and products from other manufacturers as those of the company are based on the technology of the Oscillating U-Tube with a retail price of € 950 and € 1.676 whereas the predominant share of other entry level products are based on the technology of gravimetric measurement such as hydrometers with an average retail price of around € 25.

For the field of measurement of CO_2 content in liquids, the market size of instruments based on the technology of laser absorption as well as the market size of high-level instruments based on the technology of measuring the pressure and temperature cannot be found out due to lack of data as described in chapter 3.1.3. Nevertheless, market size of entry level instruments can be found out as the segmentation shows that there are only entry level instruments using the measurement principle of measuring pressure and temperature as shown in Table 6.

Market analyis CO2, technology: laser absorption									
Producer	**Product name**	**Kind of Product**	**Basic unit of measure-ment**	**Accuracy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
ACM GmbH	LAB.CO	Benchtop	CO2 Concentration (g/L)	0,05	0,02	12.000	m		www.acm.co.at, date of access: 04.08.2014, Price ADS
Systech Illinois	6000 Precision Headspace Analysers	Benchtop	CO2 Concentration (v/V (%))	2%		12.000	m		www.systechillinois.com, date of access: 05.08.2014, Price ADS
FT System	L.Sensor.CO2	Benchtop	CO2 Concentration (g/L)			13.000	m		www.ftsystem.it, date of access: 05.08.2014, Price ADS
Haffmans	CO2 Selector	Benchtop	CO2 Concentration (g/L)			16.000	m		www.haffmans.nl, date of access: 05.08.2014, Price ADS
Average / Sum						13.250	m	n.d.a.	
Sum								n.d.a.	
Market analyis CO2, technology: measurement of pressure and temperatur									
Producer	**Product name**	**Kind of Product**	**Basic unit of measure-ment**	**Accuracy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
Barby & Kühner	CO2-Tester Typ 85100-CC	Handheld	CO2 Concentration (g/L)			500	e		www.barby-kuehner.de, date of access: 30.07.2014, Price ADS
Barby & Kühner	Kohelnsäure Schnellbestimmungsgerät Typ4040	Handheld	CO2 Concentration (g/L)			500	e		www.barby-kuehner.de, date of access: 30.07.2014, Price ADS
Steinfurth Mlytical Service	Cup Carbonation Tester	Handheld	CO2 Concentration (g/L)		0,2	500	e		www.steinfuth.de, date of access: 04.08.2014, Price ADS
Zahm & Nagel	Series 6000 D.T. Piercing Device	Benchtop	CO2 Concentration (v/V (%))			500	e		www.zahmnagel.com, date of access: 05.08.2014, Price ADS
Zahm & Nagel	Series 14000 Computerized Piercing Device	Benchtop	CO2 Concentration (v/V (%))			2.000	e		www.zahmnagel.com, date of access: 02.10.2014, Price ADS
Haffmans	I-DGM-analog	Handheld	CO2 Concentration (g/L)			3.500	e		www.haffmans.nl, date of access: 04.08.2014, Price ADS
Haffmans	INPACK 2000	Benchtop	CO2 Concentration (g/L)	0,1		4.000	e		www.haffmans.nl, date of access: 06.08.2014, Price ADS
Average / Sum						1.643	e	5.383.672	
Steinfurth Mlytical Service	CDA MK-6	Benchtop	CO2 Concentration (g/L)		0,05	5.000	m		www.steinfuth.de, Date of access: 04.08.2014, Price ADS
Anton Paar	CarboQC At-line	Handheld	CO2 Concentration (g/L)		0,04	6.540	m	1.056.700	General Catalog Anton Paar 01.2014, Price AP
Anton Paar	Carbo QC ME	Benchtop	CO2 Concentration (g/L)		0,01	7.430	m		General Catalog Anton Paar 01.2014, Price AP
Haffmans	I-DGM-digital	Handheld	CO2 Concentration (g/L)	0,05		7.000	m		www.haffmans.nl, date of access: 04.08.2014, Price: AP
Anton Paar	Carbo-QC	Handheld	CO2 Concentration (g/L)		0,01	8.060	m	2.720.293	General Catalog Anton Paar 01.2014, Price AP
Steinfurth Mlytical Service	CDA CO2MS-1	Benchtop	CO2 Concentration (g/L)		0,1	9.500	m		www.steinfuth.de, date of access: 04.08.2014, Price ADS
Steinfurth Mlytical Service	CDA CO2MS-2	Benchtop	CO2 Concentration (g/L)		0,1	10.500	m		www.steinfuth.de, date of access: 04.08.2014, Price ADS
Haffmans	C-DGM	Handheld	CO2 Concentration (g/L) + O2	0,05		11.000	m		www.haffmans.nl, date of access: 04.08.2014
Anton Paar	CboxQC At-line	Handheld	CO2 Concentration (g/L) + O2		0,04	11.740	m	1.606.679	General Catalog Anton Paar 01.2014, Price AP
Anton Paar	Cbox-QC	Handheld	CO2 Concentration (g/L) + O2		0,01	13.750	m		General Catalog Anton Paar 01.2014, Price AP
Average / Sum						5.759	m	14.550.465	
Hach Lange GmbH	Orbisphere 6110 O2/CO2	Benchtop	CO2 Concentration (g/kg)		0,1	35.000	h		www.hach-lange.at, date of access: 04.08.2014, Price: AP
Haffmans	C-TPO	Benchtop	CO2 Concentration (g/L)	0,1		40.000	h		www.haffmans.nl, date of access: 04.08.2014, Price ADS
Haffmans	Automator	Benchtop	CO2 Concentration (g/L) + O2	0,1		45.000	h		www.haffmans.nl, date of access: 05.08.2014, Price ADS
Average / Sum						40.000	h	n.d.a.	
Sum								n.d.a.	
Total sum								n.d.a.	

Table 6; Market analysis, CO_2 measurement[104]

[104] Own illustration

The annual sales volumes depending on different product levels are shown in Table 7 and Figure 28.

Product level	Global market size [€/a]	Sales volume competition [€]	Sales volume Anton Paar [€]
Entry level	5.383.672	5.383.672	0
Medium level	14.550.465	9.166.793	5.383.672
High level	n.d.a.	n.d.a.	n.d.a.

Table 7; Measurement of CO_2 - Sales volume by product level[105]

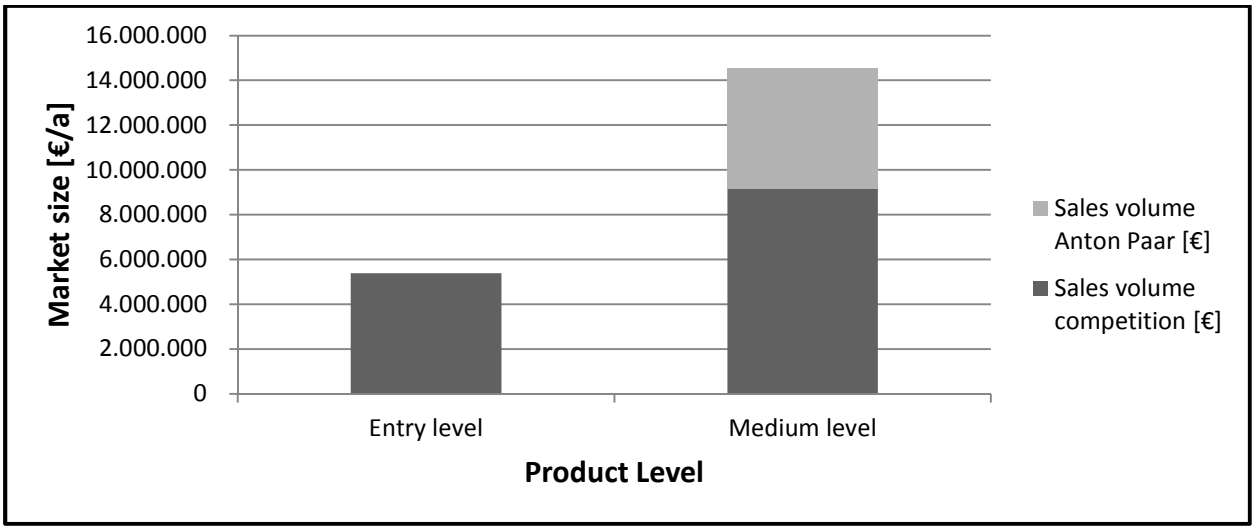


Figure 28; Measurement of CO2 - Sales volume by product level[106]

Interpretation of market analysis of CO_2 measurement;

The market size of entry level and medium level instruments for measuring the content of CO_2 in liquids using the principle of measuring the pressure and temperature is around € 20 Mio and Anton Paar has a market share of 27%. The firm does offer products only in the medium level segment and only based on the technology of

[105] Own illustration
[106] Own illustration

measuring pressure and temperature. The market of entry level products is identified being smaller than the market of medium level products.

Finally, the results of market analysis of viscometry are shown in the following tables.

Market analyis CO2, technology: basic technologies as flow cups										
Producer	**Product name**	**Kind of Product**	**Techno-logy**	**Basic unit of measurement**	**Accur-acy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
Z-VARIOUS	Flowcup Viscometer	Handheld	Flow Cup	Kinematic Viscosity (mm²/s)	3,00%		200	e		www.byk.com, date of access: 01.10.2014
BYK	Bubble Viscometer	Handheld	Rising Bubble	Kinematic Viscosity (mm²/s)	5,00%		200	e		www.byk.com, date of access: 19.08.2014
Average / Sum					4,00%		200	e	1.000.000	
Market analyis CO2, technology: gravimetric / capillary										
Producer	**Product name**	**Kind of Product**	**Techno-logy**	**Basic unit of measurement**	**Accur-acy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
Z-VARIOUS	Glaskapillarviscosimeter	Handheld	Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	423	e		www.cannoninstruments.com, date of access: 01.10.2014
Average / Sum							423	e	2.000.000	
Spectro Scientific	Spectro Visc Q3000	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)	3,00%		4.000	m		www.spectrosci.com, date of access: 19.08.2014, Price ADS
Spectro Scientific	Spectro Visc Q3050	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)	5,00%		4.500	m		www.spectrosci.com, date of access: 19.08.2014, Price ADS
Cannon Insturments	SimpleVis	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)	3,00%	2,00%	5.381	m		www.cannoninstruments.com, date of access: 06.08.2014, Price: HP
Z-VARIOUS	Glaskapillarviscosimeter	Handheld	Glass Capillary + Temp.bath	Kinematic Viscosity (mm²/s)		1,50%	6.000	m		www.cannoninstruments.com, date of access: 01.10.2014, Price: ADS
Cannon Insturments	PulpVis	Benchtop	Automated Glass Capillary	Dynamic Viscosity (mPa.s)	3,00%	2,00%	7.308	m		www.cannoninstruments.com, date of access: 06.08.2014, Price: HP
Average / Sum							5.438	m	12.000.000	
Lauda	iVisc	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	11.000	h		www.lauda.de, date of access: 11.08.2014, Price ADS
Si-Analytics	ViscoClock	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	14.000	h		www.si-analytics.com, date of access: 19.08.2014, Price ADS
PAC	VH1 & VH2	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	18.462	h		www.paclp.com, date of access: 12.08.2014, Price: AP
PSL-Rheotek	Auto KV	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	19.000	h		www.psl-rheotek.com, date of access: 18.08.2014, Price ADS
Si-Analytics	AVS 370 & AVS 470	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	27.000	h		www.si-analytics.com, date of access: 19.08.2014, Price ADS
PSL-Rheotek	Jetvisc	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	29.000	h		www.psl-rheotek.com, date of access: 18.08.2014, Price ADS
PAC	HVU 481 & 482	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	31.000	h		www.paclp.com, date of access: 12.08.2014, Price: ADS
Spectro Scientific	Spectro Visc Q300	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	38.000	h		www.spectrosci.com, date of access: 19.08.2014, Price ADS
PSL-Rheotek	Multi KV	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	41.000	h		www.psl-rheotek.com, date of access: 18.08.2014, Price ADS
Spectro Scientific	Spectro Visc Q310	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	44.000	h		www.spectrosci.com, date of access: 19.08.2014, Price ADS
Si-Analytics	AVS Pro 3	Benchtop	Automated Glass Capillary	Kinematic Viscosity (mm²/s)		1,50%	48.000	h		www.si-analytics.com, date of access: 19.08.2014, Price ADS
Average / Sum							29.133	h	26.000.000	
Average / Sum							11.665		40.000.000	

Table 8a; Market analysis, Viscometry[107]

[107] Own illustration

Market analyis CO2, technology: gravimetric / ball / needle										
Producer	**Product name**	**Kind of Product**	**Techno-logy**	**Basic unit of measurement**	**Accur-acy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
Thermo Scientific	Gilmont Falling-Ball Viscometers	Handheld	Falling Ball / Rolling Ball	Kinematic Viscosity (mm^2/s)			500	e		www.thermoscientific.com, date of access: 20.08.2014, Price ADS
Visgage	Pocket Viscosity Comparator	Handheld	Falling Ball / Rolling Ball	Kinematic Viscosity (mm^2/s)	5,00%	5,00%	1.000	e		www.visgage.com, date of access: 21.08.2014, Price ADS
Stony Brook Scientific	PDVdi-120	Handheld	Falling Needle	Dynamic Viscosity (mPa.s)	2,00%	2,00%	1.000	e		www.stonybrooksci.com, date of access: 21.08.2014, Price ADS
Stony Brook Scientific	Cva-100	Laboratory	Falling Needle	Dynamic Viscosity (mPa.s)	2,00%	2,00%	1.500	e		www.stonybrooksci.com, date of access: 21.08.2014, Price ADS
Kittiwake	FG-K1	Handheld	Falling Ball / Rolling Ball	Kinematic Viscosity (mm^2/s)	3,00%		2.000	e		www.kittiwake.com, date of access: 21.08.2014, Price ADS
Average / Sum							1.200	e	500.000	
Brookfield	Falling Ball Viscometer	Benchtop	Falling Ball / Rolling Ball	Dynamic Viscosity (mPa.s)	2,00%		2.308	m		www.brookfieldenginering.com, date of access: 06.08.2014, Price: AP
Fungilab (also Thermo Scientific)	Viscoball	Benchtop	Falling Ball / Rolling Ball	Dynamic Viscosity (mPa.s)		1,00%	2.500	m		www.fungilab.com, date of access: 07.08.2014, Price ADS
Stony Brook Scientific	FNV-200	Laboratory	Falling Needle	Dynamic Viscosity (mPa.s)	1,00%	1,00%	2.500	m		www.stonybrooksci.com, date of access: 21.08.2014, Price ADS
Stony Brook Scientific	DV-100	Laboratory	Falling Needle	Dynamic Viscosity (mPa.s)	1,00%	1,00%	3.000	m		www.stonybrooksci.com, date of access: 21.08.2014, Price ADS
Stony Brook Scientific	PDVa-100	Handheld	Falling Needle	Dynamic Viscosity (mPa.s)	1,00%	1,00%	3.000	m		www.stonybrooksci.com, date of access: 21.08.2014, Price ADS
Average / Sum							2.662	m	2.500.000	
Anton Paar	Lovis 2000 M Microviscometer	Benchtop	Falling Ball / Rolling Ball	Dynamic Viscosity (mPa.s)	0,50%	0,10%	13.580	h	1.282.195	General Catalog Anton Paar 01.2014
Grabner Instruments	Minivis 2	Benchtop	Falling Ball / Rolling Ball	Dynamic Viscosity (mPa.s)		0,30%	15.000	h		www.grabner-instruments.com, date of access: 07.08.2015, Price ADS
Grabner Instruments	Minivis 445	Benchtop	Falling Ball / Rolling Ball	Kinematic Viscosity (mm^2/s)		0,30%	22.840	h		www.grabner-instruments.com, date of access: 07.08.2014, Price: AP
Average / Sum							17.140	h	2.000.000	
Sum							7.001		5.000.000	
Market analyis CO2, technology: oscillating geometry										
Producer	**Product name**	**Kind of Product**	**Techno-logy**	**Basic unit of measurement**	**Accur-acy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
PAC	Viscolab 5000	Benchtop	Oscillating piston	Dynamic Viscosity (mPa.s)	3,50%	1,00%	4.000	m		www.paclp.com, date of access: 06.08.2015, Price ADS
AandD	SV-10 and SV-100 Series	Benchtop	Tuning fork Vibration	Dynamic Viscosity (mPa.s)		1,00%	4.615	m		www.aandd.jp, date of access: 06.08.2014, Price: AP
PAC	Viscolab 3000 and Viscolab 4000	Benchtop	Oscillating piston	Dynamic Viscosity (mPa.s)	5,00%		5.000	m		www.paclp.com, date of access: 06.08.2015, Price ADS
Cannon Insturments	Paddle Viscometers	Benchtop	Paddle Viscometer	Dynamic Viscosity (mPa.s)	5,00%		5.798	m		www.cannoninstruments.com, date of access: 06.08.2014, Price: HP
Sofraser	Sofast	Benchtop	Oscillating piston	Dynamic Viscosity (mPa.s)		0,50%	6.000	m		www.sofraser.com, date of access: 19.08.2014, Price ADS
Average / Sum							5.083	m	4.000.000	
Market analyis CO2, technology: pressurized capillary										
Producer	**Product name**	**Kind of Product**	**Techno-logy**	**Basic unit of measurement**	**Accur-acy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
Rheosense	MicroVisc	Benchtop	Pressurized Capillary	Dynamic Viscosity (mPa.s)	2,00%	0,50%	4.308	m		www.rheosense.com, date of access: 18.08.2014, Price: AP
Rheosense	M-Vroc	Benchtop	Pressurized Capillary	Dynamic Viscosity (mPa.s)	2,00%	0,50%	5.500	m		www.rheosense.com, date of access: 18.08.2014, Price ADS
Rheosense	E-Vroc	Benchtop	Pressurized Capillary	Dynamic Viscosity (mPa.s)	2,00%	0,05%	6.000	m		www.rheosense.com, date of access: 18.08.2014, Price ADS
Average / Sum							5.269	m	3.000.000	
Phase Technology	VA 300	Benchtop	Pressurized Capillary	Kinematic Viscosity (mm^2/s)		1,50%	20.000	h		www.phase-technology.com, date of access: 12.08.2014, Price ADS
Malvern	m-Vroci	Benchtop	Pressurized Capillary	Dynamic Viscosity (mPa.s)	2,00%	0,50%	30.000	h		www.malvern.com, date of access: 11.08.2014, Price ADS
Average / Sum							25.000	h	3.000.000	
Sum							15.135		6.000.000	

Table 8b; Market analysis, Viscometry[108]

[108] Own illustration

Market analyis CO2, technology: rotational										
Producer	**Product name**	**Kind of Product**	**Techno-logy**	**Basic unit of measurement**	**Accur-acy**	**Repeat-ablity**	**Alleged Price [€]**	**Level**	**Market size [€]**	**Source**
Rion	Viscotester VT 06	Handheld	Rotational	Dynamic Viscosity (mPa.s)	10,00%	5,00%	500	e		www.directindustry.com, date of access: 20.08.2014, Price ADS
Rion	Viscotester VT 04	Handheld	Rotational	Dynamic Viscosity (mPa.s)	10,00%	5,00%	500	e		www.directindustry.com, date of access: 20.08.2014, Price ADS
Rion	Viscotester VT 05	Handheld	Rotational	Dynamic Viscosity (mPa.s)	5,00%		600	e		www.directindustry.com, date of access: 20.08.2014, Price ADS
Rion	Viscotester VT 03	Handheld	Rotational	Dynamic Viscosity (mPa.s)	5,00%		600	e		www.directindustry.com, date of access: 20.08.2014, Price ADS
Brookfield	DV-E Low Cost	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	1.269	e		www.brookfieldengineering.com, date of access: 06.08.14, Price: AP
Brookfield	DV-I Prime Digitial	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	1.269	e		www.brookfieldengineering.com, date of access: 06.08.14, Price: AP
Brookfield	Dial Reading	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	1.385	e		www.brookfieldengineering.com, date of access: 06.08.14, Price: AP
Brookfield	KU-2	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,50%	1.500	e		www.brookfieldengineering.com, date of access: 06.08.14, Price:ADS
Malcom	PC-10	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	5,00%	0,50%	1.500	e		www.malcomtech.com, date of access: 11.08.2014, ADS
MYR	V1 & V2	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	1.500	e		www.myr.com.es, date of access: 02.10.2014, ADS
Hydamotion	Viscolite VL7 - D15 and D21	Handheld	Rotational	Dynamic Viscosity (mPa.s)		1,00%	2.000	e		www.hydramotion.com, date of access: 20.08.2014, Price AP
LamyRheology	Black One P	Handheld	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.000	e		www.lamyrheology.com, date of access: 11.08.2011; Price ADS
LamyRheology	CP2000	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.000	e		www.lamyrheology.com, date of access: 11.08.2011; Price ADS
Thermo Scientific	Haake Viscotester 550	Benchtop	Rotational	Dynamic Viscosity (mPa.s)		1,00%	2.000	e		www.thermoscientific.com, date of access: 20.08.2014, Price ADS
Viscotech/MYR	VP 1000	Handheld	Rotational	Dynamic Viscosity (mPa.s)	2,00%	1,00%	2.000	e		www.viscotech.es, date of access: 20.08.2014, Price ADS
Average / Sum							1.375	e	9.000.000	
Cannon Insturments	Model 2020	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.304	m		www.cannoninstruments.com, date of access: 06.08.2014, Price: HP
Brookfield	DV2T Touch	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.462	m		www.brookfieldengineering.com, date of access: 06.08.2014, Price: AP
Fungilab	Master Series	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.500	m		www.fungilab.com, date of access: 07.08.2014, Price ADS
Fungilab	Viscolead Series	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.500	m		www.fungilab.com, date of access: 07.08.2014, Price ADS
Fungilab (also Thermo Scientific)	Expert Evo	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	2.500	m		www.fungilab.com, date of access: 07.08.2014, Price ADS
Thermo Scientific	Haake Viscotester 1 Plus and 2 Plus	Handheld	Rotational	Dynamic Viscosity (mPa.s)	5,00%	1,00%	2.500	m		www.thermoscientific.com, date of access: 20.08.2014, Price ADS
Grace Instruments	M3600	Benchtop	Rotational	Dynamic Viscosity (mPa.s)			2.612	m		www.graceinstrument.com, date of access: 20.08.2014
FCC	DV II+ Pro Viscometer	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,50%	2.692	m		www.nanoclay.net, date of access: 02.10.2014
Atago	Base / Pro	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	2,00%		3.000	m		www.atago.com, date of access: 06.08.2014, Price ADS
LamyRheology	Black One	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	3.000	m		www.lamyrheology.com, date of access: 11.08.2011; Price ADS
LamyRheology	RM 100 P	Handheld	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	3.000	m		www.lamyrheology.com, date of access: 11.08.2011; Price ADS
Toki Sangyo LTD.	TVC-7	Handheld	Rotational	Dynamic Viscosity (mPa.s)	4,00%	2,00%	3.000	m		www.tokisangyo.com, date of access: 21.08.2014, Price ADS
Viscotech/MYR	VP 1000 R & M	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	2,00%	1,00%	3.000	m		www.viscotech.es, date of access: 20.08.2014, Price ADS
ATS Rheosystems	Black Pearl	Benchtop	Rotational	Dynamic Viscosity (mPa.s)			4.000	m		www.atsrheosystems.com, date of access: 20.08.2014, Price ADS
Sheen Instruments	Cone and Plate Viscometer	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	2,00%	0,50%	4.000	m		www.sheeninstruments.com, date of access: 19.08.2014, Price ADS
Viscotech/MYR	VK 2000	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	4.000	m		www.viscotech.es, Date of access: 20.08.2014, Price ADS
Brookfield	High Shear CAP 1000 & 2000	Benchtop	Rotational	Dynamic Viscosity (mPa.s)			4.231	m		www.brookfieldenginering.com, date of access: 06.08.2014, Price: AP
LamyRheology	First RM	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	5.000	m		www.lamyrheology.com, date of access: 11.08.2011; Price ADS
Viscotech/MYR	VR 3000	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	5.000	m		www.viscotech.es, date of access: 20.08.2014, Price ADS
LamyRheology	RM 100	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,00%	0,20%	5.500	m		www.lamyrheology.com, date of access: 11.08.2011; Price ADS
Thermo Scientific	Haake Viscotester IQ	Benchtop	Rotational	Dynamic Viscosity (mPa.s)			7.000	m		www.thermoscientific.com, date of access: 20.08.2014, Price ADS
Average / Sum							3.514	m	39.000.000	
Anton Paar	Rheolab QC	Benchtop	Rotational	Dynamic Viscosity (mPa.s)	1,50%	1,00%	8.013	h	2.034.154	General Catalog Anton Paar 01.2014
Brookfield	RST	Benchtop	Rotational	Dynamic Viscosity (mPa.s)			12.000	h		www.brookfieldengineering.com, date of access: 20.08.2014, Price: AP
Anton Paar	SVM 3000	Benchtop	Stabinger Method	Dynamic Viscosity (mPa.s)		0,10%	19.850	h	6.148.521	General Catalog Anton Paar 01.2014
Average / Sum							13.288	h	12.000.000	
Sum							6.059		60.000.000	
Total sum									116.000.000	

Table 8c; Market analysis, Viscometry[109]

[109] Own illustration

For the field of measuring the viscosity of liquids, the annual sales volumes depending on different technologies used are shown in Table 9 and Figure 29.

Technology	Market size [€/a]	Sales volume competition [€]	Sales volume Anton Paar [€]
Basic	1.000.000	1.000.000	-
Gravimetric / Capillary	40.000.000	40.000.000	-
Gravimetric / Ball / Needle	5.000.000	3.717.805	1.282.195
Oscillating Geometry	4.000.000	4.000.000	-
Pressurized Capillary	6.000.000	6.000.000	-
Rotational	60.000.000	51.817.325	8.182.675
Sum	116.000.000	106.535.130	9.464.870

Table 9; Viscometry - Sales volume by technology[110]

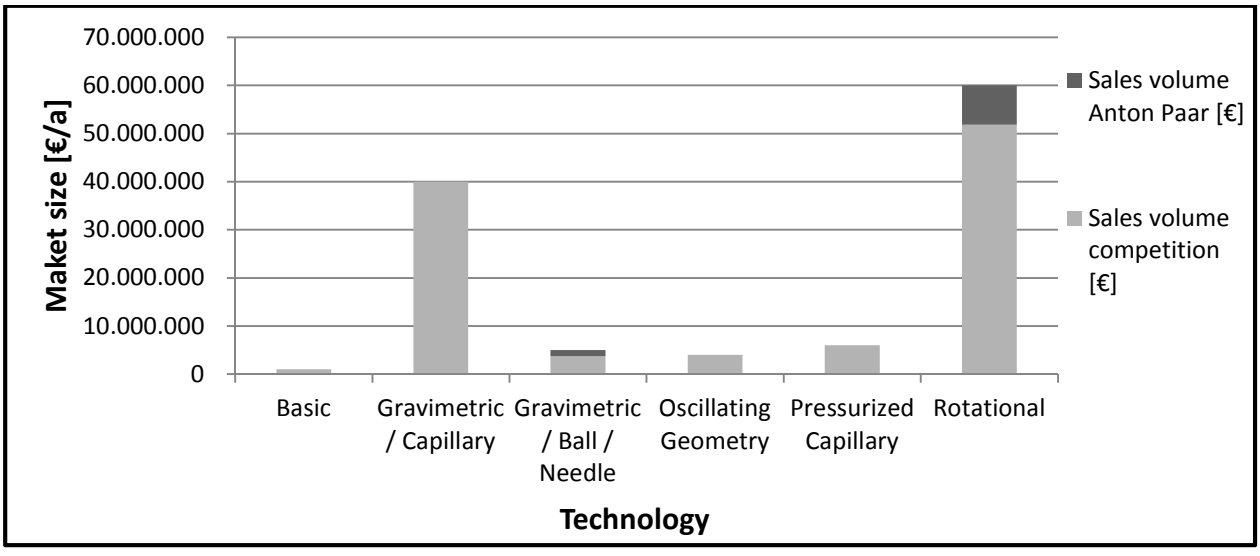


Figure 29; Viscometry - Sales volume by technology[111]

[110] Own illustration
[111] Own illustration

For the field of measuring the viscosity of liquids, the annual sales volumes depending on the different product levels are shown in Table 10 and Figure 30.

Product level	Global market size [€/a]	Sales volume competition [€]	Sales volume Anton Paar [€]
Entry level	12.500.000	12.500.000	-
Medium level	60.500.000	60.500.000	-
High level	43.000.000	33.535.130	9.464.870
Sum	116.000.000	106.535.130	9.464.870

Table 10; Viscometry - Sales volume by product level[112]

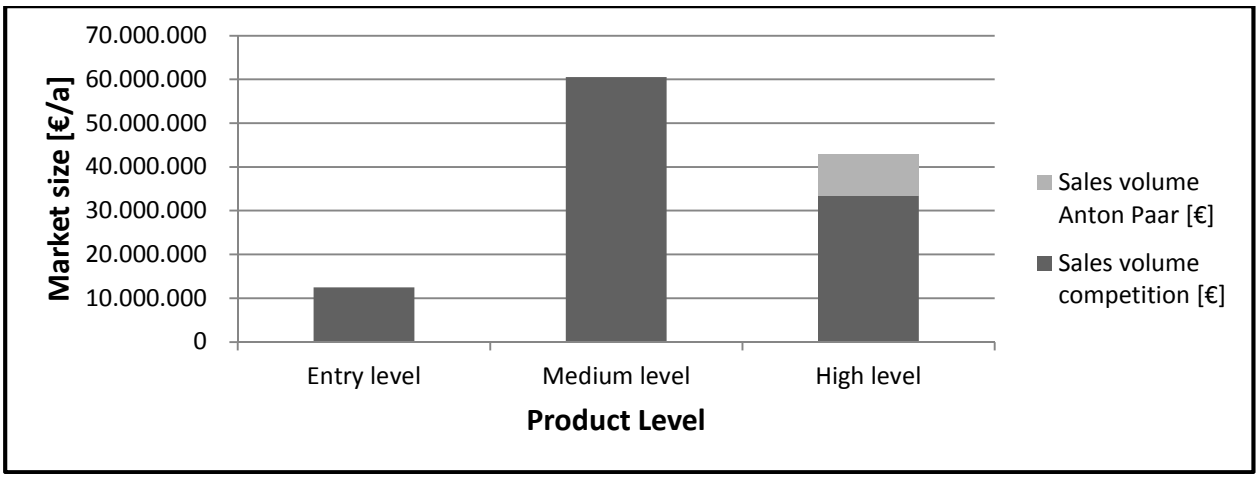


Figure 30; Viscometry - Sales volume by product level[113]

[112] Own illustration
[113] Own illustration

For the field of measuring the viscosity of liquids, the average retail prices depending on the technologies used are shown in Table 11 and Figure 31.

Technology	Average retail price competition [€]	Average retail price Anton Paar [€]
Basic	200	-
Gravimetric / Capillary	11.665	-
Gravimetric / Ball / Needl	7.001	13.580
Oszillating Geometry	5.083	-
Pressurized Capillary	15.135	-
Rotational	6.059	13.932

Table 11; Viscometry - Average retail price[114]

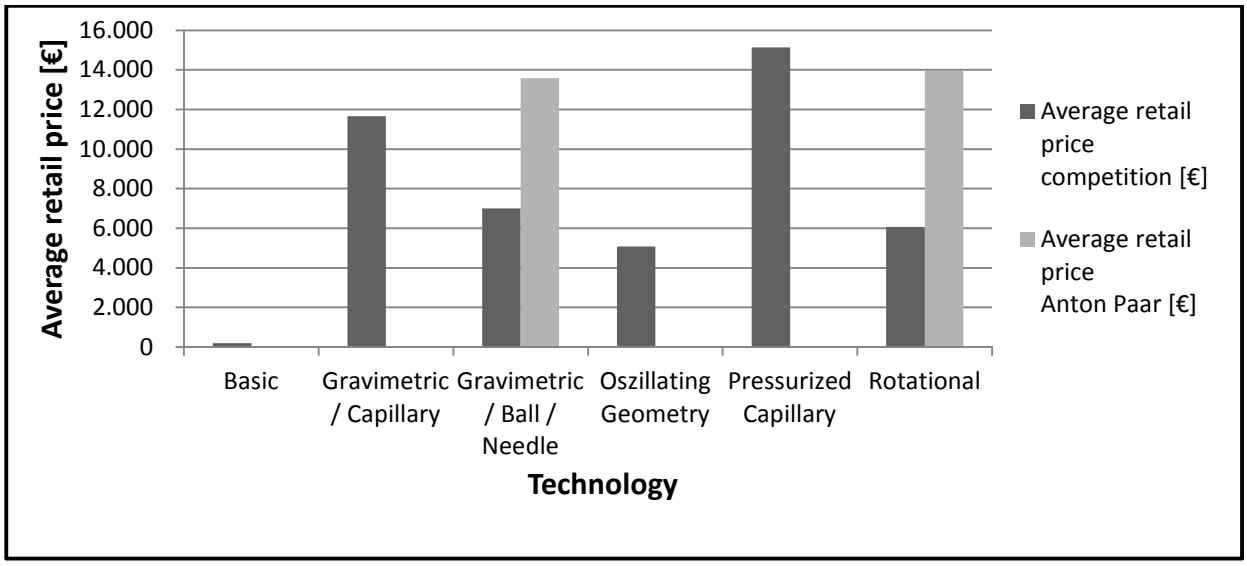


Figure 31; Viscometry - Average retail price[115]

[114] Own illustration
[115] Own illustration

Interpretation of market analysis of viscometry;

The annual global market of instruments for measuring viscosity of liquids is around € 116 and Anton Paar GmbH has a market share of 8%. Anton Paar GmbH does offer products only in the high level segment and only based on the technologies gravimetric (falling ball or falling needle) and rotational. The market of entry level products is the smallest in the field of measurement of viscosity of liquids, the market of medium level products is the biggest. The predominant products in the field of viscometry are rotational viscometers of the so called “Brookfield type”[116] which belong to the segment of medium level products.

3.1.5 Foundation of marketing decisions

As it was the objective of the first practical part to select one of the investigated product groups, finally market segment’s sizes of investigated product groups are compared with each other as shown in Figure 32. Sizes of entry level segments, each either served by the competition (left beam) or served by Anton Paar GmbH (right beam), are highlighted in red.

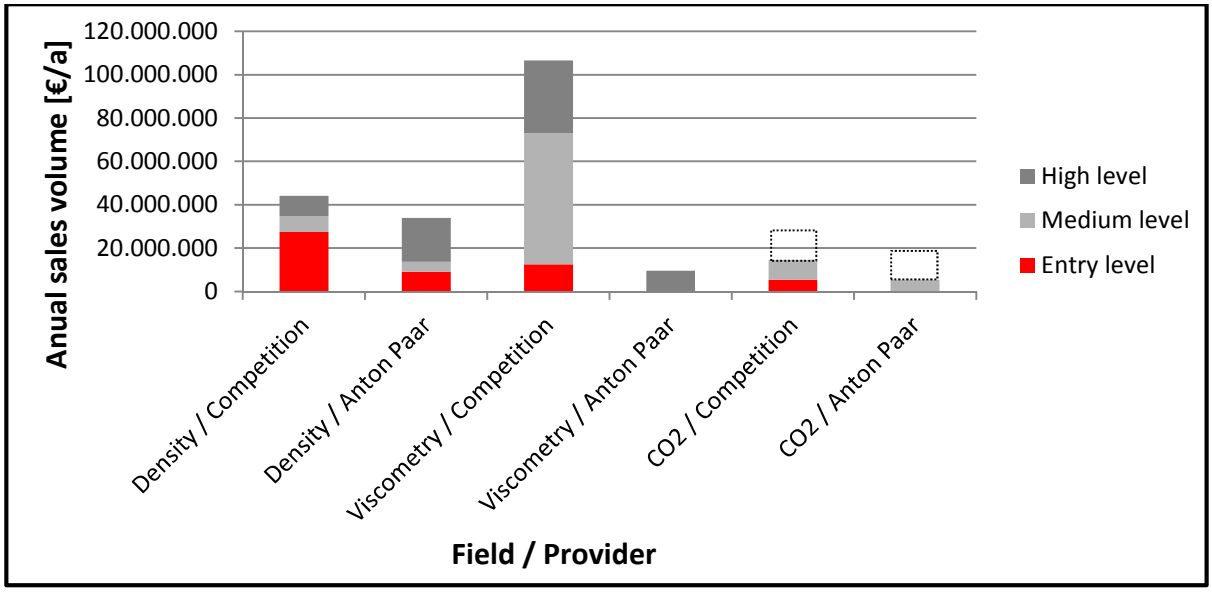


Figure 32; Comparison of market segment's sizes[117]

[116] Information provided by Anton Paar – Viscometry department 14.10.2014
[117] Own illustration

Aware that the results of the market analysis may differ from reality due to numerous simplified assumptions, density measurement is found being most interesting in terms of entry level products since market volume seems to be the biggest. Besides that, the market size of medium level product within the field of viscometry is identified being striking largely. Not being part of this thesis, it will not be discussed further; nevertheless it could be a valuable indication for further development projects.

3.2 Concept for an entry level product

After analysing the global market of instruments for the measurement of density and viscosity of liquids as well as their CO_2-content, a decision was made to take a closer look on the field of density measurement and to develop a concept of an entry level product. The concept should set the basis for a future development project and so a predetermined product concept framework is used. Anton Paar applies this framework in order to set a standard for the start of new development projects. The framework includes the following four steps;

1. Product idea; a basic description of the product idea including target markets and competition.
2. Development project; a rough estimation of development costs based on the particular steps of Anton Paar's product development process.
3. Market; a closer look on target customers and a rough market analysis.
4. Economic evaluation; an economic evaluation in the form of a net present value calculation based on previously found investment costs (costs for the development project) and market sizes.

3.2.1 Product idea

The basic idea is to develop a product that enables the user to measure the density of liquids using the measurement principle of the oscillating u-tube in order to substitute devices using gravimetric measurement methods such as hydrometers. The decision to use the oscillating u-tube method is based on two facts. On the hand, Anton Paar GmbH uses this method for almost 40 years and developed profound knowledge about it. On the other hand, the entry into the market of hydrometers does not seem to make any sense as they account for the largest share of the entry level segment and are thus part of a cutthroat competition.

The market analysis in the first part of this thesis shows one instrument for measuring density based on the method of an oscillating u-tube that costs less than € 500. The instrument's name is eDrometer produced by STM-Instruments, a manufacturer coming from the US. This device is available since the beginning of 2014 and so Anton Paar GmbH has not yet acquired any further experience. Other products using the principle of the oscillating U-tube are far more expensive e.g. DM 250 from AS Lemis Baltic with an alleged price of € 1.500. As hydrometers cost € 25 on average, these products seem to be too expensive for being a substitute of classic hydrometers. As Anton Paar GmbH also offers products in the entry level segment of density measurement, these have to be examined in more detail in order to avoid effects of cannibalization;

- The DMA 35, a portable density meter, measures the density of liquids based on the principle of an oscillating U-tube. Furthermore, it enables the customer to convert the measured density value into a variety of measurement units such as specific gravity, alcohol content, content of sugar or content of H_2SO_4 in batteries. The price for a DMA 35 in its standard version is € 1.849 excluding taxes.[118]
- The SNAP 40 is a portable alcohol meter for distilleries. It is based on the DMA 35 but converts the measured density only into a percentage value of alcohol content. The price for a Snap 40 in its standard version is € 950 excluding taxes.[119]

In any case, the aforementioned devices have to be clearly differentiated, either by price or by specification, in order to avoid effects of cannibalization.

As the new product is intended to replace hydrometers, it is investigated in which areas hydrometers are mainly used. Primarily, they are used for measuring;

- alcohol concentrations in alcoholic beverages such as spirits,
- extract concentration during the fermentation of mashes in the production of beers and wines,
- content of sugar in fruit juices,
- density of sulphuric acid (H_2SO_4) in automobile batteries as a part of battery service and
- concentration of antifreeze solution for cooling combustion engines.

[118] International list price 2014, provided by Anton Paar GmbH
[119] International list price 2014, provided by Anton Paar GmbH

The fields of measurement of alcohol concentration in spirits and of extract concentration during the fermentation of mashes in the production of beer face the highest demand, as these activities also affect the private sector while applications such as the measurement of acid density and antifreeze concentration are typically commercial ones. A detailed market analysis for these two fields is described in chapter 3.2.3. One measured value that is typical, the content of alcohol and the respective connection with the density measurement, is described in detail hereinafter. After measuring the density of a fluid, such as spirit, including water and alcohol, the content of alcohol can be derived by a linear relation as shown in Figure 33.

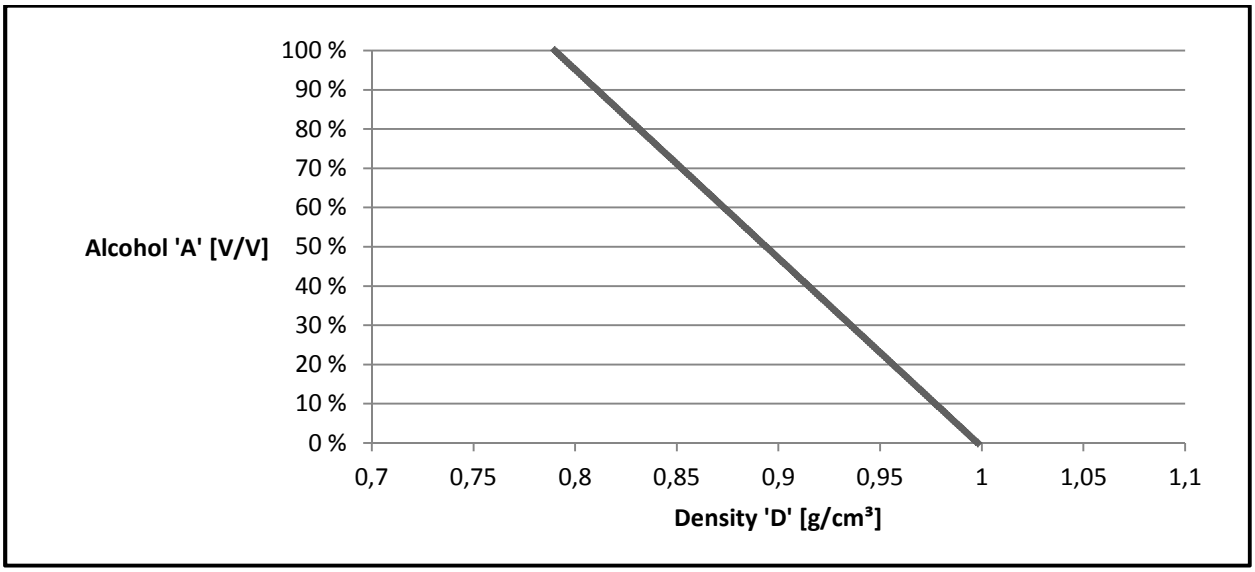


Figure 33; Correlation Density - Alcohol content at 20℃ [120]

As the density of water is 0,998 g/cm³ at a temperature of 20℃ and the density of alcohol is 0,79 g/cm³ at the same temperature[121], the accuracy of the measurement of content of Alcohol 'A' [% V/V] is derived from the accuracy of the measurement of the density value 'D' [g/cm³]. Therefore, the linear relation, with its gradient k and its ordinate intercept d, can be described by the following linear equation

$$A = k * D + d \quad . \qquad \textbf{(Equation 15)}$$

[120] Own illustration
[121] Webpage Gestis Stoffdatenbank, date of access 14.10.2014

By solving the equation using the correlations previously described, the equation becomes

$$A = -480,7692 * D + 479,8077 \quad . \qquad \textbf{(Equation 16)}$$

Therefore the correlation of accuracies can be described with

$$A = \frac{D}{0,00208} \quad . \qquad \textbf{(Equation 17)}$$

Typical accuracies of the measurement of density [g/cm³] and accuracies of derived alcohol value [% v/v] are then compared as shown in Table 12.

Accuracy of density measurement [g/cm³]	Accuracy of alcohol content [%V/V]
0,01	4,808
0,005	2,404
0,004	1,923
0,002	0,962
0,001	0,481
0,0005	0,240
0,0002	0,096

Table 12; Comparison of measurement accuracies[122]

In order to differentiate from Anton Paar's existing products, but also based on findings from the previous market analysis (see Chapter 3.2.3) the product to develop should at least meet a measurement accuracy of 1 [%V/V] alcohol content which correlates with an accuracy of 0,002 [g/cm³].

[122] Own illustration

Finally, a closer look on existing measurement instruments and the knowledge that the sensor system of Anton Paar's DMA 35 alone only costs a fraction of the entire unit, leads to the idea to combine the measurement principle of the oscillating u-tube with a mobile application on a smartphone. This gives the customer the possibility to only pay for what he actually needs. These considerations are also inspired by the principles of frugal innovation, as described in chapter 2.6. Details about the device's functions and the associated combination of different technologies are described in the next chapter.

3.2.2 Development project

In this chapter, the development project is described in order to estimate its costs which directly represent the initial investment in the net present value calculation in the final economic evaluation of this thesis. Basically, the development project has to include all activities which are necessary until the start of serial production and the possibility of selling the physical product via Anton Paar's web shop as it is later found out that the web shop in combination with selling the necessary mobile application via Android and IOS - platforms is the best sales channel in the beginning.

The project must also include the development of the mobile application itself, as the end customer could not use the instrument without it. In addition to the theoretical considerations throughout this thesis, an experimental set-up is made on the basis of the so called "DMA-Modul", shown in Figure 34. This is sold to OEM-costumers who want to add a density measurement to their measuring devices. The development of the experimental set-up is made in cooperation with Mr. David Pichsenmeister and Mr. Wolfgang Hütter. Mr. Pichsenmeister takes over the programming of the mobile application whereas Mr. Hütter implements the Bluetooth module.

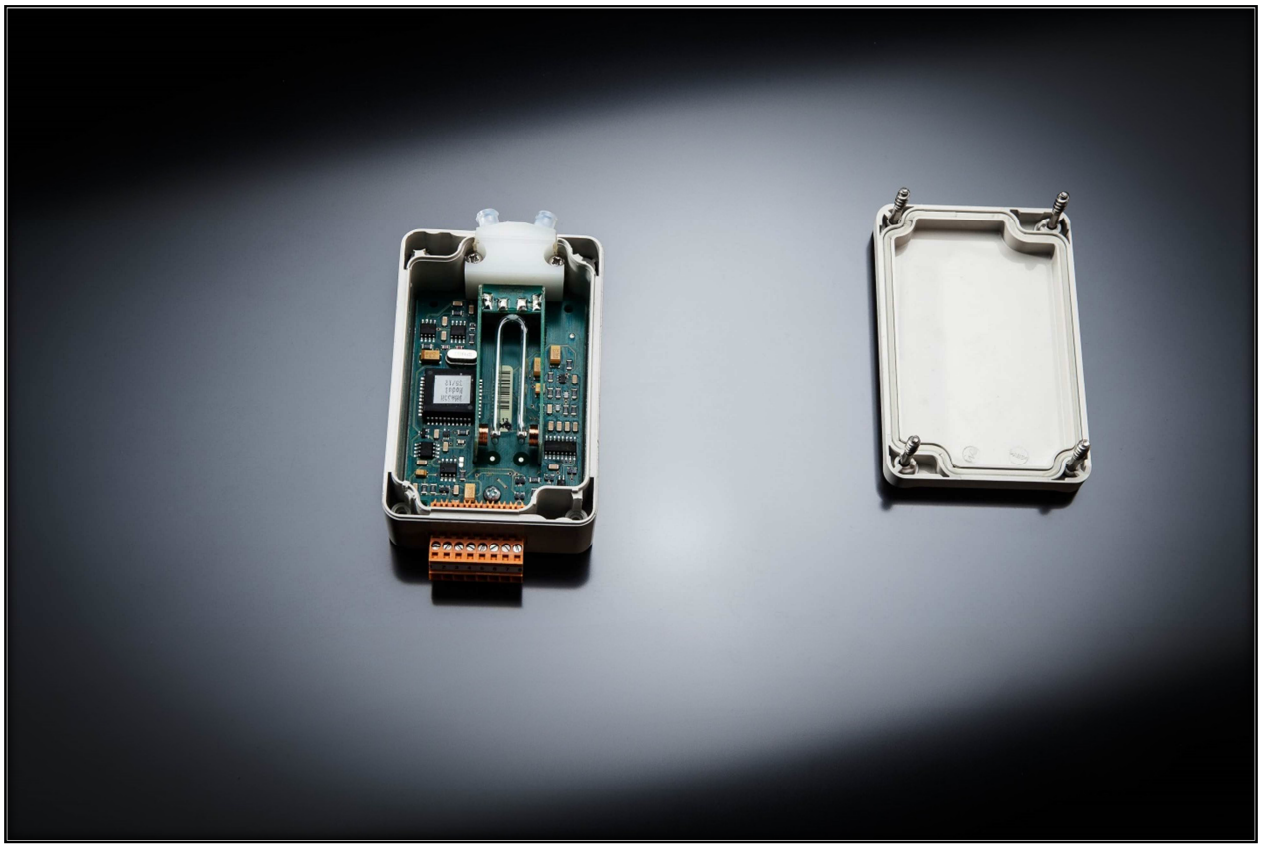


Figure 34; "DMA–Modul"[123]

Within the standard version of the density module, the density value is read out via a serial interface. At the experimental setup, an added Bluetooth module enables a wireless contact with a mobile phone and a mobile application displays the measurement value. Both, the module and the mobile application are shown in Figure 35. The experimental setup contains the "DMA-Modul", extended by a Bluetooth module, a power source and the mobile application, working on standard mobile phone based on Android.

[123] Own illustration

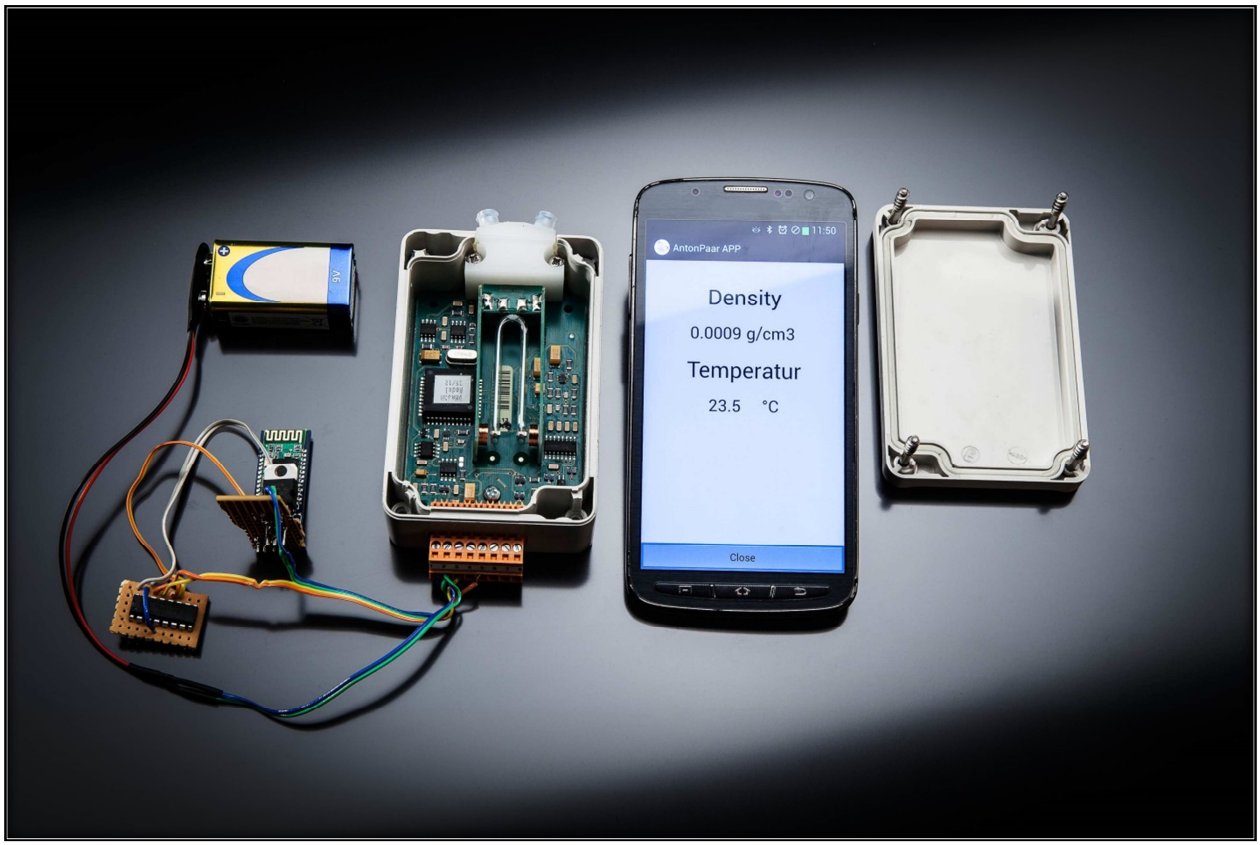


Figure 35; "DMA–Modul" extended[124]

In a next step, the estimation of the development costs, based on the existing experimental set up, is made. Furthermore, findings of later chapters are taken into account;

- Manufacturing costs of the basic instrument including the packaging must not exceed € 110, as shown in chapter 3.2.4.
- The sales volume per year is found out to be 3.224 units, as shown in chapter 3.2.3.
- The samples are filled with the help of syringes.

[124] Own illustration

The development project is divided into the following three phases.

The specification phase;

Within the specification phase, the technical feasibility must be checked, a risk analysis as well as an efficiency analysis must be made, a detailed project plan for the next phases must be created and detailed specifications must be defined.

As the housing and its functionality seems to be a critical factor, physical mock-ups have to be created already in the specification phase by rapid prototyping and their functionality and haptic has to be validated. The total costs for this phase are estimated to be € 17.250, containing the following;

- Personnel costs in the specification phase;
  - 250 h á € 65 € 16.250
- Additional costs in the specification phase;
  - Rapid prototyping € 1.000

The development phase;

In the development phase, a close-to-production prototype has to be developed and produced. The necessary quantity of prototypes is 20 units. After producing these prototypes, the compliance with its specifications has to be proofed. The total costs for this phase are estimated being € 72.500, containing the following;

- Personnel costs in the development phase;
  - 150 h mechanical engineering á € 65 € 9.750
  - 100 h electronic engineering á € 65 € 6.500
  - 150 h software engineering á € 65 € 9.750
  - 100 h testing á € 65 € 6.500
- Additional costs in the development phase;
  - Production of 20 prototypes á € 400 € 8.000
  - Injection moulds for housing € 25.000
  - Proofing of splash protection, class IP54 € 1.000
  - Verification of CE conformity € 1.000
  - 10 different mobile phones á € 500 € 5.000

The production transfer phase;

In the production transfer phase it is necessary to reach the ability to produce and sell the specified and developed product by concluding the following milestones: production equipment has to be purchased or manufactured, zero series products are to produce and the production processes have to be finalised, the production process have to be set up in Anton Paar's ERP-System, the market introduction as well as the sales via Anton Paar's web shop have to be prepared and a manual, based on the mobile application, has to be written. The total costs for this phase are estimated being € 27.000, containing the following;

- Personnel costs in the production transfer phase;
  - 300h á € 60 € 18.000
- Additional costs in the production transfer phase:
  - Production of zero series, 20 units á € 200 € 4.000
  - Production equipment € 5.000

By summing up the costs of the previous described phases, the costs for the development project are € 116.750.

3.2.3 Market

The conceptualized product, with its measurement accuracy of 1 %V/V which corresponds to 0.002 g/cm³, should primarily focus on end customers as private users as described in chapter 3.2.1. Consequently, the sectors of breweries as commercial breweries, home brewers, distilleries as commercial distilleries and home distillers are subject to the following analysis. Commercial sectors, such as the measurement of density of sulphuric acid (H_2SO_4) in batteries as a part of battery service or the measurement of concentration of antifreeze solutions for cooling combustion engines, are excluded from this investigation.

In a further step, these markets could be served simply by adding the appropriate conversion from the density value into the right unit of measurement to the mobile application. If so, it must be considered that cannibalization effects can occur as commercial users also buy other equipment from Anton Paar GmbH such as the DMA 35. Therefore, additional differentiations would be necessary. In the following, first breweries are investigated and after that the same is done for distilleries;

Commercial breweries and home brewers;

The association of “Brewers of Europe” estimates that there are 3.778 active commercial breweries on the European continent that produce at least 50.000 litres of beer per year.[125] At the same time, the production of beer in Europe was 28% of the world’s total amount of beer produced in 2012.[126] As this correlation has insignificantly changed since 2012, the number of breweries is set in quantity ratio with the amount of produced beer and is then extrapolated. This extrapolation leads to the assumption that there are 13.260 commercial breweries worldwide producing at least 50.000 litres of beer per year. There is a webpage were users list up and rate beers from all over the world since the year 2000. At the date of access, beers from more than 12.000 breweries were listed which supports the assumption of 13.260 commercial breweries worldwide.[127]

Due to the lack of information, it is difficult to determine the exact amount of home brewers. Consequently, it is decided to consider the following three scenarios;

- The worst case scenario suggests that there are as many home brewers as commercial breweries.
- The plausible scenario suggests that there are as many home brewers as commercial breweries.
- The best case scenario suggests that there are as many home brewers as commercial breweries.

The amount of breweries, commercial as well as home brewers, depending on the three previously described scenarios, is shown in Table 13.

[125] Brewers of Europe, oral information at 15.10.2014
[126] Webpage E-Malt, date of access 15.10.2014
[127] Webpage Rate Beer, date of access 15.10.2014

	Required accuracy [°P]	Worst Case	Plausible Case	Best Case
Number of commercial breweries	0,01	13.260	13.260	13.260
Number of home brewers	0,125	13.260	26520	39.780
Sum	-	26.520	39.780	53.040

Table 13; Number of breweries depending on accuracy requirements

Commercial breweries as well as home brewers control fermentation by measuring the density of beer-mash. The measured density value is further converted into so called "Degree Plato [°P]" which is the value for sugar co ntent. At the beginning of the fermentation, the mash typically has around 12 [°P] , this amount decreases with fermentation as the sugar content goes down and the alcohol content increases. At the end of the fermentation, the mesh typically has around 3.5 [°P]. For home brewers, an accuracy of 0.125 [°P] is sufficient. This correspo nds with an accuracy of the density value of 0.0005 [g/cm³]. Also for commercial breweries this accuracy is sufficient at the beginning of the fermentation process. As soon as it comes to the end of the fermentation, commercial breweries want to set the residual extract to an accuracy of 0.01 [°P]. At that point, density measurement with an accuracy of 0.00004 [g/cm³] would be necessary[128]. Consequently, commercial breweries have a measurement device meeting their accuracy requirements. This is the reason why they do not need another one, especially if it is less accurate.

Commercial distilleries and home distillers;

According to the "Verein für Abfindungs- und Kleinbrenner Österreichs", there are 1.4 million distillers in Europe. This is the sum of registered distillers and it is still increasing.[129] For estimating the number of distilleries worldwide, the number of European distilleries was extrapolated by the amount of globally consumed spirits.

[128] Sauseng, G., BM R&D AT Employee of Anton Paar, oral Information at 15.10.2014
[129] Cf. Webpage VAKÖ, date of access 13.10.2014

	Total consumption per person [litres / (year, person)]	Capita [million]	Total consumption [million litres / year]
African Region	6,15	1.136	6.986
American Region	8,67	971	8.419
European Region	12,18	741	9.025
Western Pacific Region	6,23	4.390	19.939
South East Asian Region	2,20		
Eastern Mediterranean Region	0,65		
Global sum	6,13	7.238	44.369

Table 14; Global alcohol consumption[130,131]

The “Global Status Report on Alcohol and Health” includes the necessary information for this extrapolation. On the one hand, the study shows the total amount of globally consumed alcohol. On the other hand, the detailed amounts of spirits consumed are listed separately for the different regions as seen in Table 14. The total consumption describes the worldwide annual amount of pure alcohol consumed in alcoholic beverages in million litres per year and person. This is multiplied by the number of inhabitants of each region in order to receive the total consumption of alcohol.[132]

In a next step, the worldwide amount of consumed spirits is calculated, based on information from the Global Status Report on Alcohol and Health as seen in Table 15. The report was published in 2011. However, it can be assumed that proportions did not significantly change since then. Therefore, the development since 2011 is not taken into account. Knowing the percentage of spirit consumption and the total consumption of alcohol for each region, the total consumption of spirits and finally the percentage of spirits consumption of each region is calculated.

[130] Cf. World Health Organization 2011, Global status report on alcohol and health, p.6
[131] Webpage Deutsche Stiftung Weltbevölkerung, date of access 21.10.2014
[132] Webpage Deutsche Stiftung Weltbevölkerung, date of access 21.10.2014

	Percentage of spirits of total alcohol consumption	Total consumption of spirits per anno [million litres]	Percentage of spirits of total spirits consumption
African Region	12,0	838	4
American Region	32,9	2.770	14
European Region	34,6	3.123	15
Western Pacific Region	54,0	13.546	67
South East Asian Region	71,0		
Eastern Mediterranean Region	25,2		
Global sum	45,7	20.277	100

Table 15; Global spirit consumption[133]

Next, it is assumed that the proportion of the amount of consumed spirits and registered produced spirits is similar among the different regions. It is also known that there are 1.4 million registered distilleries in Europe. Consequently, the number of distilleries is again extrapolated as seen in Table 16.

[133] Cf. World Health Organization 2011, Global status report on alcohol and health, p.6

	Percentage spirits of total spirits consumption	Number of distilleries
African Region	4	375.856
American Region	14	1.241.711
European Region	15	1.400.000
Western Pacific Region	67	6.072.806
South East Asian Region		
Eastern Mediterranean Region		
Global sum	100	9.090.373

Table 16; Number of distilleries[134]

One aim of this thesis is to find out how many of all distillers ask for a measurement with an accuracy of 1 [%V/V] alcohol content. Therefore, distilleries as well as suppliers of distilleries are interviewed as seen in Table 17 and Table 18.

[134] Extrapolated from World Health Organization 2011, Global status report on alcohol and health p. 5 ff.

Interviews - accuracy requirements of home distillers				
Interview partner	Question 1: Do you sell measurement instruments for measuring alcohol content?	Question 2: Which distillers require which measurement accuracies?	Date of Interview	Comment
Brennmeister Feindestillerie Hochstrasser Marktplatz 12 8562 Mooskirchen	no	Home distillers use hydrometers, for them an accuracy of 1% is enough.	22.10.2014	-
Fruchtbrennerei Franz Tinnauer Steinbach 42 8462 Gamlitz	no	1000 to 2000 from 100.000 distillers would spend a couple of hundreds of Euros a digital density measurement device.	21.10.2014	-
Lind Obstbau & Edelbrände Großhaide 5 8272 Sebersdorf	no	For 50% of all distillers a measurement accurcy of 1% is good enough.	21.10.2014	-
Kellereibedarf Schmickl GesnbR Dr. Helge Schmickl Ehrentalerstraße 39 9020 Klagenfurt am Wörthersee	Hydrometers	Most of distillers use hydrometers with a measurement accuracy of 1%.	22.10.2014	There are far more than 1.4 MIO distillers in Europe. There might be 1% of home distillers who spent a couple of hundreds of Euros for a digital measurement instrument simply because it is their hobby.
holzeis - Kellereibedarf GmbH Aussermanzing 28 3033 Altlengbach	Hydrometers	Far more than 50% of all hydrometers sold offer an accuracy of 1%.	22.10.2014	-
Rekru GmbH Betznauer Straße 28 D-88079 Kressbronn	Hydrometers	The number of hydrometers with an accuracy of better or worse than 1% cannot be identified.	22.10.2014	-
Carl Klein GmbH Kellereiartikel Gewerbegebiet Hafen August-Gauer-Str. 5 D-97318 Kitzingen	Hydrometers	25 out of 30 hydrometers sold offer a measurement accuracy of 1% - 2%.	22.10.2014	-

Table 17; Interviews - accuracy requirements of commercial distillers[135]

[135] Own illustration

Interviews - accuracy requirements of home distillers				
Interview partner	Question 1: Do you sell measurement instruments for measuring alcohol content?	Question 2: Which distillers require which measurement accuracies?	Date of Interview	Comment
Brennmeister Feindestillerie Hochstrasser Marktplatz 12 8562 Mooskirchen	no	Home distillers use hydrometers, for them an accuracy of 1% is enough.	22.10.2014	-
Fruchtbrennerei Franz Tinnauer Steinbach 42 8462 Gamlitz	no	1000 to 2000 from 100.000 distillers would spend a couple of hundreds of Euros a digital density measurement device.	21.10.2014	-
Lind Obstbau & Edelbrände Großhaide 5 8272 Sebersdorf	no	For 50% of all distillers a measurement accurcy of 1% is good enough.	21.10.2014	-
Kellereibedarf Schmickl GesnbR Dr. Helge Schmickl Ehrentalerstraße 39 9020 Klagenfurt am Wörthersee	Hydrometers	Most of distillers use hydrometers with a measurement accuracy of 1%.	22.10.2014	There are far more than 1.4 MIO distillers in Europe. There might be 1% of home distillers who spent a couple of hundreds of Euros for a digital measurement instrument simply because it is their hobby.
holzeis - Kellereibedarf GmbH Aussermanzing 28 3033 Altlengbach	Hydrometers	Far more than 50% of all hydrometers sold offer an accuracy of 1%.	22.10.2014	-
Rekru GmbH Betznauer Straße 28 D-88079 Kressbronn	Hydrometers	The number of hydrometers with an accuracy of better or worse than 1% cannot be identified.	22.10.2014	-
Carl Klein GmbH Kellereiartikel Gewerbegebiet Hafen August-Gauer-Str. 5 D-97318 Kitzingen	Hydrometers	25 out of 30 hydrometers sold offer a measurement accuracy of 1% - 2%.	22.10.2014	-

Table 18; Interviews - accuracy requirements of home distillers[136]

These interviews lead to the assumption that a group of at least 50% of all distilleries asks for an alcohol measurement with an accuracy of 1 [%V/V]. A second largest group is defined as the group of distilleries which ask for a measurement accuracy smaller than 0.3 [%V/V]. On the one hand, this is due to governmental regulations for commercial distilleries. On the other hand, due to the distiller's desire to measure with such accuracy. The third group is defined as the group of distilleries who do not ask for a measurement at all. Since it has no significant relevance for this thesis to further investigate the relation between the second and the third group, they are assumed of being equally large. According to these considerations, the different types of distilleries in relation to different requirements in accuracy are shown in Table 19.

[136] Own illustration

There were several assumptions necessary to find out how many distilleries there are in total. Consequently, it is again decided to consider the following three scenarios;

- The worst case scenario suggests that the extrapolated number of distilleries is too high. The real amount should only be 75% of this amount.
- The plausible case scenario suggests that the extrapolated number of distilleries is correct.
- The best case scenario suggests that the extrapolated number of distilleries is too small. The real amount should be 125% of the assumed amount.

	Required accuracy [%V/V]	Worst Case [#]	Plausible Case [#]	Best Case [#]
Home distillers	1	3.408.890	4.545.187	5.681.483
Commercial distilleries	0,3	1.704.445	2.272.593	2.840.742
Home distilleries	-	1.704.445	2.272.593	2.840.742
Sum	-	6.817.780	9.090.373	11.362.966

Table 19; Number of distilleries in terms of accuracy requirements[137]

The different market sizes are summed up in Table 19. Subsequently, devices are divided by precision, regardless of the application. This shows that the number of brewers compared to the number of distillers seems to be quite small. In case of commercial breweries, an accuracy of 0.01 [℗] which equals an accuracy of 0.00004 [g/cm³] is required. Therefore, it is decided to not cover this market demand with the product concept of this thesis. The reason for this is that an accurate measurement is hardly possible with this simple product concept. In addition, it would be in strong competition with exiting products of Anton Paar GmbH.

[137] Own illustration

	Worst case [#]	Plausible case [#]	Best case [#]	Required accuracy	Required accuracy [g/cm³]
Commercial breweries	13.260	13.260	13.260	0,01 °P	0,00004
Home breweries	13.260	26.520	39.780	0,125 °P	0,0005
Commercial distilleries	1.704.445	2.272.593	2.840.742	0,3 %V/V	0,0005
Home distilleries	3.408.890	4.545.187	5.681.483	1 %V/V	0,002

Table 20; Market sizes depending on accuracy[138]

One can see the market demand depending on accuracy in Figure 36. It clearly shows that the field of home distillers gives the greatest possibilities for an entry level product in the field of density measurement. Commercial distillers, with half as many potential buyers as home distillers, are currently the target group of Anton Paar's entry level density measuring device, the Snap 40 as described in chapter 3.2.1. Therefore, it is decided to focus on the group of home distillers in further market considerations. A more detailed analysis of other markets of density measurement by hydrometers is excluded from this thesis. Based on the market sizes depending on accuracy and on the market analysis in the first part of this thesis, a worldwide annual average sales volume of 1.000.000 hydrometers is estimated. They are sold with an average price of € 25 regardless of the application.

Finally, investigated market sizes of different business fields are shown in Figure 36.

[138] Own illustration

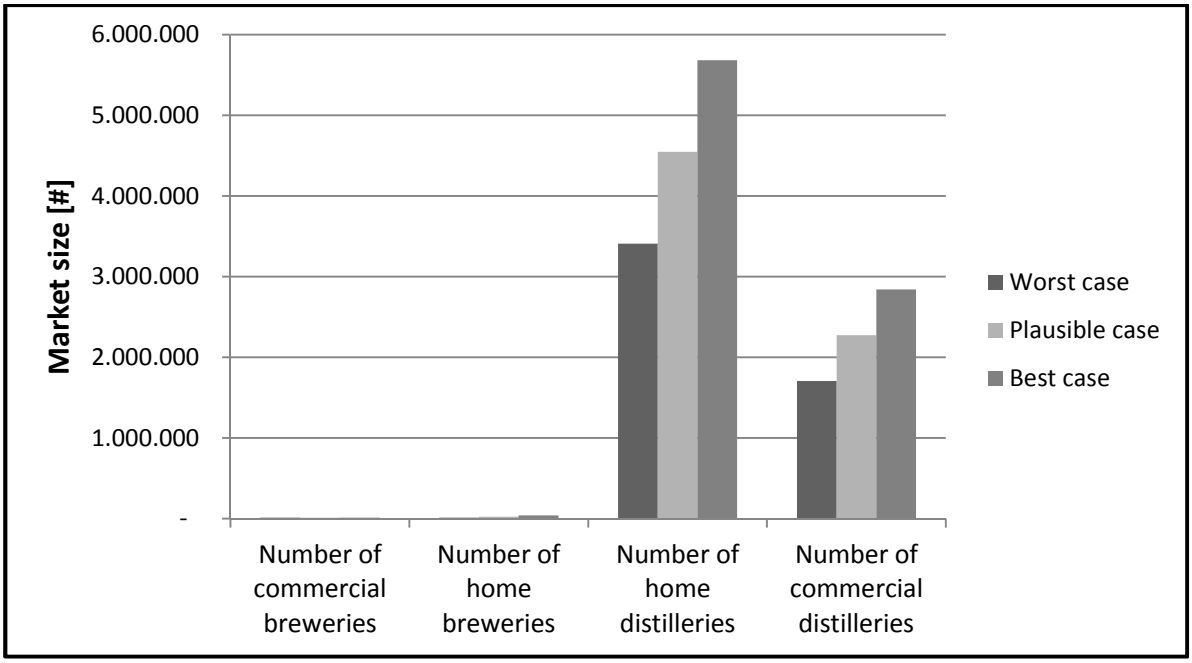


Figure 36; Market sizes depending on business fields[139]

In the next step, both factors, depending and not depending on the price, are taken into account in order to find out how many brewers and distillers are actually willing to buy an instrument based on the elaborated product. It is assumed that the retail price will have a major impact on the number of buyers. Consequently, the optimal price as a function of the number of buyers is calculated. Before that, the following price-independent factors are defined and investigated;

- The reduction of potential buyers by the reach of Anton Paar's web shop
- The reduction of potential buyers by the number of smart phone users

At the time of investigation, Anton Paar's online store did not reach all potential customers worldwide as it did not yet operate in all countries. The biggest markets it did not serve were Russia, Turkey and Brazil. In general, the reach of the web shop is assumed being 90% of the total market.[140]

As only smartphone users are able to use the elaborated product, they are the only possible buyers. In order to find out the proportion of smart phone users, the development of the number of smartphone users is extrapolated to the year 2018. It is assumed that the number of smart phone users reaches saturation at a certain point in

[139] Own illustration
[140] Wenger, S., REA eCommerce Manager of Anton Paar, oral Information at 24.10.2014

time. A second degree polynomial function, as shown in Figure 28, seemed sufficiently accurate for extrapolation of the development from 2009 to 2013. This polynomial function shows that there will be 3.871 million smart phone users in 2018. Studies of mobile operators confirm the validity of this extrapolation with the specification of 3.3 billion smart phone users worldwide in 2018.[141]

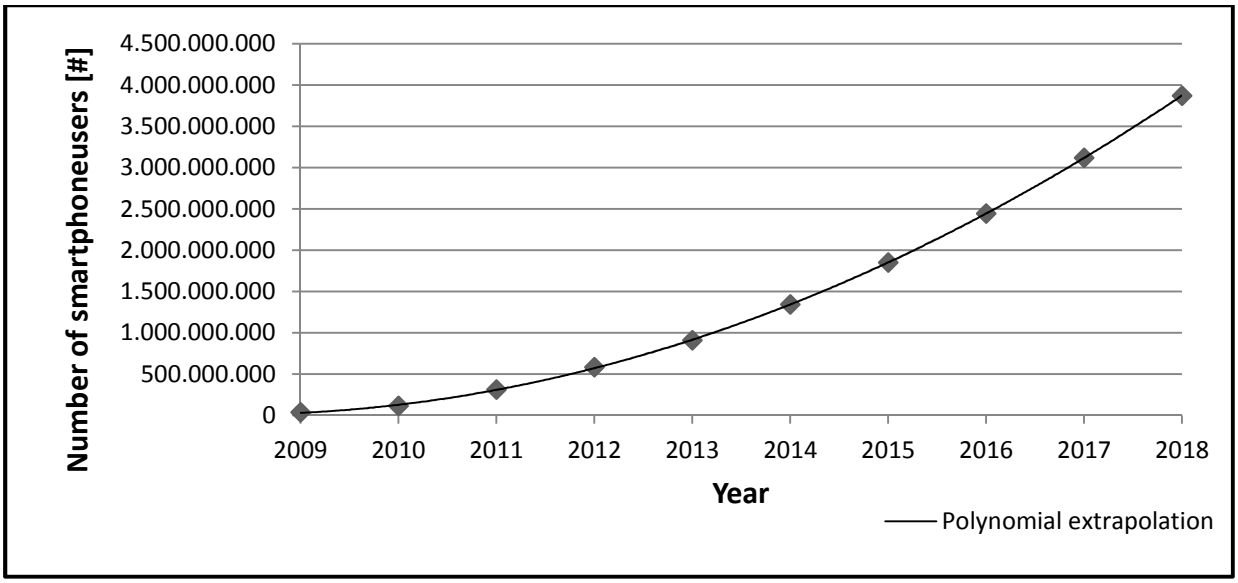


Figure 37; Development of smartphone users[142]

It is assumed that the world's population of around 7.2 billion people will not change eminently in the following few years. Due to this, further investigations on this number are omitted. The reduction of the potential markets by the limited use of smart phones is consequently taken into account with the proportion between 3.871 million smartphone users in 2018 and a world population of 7.200 million. This gives a number of 53.8%.

The number of potential costumers is calculated by the reduction of the market sizes by 10% as the reach of Anton Paar's web shop was previously defined with 90% and 46.2% as the extrapolation assumes that 53.8% of all potential customers use a smartphone and are able to work with an instrument based on the elaborated product concept.

[141] Ericsson AB 2012, Ericsson Mobility Report, p. 6
[142] Webpage Statista, date of access 24.10.2014

	Worst case [#]	Plausible case [#]	Best case [#]
Home distilleries	3.408.890	4.545.187	5.681.483
Reduction by reach of web shop and number of smartphone users	- 1.758.305	- 2.344.407	- 2.930.509
Potential customers	1.650.585	2.200.780	2.750.974

Table 21; Number of potential customers[143]

At the end of the market analysis, it is tried to find out how many of the potential customers, as shown in Table 20, would buy the simple measurement device depending on the retail price. The price range is defined from € 200.- excluding taxes to € 500.- excluding taxes. Selling at a lower price would not leave any room for profit. Selling at a higher price means that customers might tend to buy the more accurate density measurement device from Anton Paar GmbH, the Snap 40 for € 950.-, as described in chapter 3.2.1. To determine the ideal price, the number of customers as a percentage of all potential customers is assigned to predefined retail prices. As basis for these assumptions, previous interviews with distillers and retailers were taken into account. The most significant information is the following;

- From 100.000 distillers, 1.000 to 2.000 would spend some hundreds of Euros for an alcohol measurement device with an accuracy of 1% V/V.[144]
- Approximately 1% out of all home distillers might spend some hundreds of Euros for a digital measurement instrument simply because it is their hobby.[145]

[143] Own illustration
[144] Tinnauer, F., Fruchtbrennerei Tinnauer, oral information at 21.10.2014
[145] Schmickl, H., Kellereibedarf Schmickl, oral information at 22.10.2014

Despite this information, it is difficult to derive information about the entire global market. Therefore, further assessments are kept conservative;

- With the highest price of € 500 excluding taxes, 0.3% of all potential customers could be reached.
- With the lowest price of € 200 excluding taxes, 1.37% of all customers could be reached.

Furthermore, it is estimated that a reduction of € 50 within this price frame would lead to an increase of sales by 25%. The assumption that the period of time until a customer is willing to repurchase a new device would be shorter in case of smaller retail price is taken into account. The increasing number of customers in relation to a decreasing price is shown in Table 22.

Retail price [€]	Percentage of potential customers [%]	Product life in years	Percentage of potential customers per year [%/a]
200	1,37	5	0,275
250	1,10	6	0,183
300	0,88	6	0,146
350	0,70	7	0,100
400	0,56	7	0,080
450	0,45	8	0,056
500	0,36	8	0,045

Table 22; Percentage of potential customers per year[146]

With the percentage of potential customers per year, the total sales volume per year is again calculated for the worst, plausible and best case scenario. Previously made assumptions are based on limited information. Therefore, a further correction factor for the worst, plausible and best case scenario is defined;

[146] Own illustration

- Worst case scenario; the percentage of potential customers, as shown in the table above, is too high and in fact there are only 50% thereof.
- Plausible case scenario; the percentage of potential customers, as shown in the table above is correct.
- Best case scenario; the percentage of potential customers, is too low and in fact there are 150% thereof.

This finally leads to a range of possible sales volumes depending on different retail prices, as shown in Figure 38. This was used as the basis for further calculations in chapter 3.2.4.

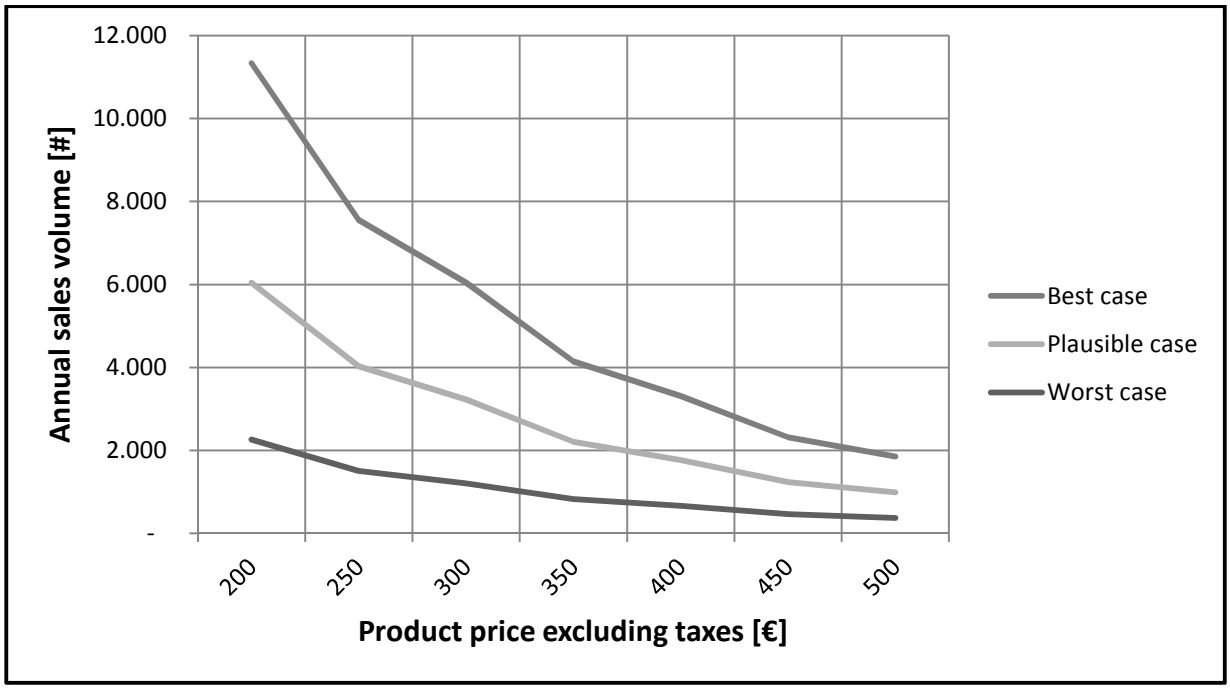


Figure 38; Annual sales volume[147]

A change of the gradient of the above shown curves in Figure 38 results from the fact that the time period for a repurchase decreases together with the retail price.

[147] Own illustration

3.2.4 Economic evaluation

The economic evaluation is carried out on the basis of previous findings. Its aim is to serve as a basis for further decisions in terms of starting a development project based on the product concept and therefore entering the market of entry level products.

As evaluation method, the net present value method is selected as it is used regularly by Anton Paar employees to evaluate the economic efficiency of projects and to compare different development projects with each other. As the chosen approach for making the economic evaluation, the method may be described in more detail;

Within the net present value method, future cash flows, inflows and outflows, are discounted to the present value and summed up. The rate for discounting is typically the internal rate of return. In general, this is the rate capital is paid interest on within a specific organisation or project. In this special case, it is the rate of return of the whole Anton Paar group. After summing up all discounted inflows and outflows the net present value could either be positive, it could be zero and it could be negative. If it is negative, the investment has a negative effect on financial results of Anton Paar GmbH and one should therefore refrain from investing. If the value is zero, the investment is neutral. If it is positive, the investment has a positive effect on the company's financial result and should therefore be made. The value can also be taken for comparing different projects in order to choose the one with the most positive effect.

Before the net present value method can be applied, the optimal retail price has to be found. Therefore, a contribution margin calculation, including revenues as well as variable costs such as manufacturing costs and costs for sales, is made;

In a first step the annual revenue is calculated based on the annual sales volume. Depending on the retail price and the best, plausible and worst case scenario, the annual revenue lies between € 154.742 and € 2.266.732 as shown in Figure 39.

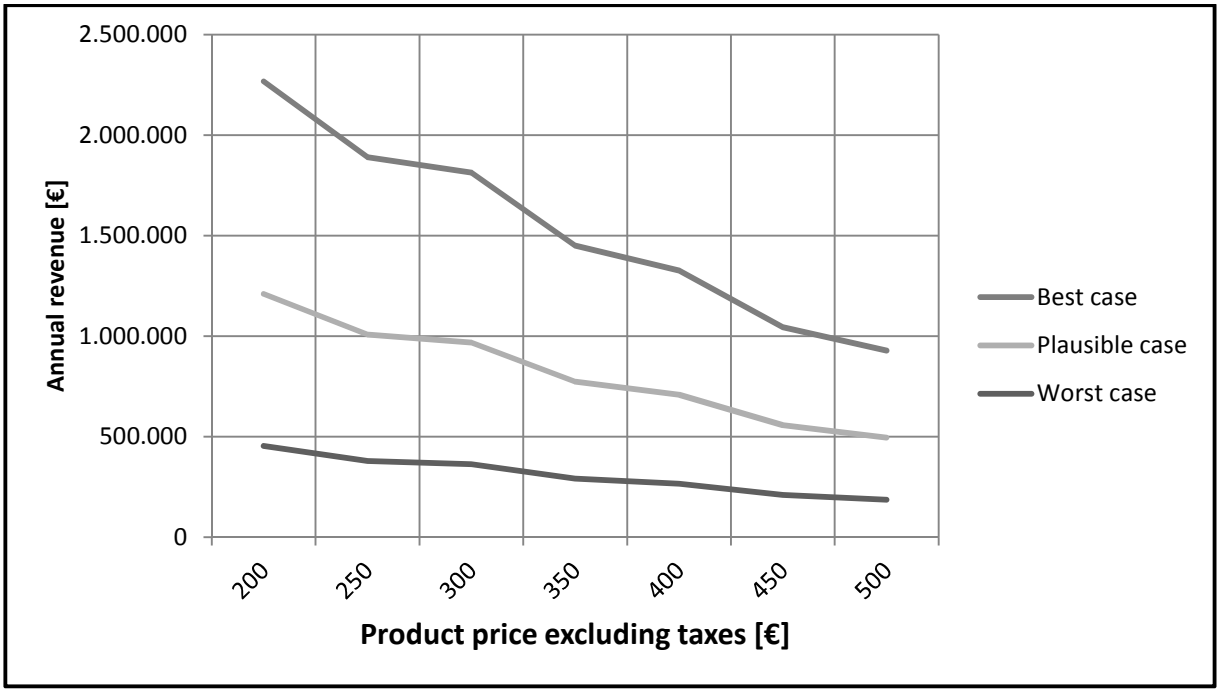


Figure 39; Annual revenue[148]

In a next step, the manufacturing costs are determined by using the Bill of Material (BOM) of the "DMA–Modul" which was the basis for the experimental set-up. Anton Paar GmbH sells this module to OEM-costumers who want to add a density measurement to their measuring devices. The density value is normally read out via serial interface. Parts of this module would not be needed for the future product and are therefore deducted from manufacturing costs. Vice versa, additional costs for a new housing, a battery, a Bluetooth module and the packaging are added as shown in Table 23. The BOM already includes costs for purchasing and assembling and is found out via Anton Paar's ERP system. Costs for additional parts are estimated in cooperation with engineers from Anton Paar GmbH.

[148] Own illustration

Name	Quantity	Costs
DMA-Modul	1	€ 100,33
Parts taken over		
MODULPRINT DMA 35N-Modul	1	
SPULENSATZ DMA 35N-Modul	1	
Messzelle DMA 35N-Modul	1	
Dichtungsscheibe 6,2x3,15x1,0	2	
Schwingerhalter	1	
Luerbuchse DI=2mm	2	
Zyli-Schraube I-6Kt M2x18	2	
Blechschraube Lins B2,9x6,5	1	
Linsenschraube M3x16	2	
Kennzeichnungsstreifen	1	
Parts to be omitted		
Klebeschild 30x10	1	-€ 0,12
Gehäuse DMA 35N-Modul	1	-€ 9,09
Buchsenleiste 8pol.	1	-€ 2,54
Parts to add		
Housing	1	€ 15,00
Battery	1	€ 1,00
Bluetooth module	1	€ 7,00
Packaging	1	€ 5,00
Sum	€ 116,58	

Table 23; Manufacturing costs[149]

The planned instrument would be produced in much larger quantities than the “DMA-Modul”. Therefore, for further calculations manufacturing costs of € 110 per unit are taken into account.

[149] Information from Anton Paar’s ERP-System SAP, 05.11.2014

In the course of the selection of an appropriate distribution channel, selling via an online mail order house as well as over a catalogue dealer is taken into consideration. Established online mail order houses charge between 10% and 20% of a products retail price for storage and distribution[150] whereas catalogue dealers charge 30% to 40% of a product's retail price[151].

Since the cost rate for the web shop of Anton Paar GmbH is 15% of a product's retail price, this sales channel is chosen and its cost rate is used for further calculations. Furthermore, the costs for Anton Paar's web shop are mainly fixed costs which results in an additional positive effect on the organization's result. The cost rate of 15% includes the operation of the web shop as well as internet marketing. The optimal retail price, due to the highest contribution margin as shown in Figure 40 is € 300. This will be explained in detail below. Consequently, costs for sales of € 45 per unit are taken into account.

The contribution margin is calculated on an annual basis by deducting the variable costs for manufacturing and sales from revenue as shown above. By this means, the ideal retail price, based on previous considerations and calculations made so far is € 300, as shown in Figure 40.

The results show that 3.224 units can be sold annually in the plausible case scenario at a retail price of € 300 in average. In the worst case scenario this amount is 1.209 units and in the best case scenario 6.045 units.

[150] Wenger, S., REA eCommerce Manager of Anton Paar, oral Information at 19.11.2014
[151] Murer, G., Business Area Manager of Anton Paar, oral Information at 17.11.2014

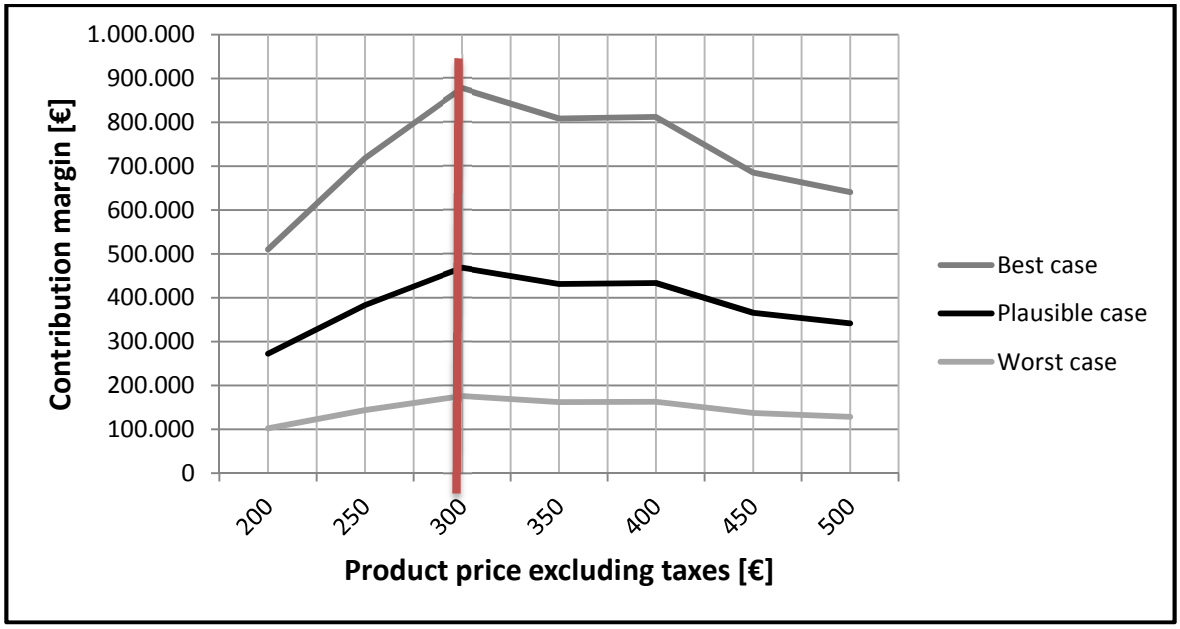


Figure 40; Contribution margin[152]

To complete the economic evaluation, all previous data such as the market size, the costs for the development project, the optimal retail price and the manufacturing costs are used to calculate the net present value. The three scenarios do neither affect the investment for the development project, nor the retail price, nor the manufacturing costs as shown in Table 23.

	Investment 2015 [€]	Retail price [€]	Manufacturing costs [€]
Worst case	116.750	300	110
Plausible case	116.750	300	110
Best case	116.750	300	110

Table 24; Net present value calculation, input parameter[153]

It is assumed that the actual number of units sold would double annually and reach its maximum after three years, in 2019 as shown in Table 24.

[152] Own illustration
[153] Own illustration

	Sales [#] 2016	Sales [#] 2017	Sales [#] 2018	Sales [#] 2019	Sales [#] 2020	Sales [#] 2021
Worst case	151	302	605	1.209	1.209	1.209
Plausible case	403	806	1.612	3.224	3.224	3.224
Best case	756	1.511	3.023	6.045	6.045	6.045

Table 25; Expected sales volume[154]

Additional surcharges for the profit centre Lab Density and Concentration, which is the profit centre the conceptualized product would be associated with, as well as additional corporate costs have to be considered. The surcharge for the profit centre LDC is taken into account by 36.53%, the additional corporate costs by 35.96% and the additional cost for corporate development by 4,58%[155]. All surcharges are added to manufacturing costs for the calculation. As the retail price is the basis for costs for sales, it is deducted from the revenue per piece. All additional surcharges are summarized in Table 25.

Additional surcharges	[%]	Basis
Costs of sales	15,00	Retail price
Profit centre surcharge	36,53	Manufacturing costs
Corporate costs	35,96	
Cost for corporate development	4,58	

Table 26; Net present value calculation, additional surcharges[156]

Based on previous made assumptions of annual sales volume, optimal retail price, manufacturing costs and additional surcharges, the expected annual cash flow is calculated as shown in Table 27.

[154] Own illustration
[155] Information provided by Anton Paar GmbH, Controlling Department 18.11.2014
[156] Own illustration

	CF 2015 [€]	CF 2016 [€]	CF 2017 [€]	CF 2018 [€]	CF 2019 [€]	CF 2020 [€]
Worst case	-116.750	9.101	18.202	36.405	72.810	72.810
Plausible case	-116.750	24.270	48.540	97.079	194.159	194.159
Best case	-116.750	45.506	91.012	182.024	364.048	364.048

Table 27; Expected cash flow[157]

For calculating the net present values of the above cash flows, the internal rate of return of Anton Paar GmbH is taken into account with IRR = 15%[158]. Finally, the net present values are cumulated as shown in Figure 41.

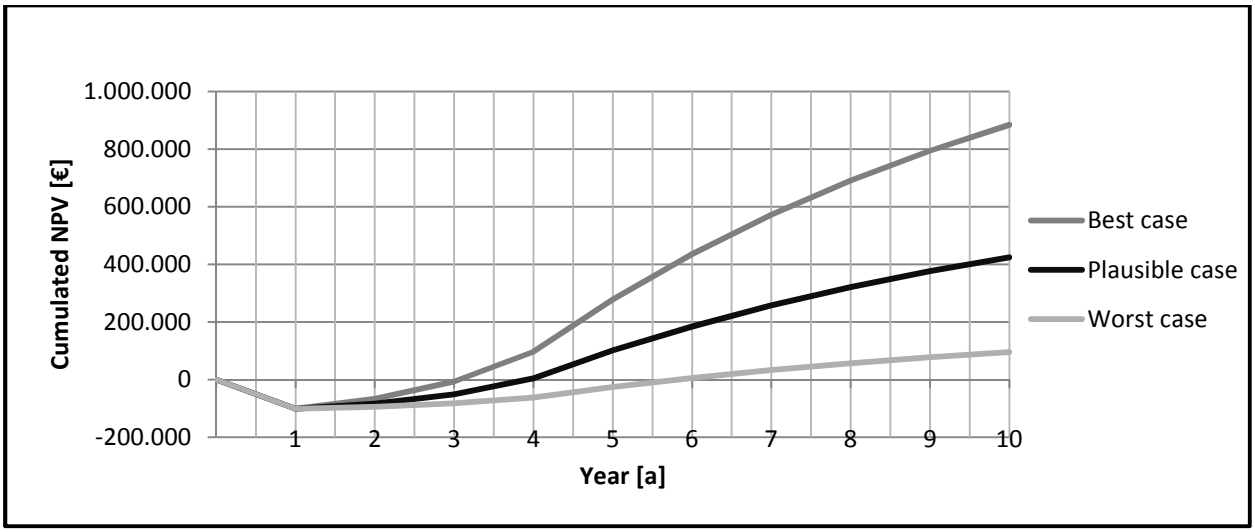


Figure 41; Net present values, cumulated[159]

[157] Own illustration
[158] Information provided by Anton Paar GmbH, Controlling Department 18.11.2014
[159] Own illustration

The calculation shows two results. On the one hand, the net present value for each scenario previously defined and on the other hand the amortization time. Both results for each scenario are shown in Table 28.

	NPV 2015 [€]	Amortization [a]
Worst case	95.688	5,8
Plausible case	424.370	4,0
Best case	884.526	3,1

Table 28; Net present value and amortization[160]

The calculation shows that even in the worst case scenario, the net present value is positive. This means that the investment has a positive effect on Anton Paar's financial result and should therefore be made. If personal resources are limited, net present values and times amortization have to be compared with other projects in order to choose the best.

[160] Own illustration

4 Conclusion and outlook

Market analysis show that from three investigated product groups; density measurement, viscometry, and measurement of dissolved CO_2 in liquids, the field of density measurement shows the most appreciable market potential in the segment of entry level products. Therefore, a product concept for this specific field is developed. As market analysis is limited on above selected product groups, it is recommended to extend the survey to all product groups featured at Anton Paar GmbH in the future in order to identify further market potentials in the entry level segment.

Throughout the development of the product concept for an entry level density meter, home distillers are identified being the most relevant target group. Detailed market assessments as well as considerations of development and manufacturing costs lead to an economic evaluation of the product concept which economically justifies an entry in the segment of entry level products by means of a positive net present value. In addition to this positive net present values for three scenarios investigated; worst case, plausible case, and best case scenario, economic evaluation let expect an amortization period of four years within the plausible case scenario. As distribution channel for the developed product concept, Anton Paar's online store turns out to be the most cost efficient.

In general, the implementation of a second brand including a separate legal entity as well a separate distribution network seems to be too ambitious at this stage as there is only one product concept economically evaluated. Nevertheless, the realization of the developed entry level product concept is recommended due to its positive economic evaluation. Consequently, it could be a first step towards a second brand, an entry level brand, for Anton Paar GmbH with separate sales channel at a later stage.

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7 List of figures

8 List of tables

9 List of abbreviations

BOM	Bill of Material
°Bx	Degrees brix
CboxQC	Product name at Anton Paar GmbH for a carbon dioxide meter
CRM	Customer relationship management
DMA 500	Product name at Anton Paar GmbH (Dichtemessapparatur 500)
DMA 35	Product name at Anton Paar GmbH (Dichtemessapparatur 35)
ERP	Enterprise-Recourse-Planning
IRR	Internal rate of return
LDC	Lab Density and Concentration
Lovis 2000 M/ME	Product name at Anton Paar GmbH for a Viscometer
MKT 50	Product name at Anton Paar GmbH (Milli Kelvin Thermometers 50)
OEM	Original Equipment Manufacturer
R&D	Research and development
SAP	Brand name (Systeme, Anwendungen, Produkte)
SVM 3000	Product name at Anton Paar GmbH (Stabinger Viscometer 3000)
SWOT	Strengths, Weaknesses, Opportunities, and Threats