

CARO Market Analysis



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1. Executive summary

This report is published as a part of the CAROTS (Commercial Analytical Research Organisations Transnational Strategy) project, which is financed by Interreg Baltic Sea Region - European Regional Development Fund.

The overall objective of the CAROTS project is regional development. It aims to boost innovation and encourage entrepreneurship in the Baltic Sea Region, strengthen its competitiveness and co-operations between the countries bordering the Baltic Sea and thus reduce brain drain in the region. The CAROTS project has chosen materials research to be the tool of its operation. Strong industry catalyses economic growth and materials research is an essential backbone for innovation and wise production solutions. The CAROTS project's specific objective is to enhance the market uptake of innovation based on the improved capacity of research and innovation infrastructures and their users.

The CAROTS project aims to establish a new type of materials service provider in the Baltic Sea Region: Commercial Analytical Research Organisations (CAROs). According to the definition, a CARO is a profit-seeking organisation acting as an intermediary between research infrastructures and industrial customers, providing support, consultation, analytical research and measurement services in the field of new materials/material sciences (including engineering), Life Science/BioTech, NanoTech and CleanTech on a contractual basis. CAROs have to be private companies and for-profit.

The purpose of this report is to analyse the nature of CAROs in Europe. In the first part of this report, existing CAROs are identified, and then financial and other data of existing CAROs is provided and analysed.

During the data collection, only 45 European "Core" CAROs in fourteen different countries were identified. Therefore, they represent a negligible proportion of all European companies. Most of the "Core" CARO companies are not limited to one service though offer a wide range of different services including consultancy, testing, analysis, equipment, and other services. The category "Other services" included for example training, seminars, and software. The "Core" CARO companies are international by nature and most of them operate in international markets.

Analysis of the "Core" CAROs on the productivity and profitability axes revealed that in 2018, one of them could be classified as an unprofitable company with low productivity. On the other hand, approximately one third of the "Core" CARO companies are in spite of low productivity still profitable. In 2018, almost half of the analysed "Core" CARO companies had good productivity and they were profitable.

In the second part of this report, potential CARO markets are assessed by investigating materials research usage and needs in various industrial sectors, with a particular focus on the medical sector, and by giving an estimate on the future need of materials research.

The importance of materials research has been recognised as a crucial part of important research issues in several industries, such as the pharmaceutical industry. The pharmaceutical industry has outsourced a considerable amount of its research. Contract

research organizations (CRO) specialised in drug development are operating worldwide to support drug development during the various phases of drug discovery, from the very beginning to the final product on the market. The results have been remarkable and in the second half of the 20th century, rapid progress has been made in developing powerful new medicines. However, in traditional industrial fields, the services have not been organised and easily available to a similar extent as in the pharmaceutical industry.

New clean energy technologies, biobased materials, recycled materials and quality products represent future trends in the manufacturing industry sector. New materials play a key difference in our future: the modern society is extremely technical and consumes an increasing amount of natural resources, and unfortunately produces many types of waste and waste effluents. Materials research provides methods to help in tackling the biggest global challenges of the 21st century; climate change, increasing CO₂ emissions, depleting energy resources, sustainability, pollution, labour change by automatisisation and robotics, global health, and food and water security. New materials research services can create value and solutions for industries and the society in general by solving local and global challenges through research.

The importance of networking is common to all CAROs irrespective of their specialisation. Networking can help CAROs in various regards: leveraging synergies with partner organisations, generating leads and receiving new business opportunities, gaining visibility on the market, building credibility among potential customers, and accessing complementing expertise. As one of the main ways to support the growth and societal impact of the CARO industry would be to develop and market networking activities to the industry stakeholders.

The SWOT analysis conducted in this report indicates that the CARO business reflects in many ways characteristics similar to business activity related to the provision of other types of expert services. Demand-related uncertainties represent some of the most central challenges of CAROs. CARO services are not yet known well among potential customers. In addition, potential customer organisations may operate similar functions in-house, or their strategies or procedures do not support the outsourcing of such services. Therefore, it would be a recommendable course of action for CAROs to strive to increase general awareness about them on the market by increasing their focus on marketing and networking activities.

2. Introduction

This report is published as a part of the CAROTS (Commercial Analytical Research Organisations Transnational Strategy) project, which is financed by Interreg Baltic Sea Region - European Regional Development Fund. CAROTS aims to establish a new type of private or public-private companies in the Baltic Sea Region, namely Commercial Analytical Research Organisations (CAROs). CAROs, as intermediary bodies between industry and academia, provide enterprises quick, yet complete assistance in analytical research in areas such as New Materials, NanoTech and Life Sciences, thus significantly expediting innovation in analytical research.

The need for CAROs has been identified during the previous projects of CAROTS project partners. Materials research is an essential background for the innovation, production and growth of all manufacturing industries. Companies recognize the need, but in many cases finding the solution has proven to be difficult. The methods of materials research are wide. In the manufacturing companies, the knowledge of suitable methods of research may be incomplete and the knowledge of finding the places for research is even more scant. The need for assistance is obvious.

CAROs are experts on materials research operating as an intermediary between manufacturing companies and commercial research providers. They are not just analysis laboratories, but they offer complete service by operating as interpreters in between manufacturers and researchers. In an optimal scenario, they 1) provide consultation in order to define the required research goals and methods, 2) develop concepts for experiments 3) get the actual measurements done and 4) conclude with an interpretation of the results.

The aim of this report is to provide the necessary information for the CAROTS project in terms of collecting, analysing and providing market and financial data about existing CAROs. At the end, the data will contribute to the development of a transferable business model of CAROs. It will also provide recommendations for policy makers.

In the first part of this report, financial and other data of existing CAROs is provided and analysed. Two datasets containing company information of CAROs were created by conducting data searches in the Orbis Europe database and on the Internet. The first, wider, dataset contained information on materials research support organisations operating on all the selected branches (New Materials/Material Sciences [including Engineering], Life Science/BioTech, NanoTech and CleanTech) and many firms operating in/for the medical industry. In addition, some non-profit organisations and analysis laboratories were included. In the second stage, an addition to the definition for CAROs was made to clarify that CAROs have to be private companies and for-profit. In this stage, CAROs operating only for medical development were also excluded. Furthermore, analysis laboratories with only minimum resources or interest in supporting activities were excluded as well. The analyses were conducted in terms of a main group of companies that fully fulfilled the conditions of the CARO definition, and another separate group of companies that fulfilled the conditions to a great extent, but not fully (see chapter 3.2. for details).

In the second part of this report, a trend analysis of materials research is provided. The needs are presented by providing showcases of the need of materials research in the fields of

geology, bioeconomy, food industry, shipbuilding, and health and wellbeing. Then, trends in the development of medicines and medical instruments are discussed shortly, and at the end of this part of the report, the future needs of materials research in different industrial fields are presented.

The third part of this report presents a SWOT analysis conducted to assess the strengths, weaknesses, opportunities and threats of European CAROs. The results of the SWOT analysis are primarily based on thematic interviews conducted in the countries participating in the CAROTS project. In the fourth part, we proceed to discuss the potential benefits of networking for European CAROs. The final chapter presents briefly the main conclusions of the report.

3. Data and methods

3.1 Definitions of CARO companies

At the outset of the CAROTS project, project partners collaborated to develop a definition of CARO. According to the definition, a CARO is a profit-seeking organisation acting as an intermediary between research infrastructures and industrial customers, providing support, consultation, analytical research and measurement services in the field of New Materials/ Material Sciences (including Engineering), Life Science/BioTech, NanoTech and CleanTech on a contractual basis. CAROs have to be private companies and for-profit. According to the EU definition used for the research infrastructures action within the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-13), “Research infrastructure” means facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields and covers major scientific equipment or sets of instruments; knowledge based resources such as collections, archives or structures for scientific information; enabling Information and Communications Technology-based infrastructures such as Grid, computing, software and communication, or any other entity of a unique nature essential to achieve excellence in research. Such infrastructures may be “single-sited” or “distributed” (an organised network of resources).

3.2 Period of analysis, collection of data and measuring techniques

The unit of analysis used to identify CARO companies is the company – a business organisation consisting of one or more establishments that are under common ownership or control. Throughout this report, the figures and statistics used are those reported at the company, not the establishment level.

In the first phase of the identification of CAROs, the research team made data searches in the Orbis Europe database and on the Internet, implementing the definition of CAROs that was presented in the kick-off meeting of the project. According to the original definition,

CARO is a profit-seeking organisation acting as an intermediary between research infrastructures and industrial customers, providing support, consultation, analytical research and measurement services in the field of new materials/ material sciences (including engineering), Life Science/BioTech, NanoTech and CleanTech on a contractual basis.

Once the first dataset of company information of CAROs had been acquired, it became apparent that the original definition of CAROs used in the first phase of the data collection needed a sharper focus in order to purposefully represent the CARO companies in a way that was envisaged in the work plan of the project.

Challenges with the original definition of CARO verified a need for a refined definition, which would emphasize that companies to be selected to the group of CAROs had to be private

companies and for-profit. A private company is a business company owned either by non-governmental organizations or by a relatively small number of shareholders or company members, which does not offer or trade its company stock (shares) to the general public on stock market exchanges, but rather the company's stock is offered, owned and traded or exchanged privately, or over-the-counter. Therefore, in order to ensure that results are more accurate, the research team used the revised definition in the second identification round, based on the dataset collected during the first stage. After that, a crucial part of the study was done manually, for example by visiting the websites of the companies and receiving additional data from the project partners. All companies that fulfilled the new revised definition were included in the main dataset of CAROs, which we call "Core" CAROs. The group of "Core" CAROs consists of 47 companies. Two of the identified CAROs were non-European companies based in the United States, and were thus excluded from the financial analysis. The companies that fulfilled most of the criteria of the CARO definition, but not all, were included in another group of companies, which we call "Secondary" CAROs. The group of "Secondary" CAROs consists of 93 companies and other entities. "Secondary" CAROs are companies or other entities that fulfil most conditions of the definition of a CARO company. However, they are not necessarily private companies and they can be non-profit companies, or other types of non-profit organisations. The CARO identification and analysis process is described in Figure 1.

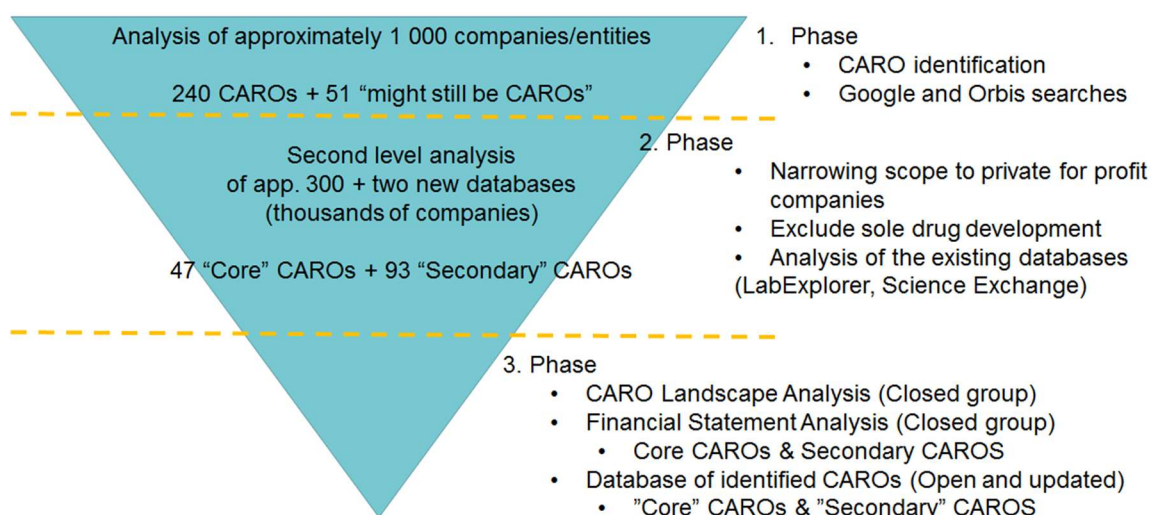


Figure 1. The CARO identification and analysis process

After the identification of CAROs, a financial statement analysis of the data set was done for both of the groups. Financial statement analysis is defined as the process of identifying financial strengths and weaknesses of the firm by properly establishing a relationship between the items of the balance sheet and the profit and loss account. Financial statement ratio analysis provides a broader basis for comparison than raw numbers do. However, ratios on their own, without year-to-year or other industry/firm comparative ratios, the financial analysis is first and foremost based on financial figures for the year 2018. Time series analyses cover the years 2010-2018. The Bureau Van Dijk Orbis Europe database¹ was used as the main

¹ <https://www.bvdinfo.com/en-gb/our-products/data/international/orbis>

source of financial information. The Orbis database includes the economic information of approximately 112 million European companies.

3.3 Research questions

The purpose of this report is to analyse the nature of CAROs in Europe.

- How many CAROs are there in Europe?
- How old are CAROs?
- What size are CAROs (in employment terms)?
- In what countries are CAROs located?
- What is the financial condition and development of CAROs?
- For what are CAROs needed?
- What do CAROs do?
- Why do CAROs work on materials research?
- Why are CAROs needed in the medical sector and what do they do there?
- What are the future trends in the medical sector?
- What is the future need for CAROs?

4. European CARO companies

4.1 European CARO landscape

This chapter of the report looks at some of the characteristics of CARO companies, such as age, size, geographical location, ownership, industry, and business cluster. Findings related to variables mentioned above are presented first. The second part of this section concentrates issues related to financial performance and development of CARO companies.

Out of the 47 analysed “Core” CARO companies, 45 were European. The European Core CAROs are presented on the map in Figure 2. More than one fourth (29%) of the identified “Core” CAROs were German. Somewhat over one tenth were located in either France (13%), United Kingdom (11%) or Poland (11%) (Fig 3). According to Eurostat data published in January 2020, in 2017, the EU’s business economy was made up of almost 27.5 million active enterprises with more than 150 million persons employed. The business economy covers sections B to N of the Statistical classification of economic activities in the European Community (NACE)², excluding activities of holding companies. Therefore, the identified 43 “Core” and 91 “Secondary” CARO companies in the EU area represent a negligible proportion of the total European Union business.

² The Statistical classification of economic activities in the European Community, abbreviated as NACE, is the classification of economic activities in the European Union (EU); the term NACE is derived from the French *Nomenclature statistique des activités économiques dans la Communauté européenne*. Various NACE versions have been developed since 1970. NACE is a four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) and in other statistical domains developed within the European statistical system (ESS). *NACE Rev. 2*, a revised classification, was adopted at the end of 2006 and, in 2007, its implementation began. The first reference year for NACE Rev. 2 compatible statistics is 2008, after which NACE Rev. 2 will be consistently applied to all relevant statistical domains.



Figure 2. Map of the European Core CAROs

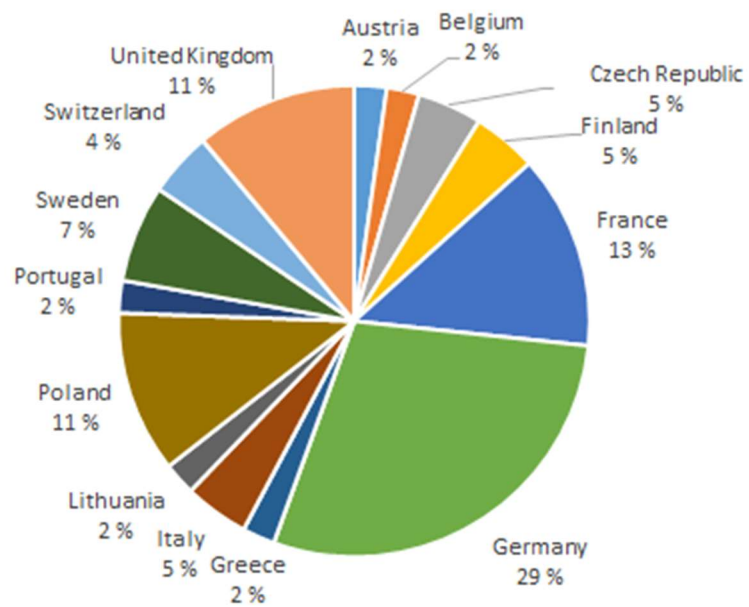


Figure 3. Distribution of identified European "Core" CAROS by country, n = 45

Out of the 93 analysed “Secondary” CARO companies all 93 were European (Fig. 4). Approximately one-fifth (18%) of the identified CAROs were located in the United Kingdom. One in six (16%) of the “Secondary” CAROs was German and one in seven (14%) was Finnish. Approximately one in eight (12%) companies was Dutch.

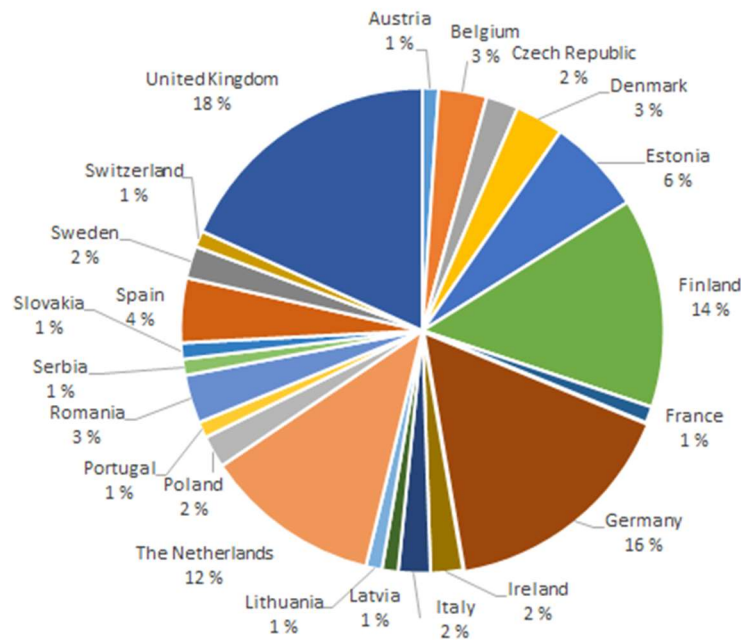


Figure 4. Distribution of identified European Secondary CAROS by country, n = 93

Table 1. Distribution of identified Core and Secondary CAROS by country, n = 47/93

	CARO Core		CARO Secondary		Total	
Austria	1	2 %	1	1 %	2	1 %
Belgium	1	2 %	3	3 %	4	3 %
Czech Republic	2	4 %	2	2 %	4	3 %
Denmark	0	0 %	3	3 %	3	2 %
Estonia	0	0 %	6	6 %	6	4 %
Finland	2	4 %	13	14 %	15	11 %
France	6	13 %	1	1 %	7	5 %
Germany	13	28 %	15	16 %	28	20 %
Greece	1	2 %	0	0 %	1	1 %
Ireland	0	0 %	2	2 %	2	1 %
Italy	2	4 %	2	2 %	4	3 %
Latvia	0	0 %	1	1 %	1	1 %
Lithuania	1	2 %	1	1 %	2	1 %
The Netherlands	0	0 %	11	12 %	11	8 %
Poland	5	11 %	2	2 %	7	5 %
Portugal	1	2 %	1	1 %	2	1 %
Romania	0	0 %	3	3 %	3	2 %
Serbia	0	0 %	1	1 %	1	1 %
Slovakia	0	0 %	1	1 %	1	1 %
Spain	0	0 %	4	4 %	4	3 %
Sweden	3	3 %	2	2 %	5	4 %
Switzerland	2	4 %	1	1 %	3	2 %
United Kingdom	5	11 %	17	18 %	22	16 %
USA	2	4 %	0	0 %	2	1 %
Total	47	100 %	93	100 %	140	100 %

Our study analysis revealed that the average age of Core CARO companies in late 2019 was 19 years, while the median was 14 (Fig 5). The companies identified were therefore not as new as expected at the start of the research project. However, approximately one in ten (9%) of the “Core” CARO companies were at most five years old and more than one third (39%) were at most ten years old. The “Secondary” CARO companies are on average somewhat older than the “Core” CAROs. The average age of “Secondary” CARO companies was 22 years, while the median was 19. Seven percent of the “Secondary” CARO companies were at most five years old and approximately one out of (21%) were at most ten years old.

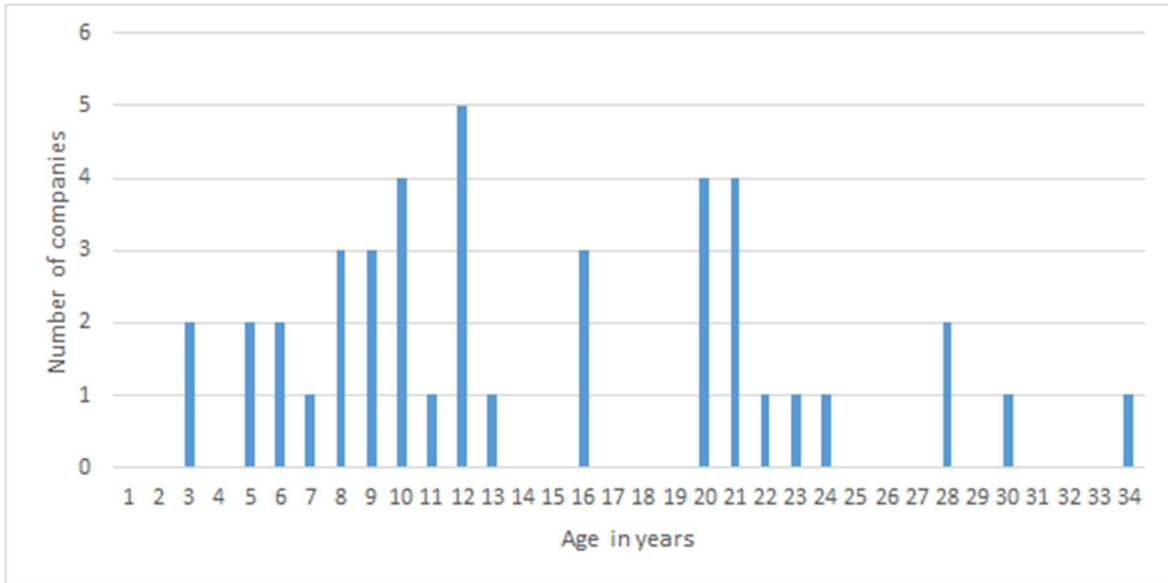


Figure 5. The age distribution of “Core” CAROs, n = 45

In our analysis, we divided the CARO services in five different categories: consultancy, testing, analysis, equipment, and other services (Fig. 6). Category “Other services” included for example training, seminars, and software. Almost all (94%) “Core” CAROs offer consultancy services. Nine out of ten “Core” CAROs also offered testing (87%) and analysis (85%) services.

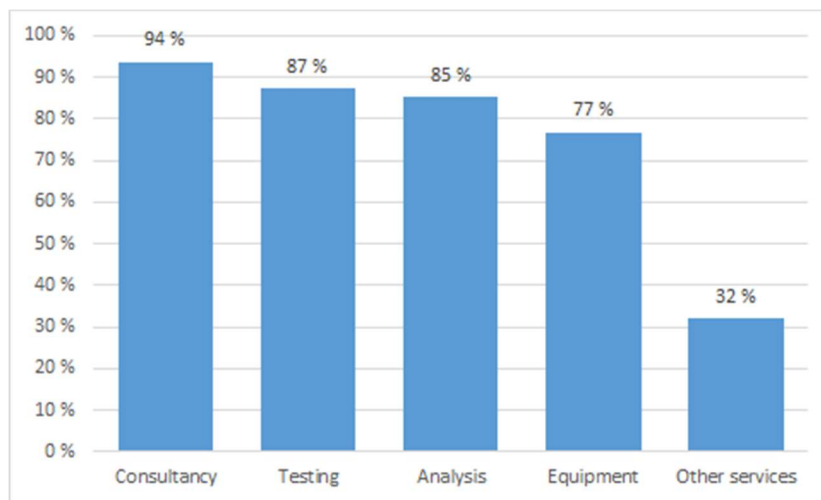


Figure 6. CARO services provided by the “Core” CAROs (%), n = 47

Most of the “Core” CARO companies offer a wide range of different CARO services (Fig 7). Three quarters (75%) of the “Core” CAROs provide services in at least four above mentioned service categories. Nine out of ten (87%) “Core” CAROs provide services in at least three different service categories. Approximately 10% of the “Core” CAROs provide services in only one service category.

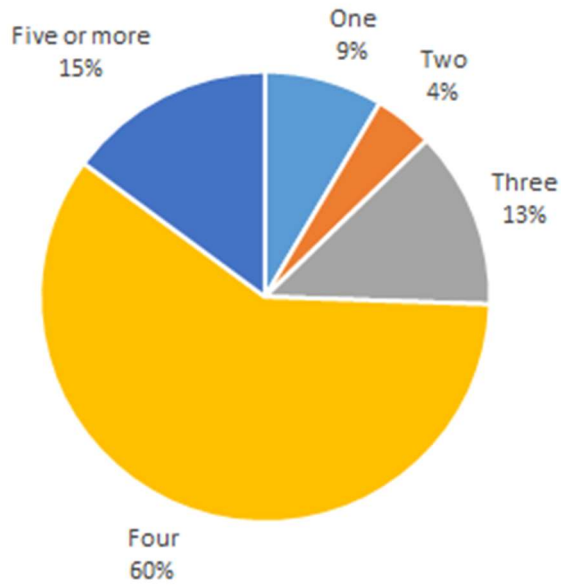


Figure 7. Distribution of “Core” CAROs by number of CARO services, n = 47

Nine out of ten analysed “Core” CARO companies operate in international markets (Fig. 8). Less than one-tenth (6%) of the “Core” CAROs are operating only at a national level. More than four fifths (83%) of the companies analysed are active in all three markets (international, national and regional). Approximately one-tenth (11%) operate on two markets and only 6 percent of the “Core” CAROs have a single target market scope.

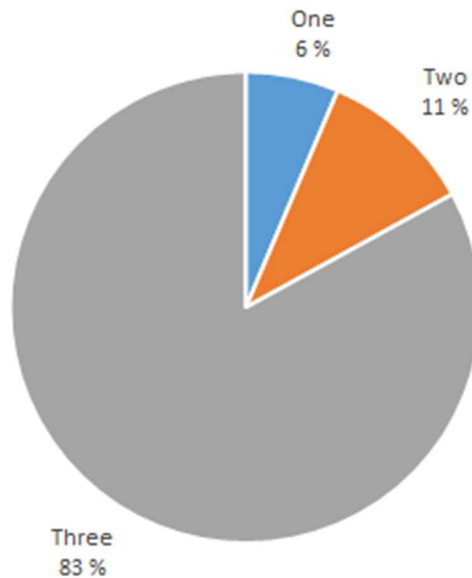


Figure 8. Distribution of “Core” CAROs by number of market served, n = 47

Small and medium-sized enterprises (SMEs) are often referred to as the backbone of the European economy, providing a potential source for jobs and economic growth. SMEs are defined by the European Commission as having less than 250 persons employed. They should also have an annual turnover of up to EUR 50 million, or a balance sheet total of no more than EUR 43 million (Commission Recommendation of May 6, 2003). Eurostat size classes of enterprises are presented in Table 2. These definitions are important when assessing which enterprises may benefit from EU funding programmes aimed at promoting SMEs, as well as in relation to certain policies such as SME-specific competition rules.

Table 2. Eurostat size-classes of enterprises (Source: Eurostat Annual Structural Business Statistics)

Size-class	Number of employees	Turnover	Total balance-sheet
Micro enterprises	Less than 10 persons	and/or ≤ 2 M€	or ≤ 2 M€
Small enterprises	10-49 persons	and/or ≤ 10 M€	or ≤ 10 M€
Medium-sized enterprises	50-249 persons	and/or ≤ 50 M€	or ≤ 43 M€
Large enterprises	250 or more persons	and/or > 50 M€	or > 43 M€

Distribution of now identified European “Core” CAROs by number of employees is presented in Figure 9. Two-thirds (69%) of the identified “Core” CARO companies are SMEs. Somewhat over one quarter of the “Core” CAROs are micro enterprises (29%) or small enterprises (27%). One out of ten (9%) “Core” CAROs can be categorized as large enterprises with more than 250 employees.

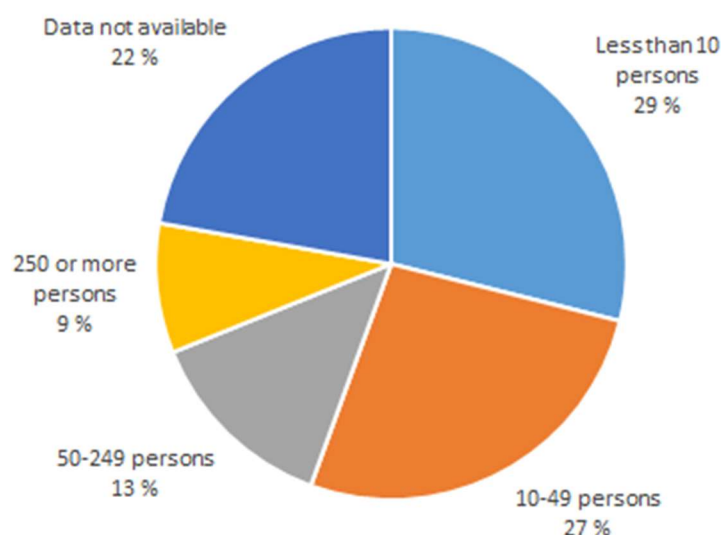


Figure 9. Distribution of identified European “Core” CAROs by number of employees³, n = 45

³ When data from 2018 has not been available, we have used data from 2017.

4.2 Financial statement analysis of European CAROs

Financial statement analysis is defined as the process of identifying the financial strengths and weaknesses of the firm by properly establishing the relationship between the items of the balance sheet and the profit and loss account. On average, the various financial figures and ratios that were assessed were available from approximately twenty "Core" CARO companies and approximately thirty "Secondary" CARO companies yearly. However, availability of data varies significantly between different countries.

Financial statement ratio analysis provides a broader basis for comparison than raw numbers. However, ratios on their own, without year-to-year or other industry or firm comparative ratios are of little use in judging the health or future of the industry or firm being analysed. Various methods and techniques are in use to analyse financial statements, such as comparative statements, schedule of changes in the working capital, common size percentages, funds analysis, trend analysis and ratios analysis.

In this study, the objectives of the financial statement analysis were to:

- provide a picture of the company's profitability and financial status that was as real and accurate as possible,
- make it possible to compare different financial years, and
- make it possible to compare different companies with each other.

Ratio analysis is a time-tested important technique of financial analysis used to conduct a quantitative analysis of the information in a company's financial statements. Ratio simply means one number expressed in terms of another, and the term "accounting ratios" is used to describe significant relationships between figures shown on a balance sheet, as compared with a profit and loss account, a budgetary control system or any other part of the accounting organization, for example. Ratio analysis is nevertheless incomplete because it relies on only the information reported in the financial statements. Non-financial changes, for example, though important for the company, are not listed in financial statements.

Our research team measured several dimensions of the financial performance of CAROs. These dimensions included:

- The extent of operations
- Profitability
- Solidity/solvency
- Productivity

Key figures or ratios used in this report can be divided into four main categories.

- Profitability ratios measure the results of business operations or overall performance and effectiveness of the company.

- Activity ratios are calculated to measure the efficiency with which the resources of a firm have been employed. These ratios are also called turnover ratios because they indicate the speed with which assets are being turned over into sales.
- Leverage ratios or long-term solvency ratios convey a firm's ability to meet the interest costs and payment schedules of its long-term obligations.
- Productivity ratios give information about the effectiveness and efficiency of personnel and capital use.

There are limitations to a study of this kind. The analysis employed in this report is quantitative and based primarily on key financial figures deriving from the financial statements of the companies. Therefore, it only answers questions related to “what”, “where”, and “how many”. While an analysis of this kind is useful, it is by no means exhaustive. Knowing where CAROs are located, how many exist, and the degree to which they contribute to job creation is helpful to many audiences, including policymakers, industry leaders, academics and researchers, media organizations, and even the CAROs themselves. However, quantitative analysis does not answer other important questions, such as those related to the ‘how’ and ‘why’ of research.

4.2.1 Interpretation of statistical figures

The following key figures are used to describe the development of indicators and cost-structure: average, median, lower quartile and upper quartile (Fig. 10). The interpretation of the figures always depends on the size and quality of the data utilised. The general interpretation of these indicators is presented below.

Average is the sum of a list of numbers divided by the number of items in the list. The weakness of using average as an indicator is its sensitivity to exceptionally large or small observation values. Likewise, if the dataset is small, the average becomes more sensitive.

Median is based on placing the indicators in their order of magnitude. It is the number separating the higher half of the data from the lower half. The median of a finite list of numbers is found by arranging them from lowest to highest. The number in the middle of the list is the median. If there is an even number of observations, the median is usually defined as the mean of the two middle values. Researchers agree that the median is a better indicator of the average value of the indicators.

Upper quartile, or the 75th percentile, splits off the highest 25 percent of the data from the lowest 75 percent.

Lower quartile, or the 25th percentile, splits off the lowest 25 percent of data from the highest 75 percent.

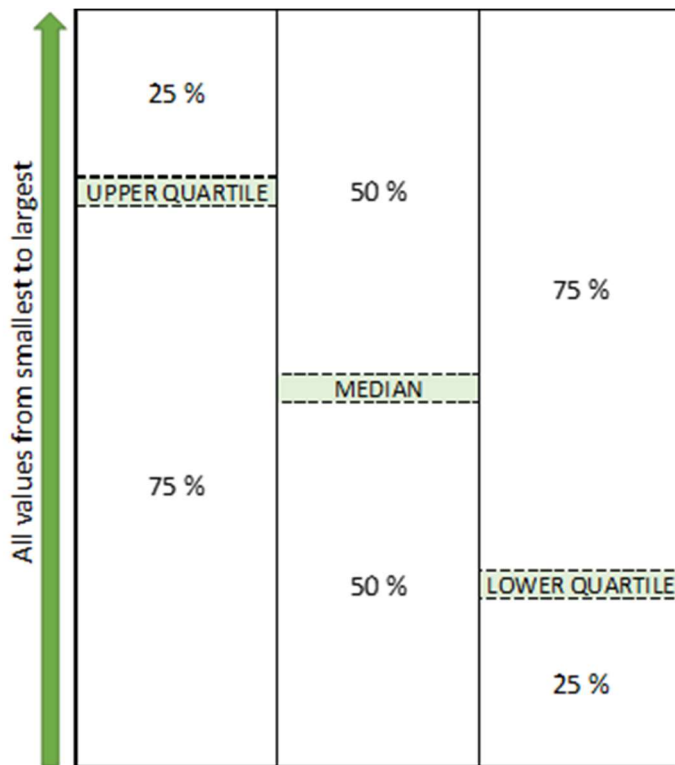


Figure 10. Quantiles employed in the report

4.2.2 Interpretation of financial statements analysis indicators

4.2.2.1 Scale of operations

In this study, the number of employees and turnover are used as indicators of size and development among European CAROs. Turnover enables a comparison of the volume of business activities, but comparability varies, even on a company level, due to the different structures of the companies. In assessing the development of turnover, one must also take into account the effect of inflation.

The number of employees indicates the size of the company, in this case two half-time employees equal one full-time employee (FTE), for example. Comparison between companies is difficult because companies can also purchase personnel as an external service. Likewise, average personnel figures are not always comparable, and may include laid-off staff. Companies have varying methods of calculating part-time and temporary staff.

4.2.2.2 Profitability

EBITDA (%), or Earnings Before Interest, Taxes, Depreciation and Amortization, measures a company's operational productivity – revenue minus expenses. It shows how profitable a company is before taxes, interest expenses on debt and depreciation costs have been deducted. In other words, it indicates how efficiently a business is using its materials and labour in the production process. A company's EBITDA level depends largely on its line of business and capital structure. In assessing EBITDA accuracy, one must take into account

the magnitude of the company's financing costs, the depreciation of its fixed assets requirements and its profit distribution target.

Net profit margin (%), also referred to as the bottom line, net income or net earnings is a measure of the profitability of a venture after accounting for all costs. A company's cumulative net result should be positive for it to be considered profitable. Positive net result indicates that the company has been able to cope with interest rates from its regular business operations, as well as managing working capital loans and investment co-financing. The adequacy of net income and the required minimum level is mainly determined by the company's profit distribution objectives. As a rule, net profit margin is better suited for comparing companies operating in different sectors than EBITDA.

Return on investment (%) measures how effectively the firm uses its capital to generate profit – the higher the ROI, the better. The level of interest the company must pay for outside financing has been regarded as the minimum ROI level. Equity and loan capital should receive a minimum return, in line with the prevailing money market interest rates. However, equity investors usually require a higher return on risk to their investments in equity than secured interest-bearing loan capital financiers do. Therefore, if the company's profitability is good, the ROI level should rise significantly above the interest rates. ROI is a suitable measure for comparison between different business sectors. The indicative norm values for ROI are:

Excellent	Good	Satisfactory	Poor	Weak
> 15 %	10 to 15 %	6 to 10 %	3 to 6 %	< 3 %

4.2.2.3 Productivity

Value added per personnel costs measures “real productivity”, in other words how much value added the company has produced per euro of personnel cost. If the value of the indicator is 1, all the value added created in the company is used for covering personnel expenses. The higher the value of the indicator gets, the higher the productivity of labour. This indicator can also be useful when you want to draw conclusions about the company's labour-intensity. The ratio varies by industry.

4.2.2.4 Solidity/solvency

Equity ratio (%) measures a company's capital and reserves/equity, as divided by total assets. The equity ratio measures a company's solidity, ability to tolerate losses and ability to manage long-term liabilities, as the company's asset levels constitute a buffer against any losses. If the capital buffers fall too low, then even one bad year could knock the company down.

If a company's profitability is reasonable and stable, but it records high losses, it is considered to have low self-sufficiency. Low equity ratios contain a large risk when profitability is reduced. For this reason, companies should maintain a sufficiently large safety buffer against potential bad years. A high equity ratio also gives a company significantly greater freedom of movement because its dependence on economic cycles and other changes in the operating environment is less pronounced.

Companies whose solvency ratios are lower than their competitors are usually the first to encounter difficulties in a recession. The equity ratio is usually dependent on the age of the company. Young companies are often more indebted than their more established counterparts. The indicative norm values for equity ratio (%) are:

Excellent	Good	Satisfactory	Poor	Weak
> 50 %	35 to 50 %	25 to 35 %	15 to 25 %	< 15 %

4.2.2.5 Liquidity

Liquidity refers to the ability of a company to meet its payment obligations on time and in the most affordable way. For example, if the company cannot pay salaries or purchases, it may due to their poor liquidity become insolvent. Liquidity can be to measure both static balance sheets and dynamic cash flow based indicators. Dynamic liquidity measures the adequacy of income financing to meet payment obligations. The static perspective indicates the situation at the balance sheet date. In this paper, we have measured companies' static liquidity and quick ratio is used as an indicator of it. It measures a company's ability to survive with its short-term assets that can be rapidly turned into cash. Indicative norm values for quick ratio are:

Excellent	Good	Satisfactory	Poor	Weak
>1.5	1–1.5	0.5–1	0.3–0.5	< 0.3.

4.2.3 Financial performance of “Core” CAROs in Europe

The number of employees measures the amount of people involved in the company's operations. Employment statistics are an important indicator of an industry's development as well as its overall contribution to a country's employment. This indicator should preferably be counted as the number of full-time equivalent employees; however, this number is rarely available from statistical sources.

In our figures (Fig. 11), the number of employees includes all temporarily employed and part-time employed persons in full-time units converted into full-time employees for each given year. In the past years, the median number of employees in “Core” CAROs has varied between 7 (2014) and 14 (2017). Although the majority of the analysed “Core” CARO companies are either micro or small enterprises there are also few medium-sized and large enterprises. In comparison, the median number of employees of the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=16377) was 2 in 2018.

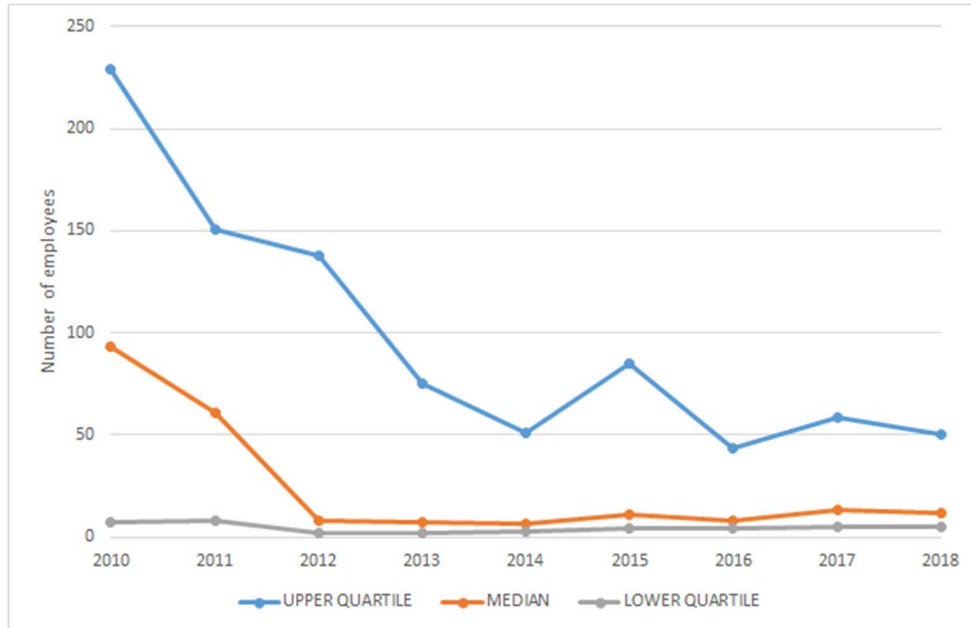


Figure 11. Number of employees in “Core” CAROs in 2010-2018 (n=10-34)

The “Core” CARO turnover in 2010–2018 is presented in Figure 12. The median turnover of European “Core” CAROs has in the past few years shown a somewhat increasing trend until 2017, when it was approximately 1.6 million euro. For 2018, it declined to approximately 1.1 million euro. As can be seen in the median majority of the analysed “Core” CAROs had a relatively small turnover. However, in 2018 the turnover of companies ranged from less than one hundred thousand euros to more than 100 million euros. In comparison, the median turnover of the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=14 231) was 119 thousand EUR in 2018.

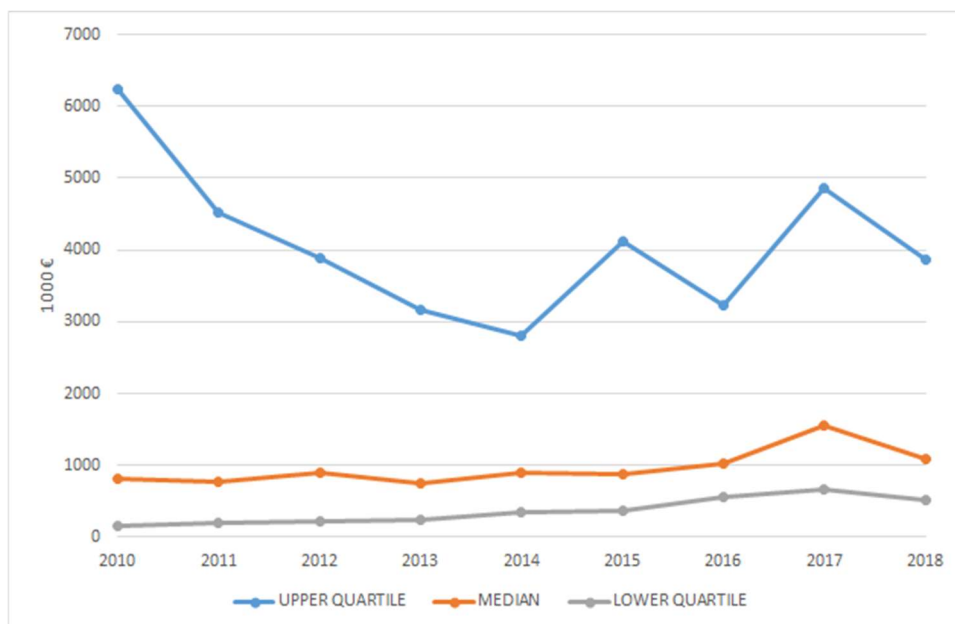


Figure 12. “Core” CARO turnover in 2010-2018 (n=13-22)

The EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) margin (or operating margin) indicator measures profit after operational costs (goods, services and personnel), as a percentage of turnover. The need for operating profit depends to a great extent on the investment intensity of the industry at large.

The CARO “Core” median EBITDA margin has been on the increase since 2012 when it was 8.5%, to 16.3% in 2018 (Fig. 13). In comparison, the median EBITDA margin of the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=10654) was 13% in 2018.

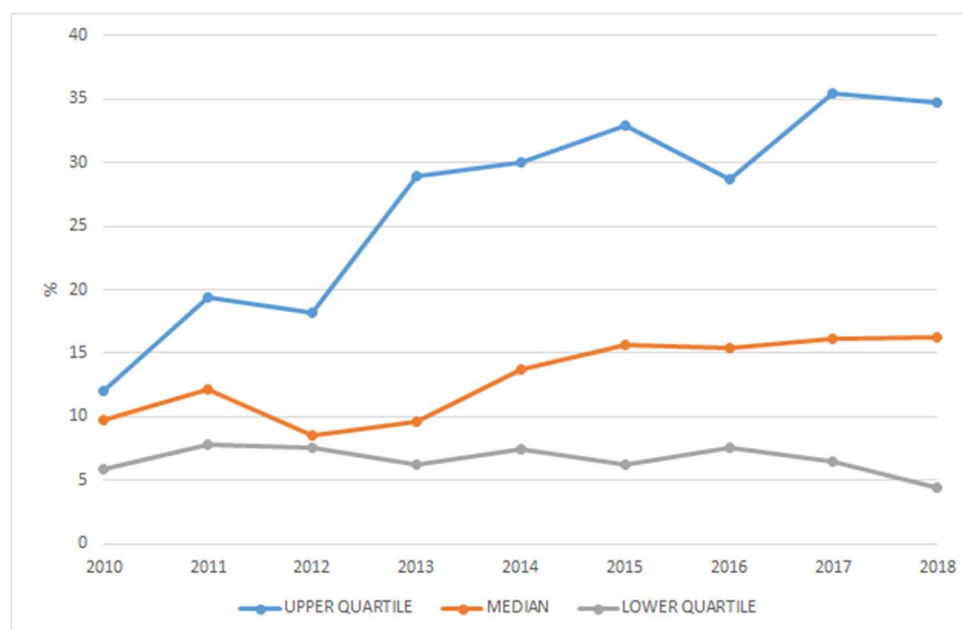


Figure 13. EBITDA (%) of “Core” CAROs in 2010-2018 (n=11-18)

Net result, also known as net income before extraordinary items, is the profit after all regular revenue and costs are taken into account. In practice, net result is calculated from the financial result by deducting depreciation. Net result also assists to estimate the ability of the company to create wealth for investments, to return capital to the owners as dividends and to make the most of borrowed capital. A company’s cumulative net result should be positive for it to be considered profitable.

The median net result margin (how many percent net result is of the turnover) of “Core” CAROs has displayed some volatility in the past couple of years, having been varying between 5.4% (2012) and 12.8% (2016), ending up at 9.5% in 2018 (Fig. 14). However, almost one out of five (17%) of “Core” CARO companies were unprofitable in 2018. On the other hand, one quarter (27%) of the “Core” CAROs had net profit margin above twenty percent in 2018. In comparison, the median net result of the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=13972) was 7% in 2018.

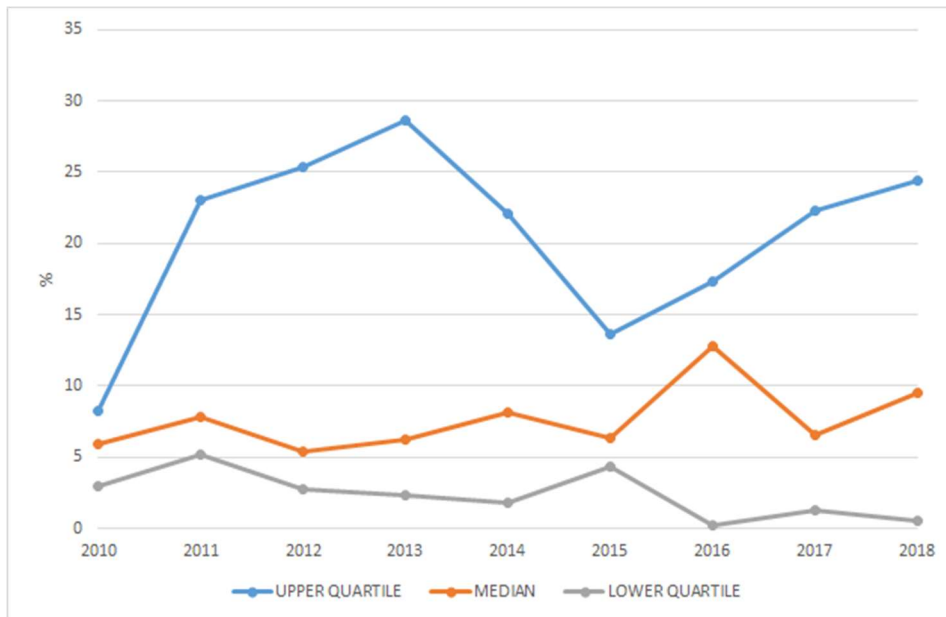


Figure 14. Net result (%) of “Core” CAROs in 2010-2018 (n=13-22)

Return on investment (ROI) measures the relative profitability of an enterprise, or the profit generated on the capital invested in the company, with an aim to gain interest or another type of profit. ROI is calculated by dividing net profit and financial expenses from capital invested. It should not only at least exceed the cost of the foreign capital, but also, in practice, be clearly higher than the current loan interest to satisfy the profit demand (including risk premium) of capital investors.

Throughout the 2010’s, the median ROI of European “Core” CAROs has been on a good level. In 2010, it was 10.9%, and in 2018, 15.2% (Fig. 15). In comparison, the median ROI of the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=11545) was 9% in 2018.

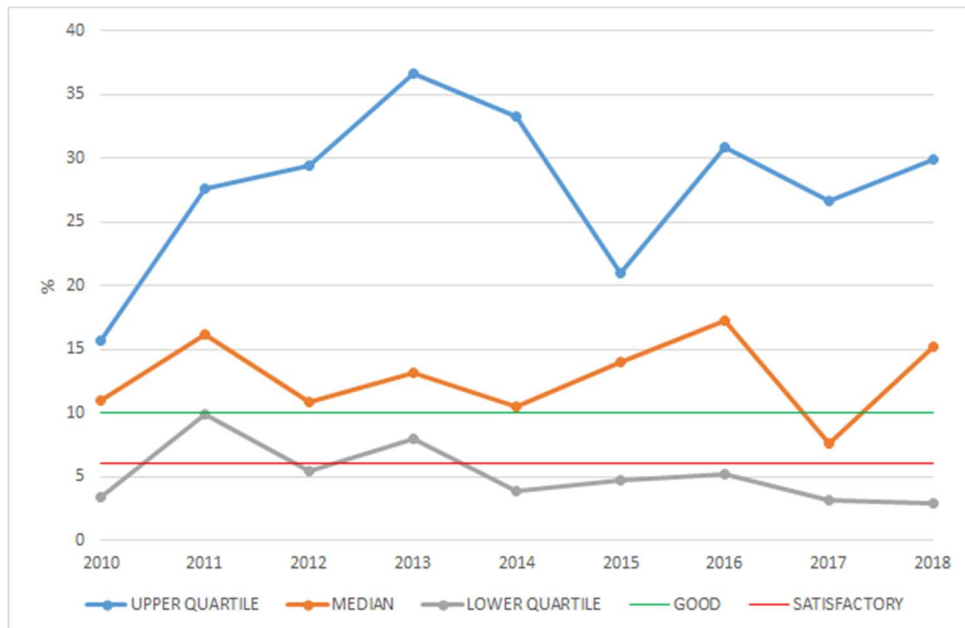


Figure 15. Return on investment in “Core” CAROs in 2010-2018 (n=12-22)

Solvency is the ability of an entity or individual to pay debts. Solvency can also be described as the ability of a corporation to meet its long-term fixed expenses, sustain losses and accomplish long-term expansion and growth. The better a company's solvency, the better shape it is in financially. When a company is insolvent, it can no longer operate and is undergoing bankruptcy. In this report, we use equity ratio to assess the solvency of CAROs.

Equity ratio (%) in “Core” CAROs in 2010 - 2018 is presented in Figure 16. In European “Core” CAROs, the median equity ratios have been on an excellent level during the past three years, rising to 66.6% in 2018. Even earlier in the past decade, the median values have been on a good level. In 2018, approximately one out of eight (13%) of the “Core” CARO companies had poor equity ratio below 25%. In comparison, the median equity ratio in the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=17071) was 56% in 2018, which is very good as well.

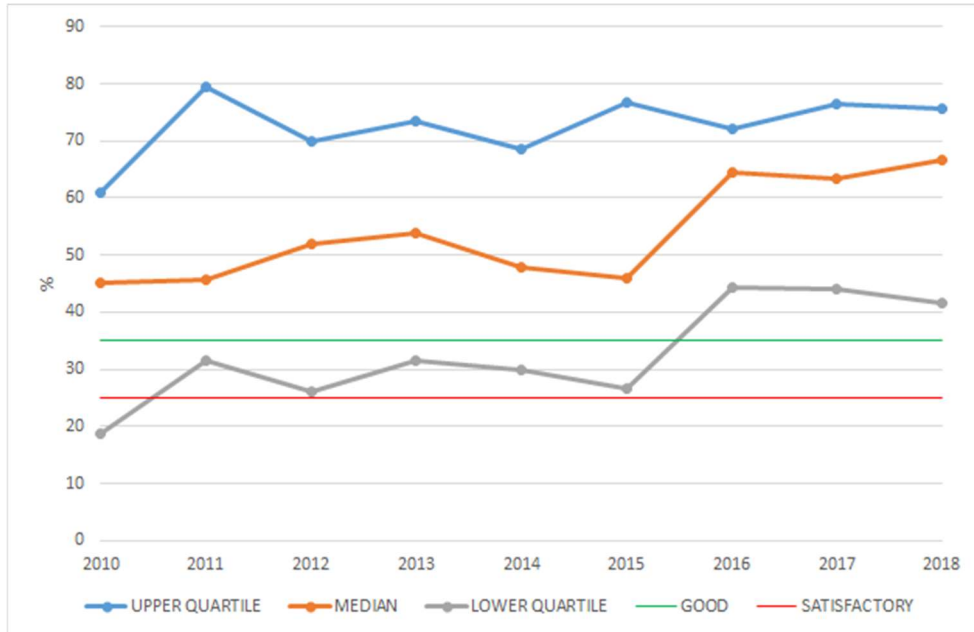


Figure 16. Equity ratio (%) in “Core” CAROs in 2010-2018 (n=20-30)

The liquidity of a company can be assessed through its quick ratio. It describes the ability of a company to pay off its short-term debt with its assets that can be turned into cash quickly. At a quick ratio value of 1, a company can pay off its short-term wholly with its liquid financial assets.

During the past decade, the median quick ratios of the group CARO “Core” have been varying between 1.5 (2011) and 2.4 (2017) (Fig. 17). In 2018, the median value in this group was 2.1. In comparison, the median quick ratio in the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=18056) was 1.8 in 2018.

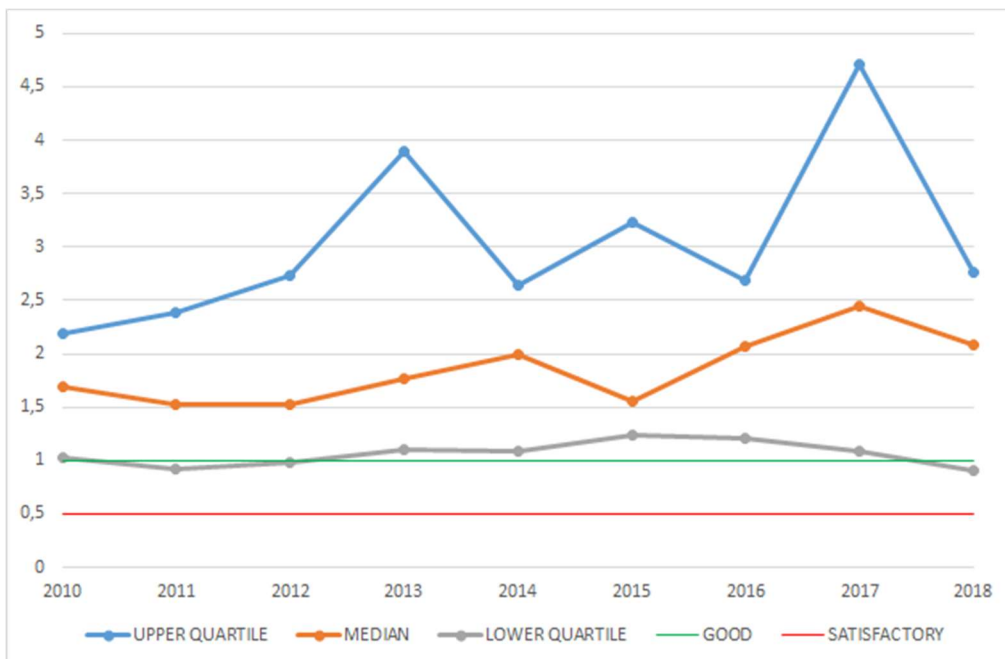


Figure 17. The quick ratio of “Core” CAROs in 2010-2018 (n=21-30)

Value added is a measure of the total annual output of goods and services produced by the residents of a particular country. It is the value of turnover less the value of inputs from other industries. On a single firm level, it refers to the value that is created by the factors of production of that company.⁴ Value added is an important measure, as it has a considerable impact on the ability of an enterprise to pay its workforce and generate profit.

The ratio of value added to personnel costs is an alternative way of looking at the relationship between the costs of the people employed in the industry and the value generated. It is a relative measure, and thus not subject to distortions such as exchange rate variations or inflation. Rather than being a direct measure of productivity, it is a measure of the company's effectiveness in terms of the money spent on employment, regardless of the number of people who are employed. The critical value is 1. If the indicator is below 1, it means the value created does not cover the employment costs, creating an operational loss.

The value added/personnel costs ratio of European “Core” CAROs has during the past decade varied between 1.21 (2012) and 1.39 (2018) (Fig. 18). In 2018, none of the “Core” CARO companies had a value added per personnel costs below zero. Whereas one-third (33%) of “Core” CAROs had a value added per personnel costs above two. In comparison, the median ratio of value added to personnel costs in the European companies (EU28) in NACE (Rev. 2) “7120 - Technical testing and analysis” (n=11674) was 1.28 in 2018.

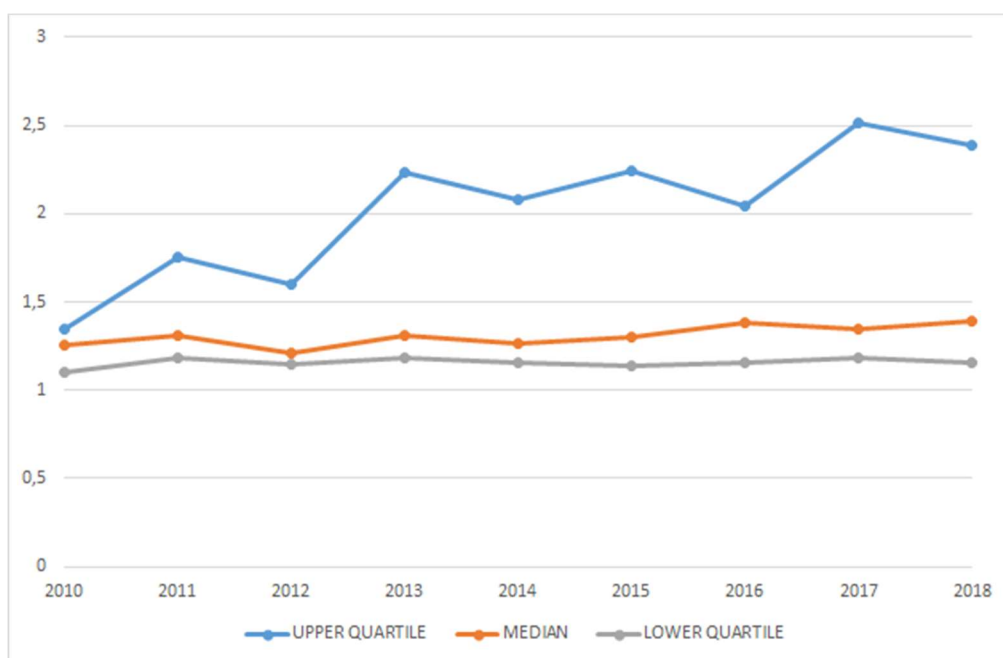


Figure 18. Value added/personal costs in “Core” CAROs in 2010-2018 (n=13-21)

In order to be able to analyse our sample of companies in greater depth we produced a scatter graph (see Figure 19) using 2018 productivity and profitability figures as the axes. The X-axis

⁴ The sum of value added of all industries and households is equal to the Gross Domestic Product (GDP). Therefore, the share of an industry's value added to a country's GDP measures directly that industry's contribution to the national economy.

is drawn at the median value added per personnel costs (in the case of European “Core” CAROs, 1.39 [2018]), and the Y-axis is drawn at the net result percentage of 0. These axes divide companies into four quadrants indicative of their economic conditions: “swamp”, “capital graveyard”, “kindergarten”, and “business class”⁵. In our research, there were 16 European “Core” CAROs with sufficient data for defining their location in the matrix in 2018.

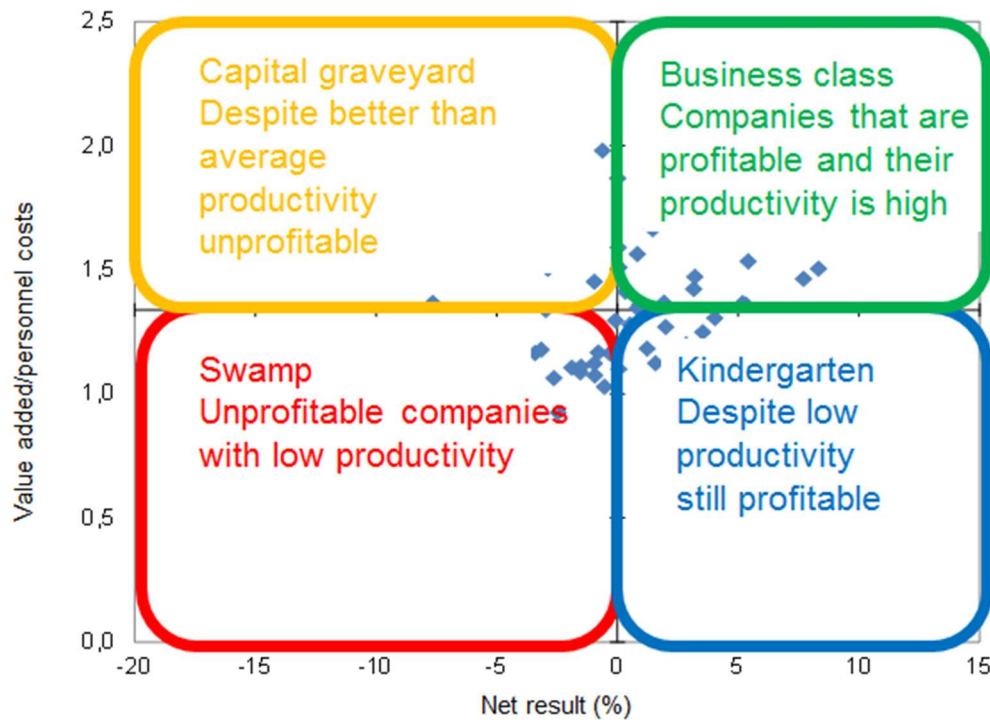


Figure 19. Description of the quadrants in a productivity-profitability matrix (data points are used in this figure for illustrative purposes only)

Unprofitable companies with low productivity are located in the swamp quadrant. Of 16 European “Core” CAROs, 2 (13%) were situated there in 2018. The capital graveyard quadrant contains firms that are unprofitable, despite better than average productivity. One of the “Core” CAROs (6%) fall into that category.

Companies located in the kindergarten quadrant have low productivity, but are still profitable. Six (38%) of the analysed European “Core” CAROs belong to this quadrant. The last quadrant, business class, consists of elite companies of the industry: they are profitable and their productivity is high. Of the “Core” CAROs analysed, 7 (44%) are classified as business class companies based on their 2018 economic figures.

Dividing these companies merely by median productivity and profitability however can be somewhat misleading because doing so ignores the fact that some of the results may be atypical, temporary or single-year results created by specific business decisions or

⁵ Paasio, A., Picard, R. G. & Toivonen, T. E. (1994) Measuring and Engineering Personnel Productivity in Graphic Arts Industry, *Journal of Media Economics*, 7:2, 39-53

uncontrollable national economic conditions. According to Paasio et al⁵ (1994), some companies located in undesirable quadrants may actually be very close to average performance in the industry.

CAROs were also compared in a productivity-profitability matrix (Fig. 20). Comparing the locations of “Core” CAROs in the matrix in 2017 and 2018, 5 were in the business class quadrant also in 2017 and had remained there in 2018. One advanced from capital graveyard to business class and one from kindergarten to business class. One declined from business class to kindergarten, and one from kindergarten to swamp. One moved from the swamp to the capital graveyard. Five CAROs that were in kindergarten in 2017, had remained there in 2018 as well. (Regarding one company, the data was missing for 2017.)

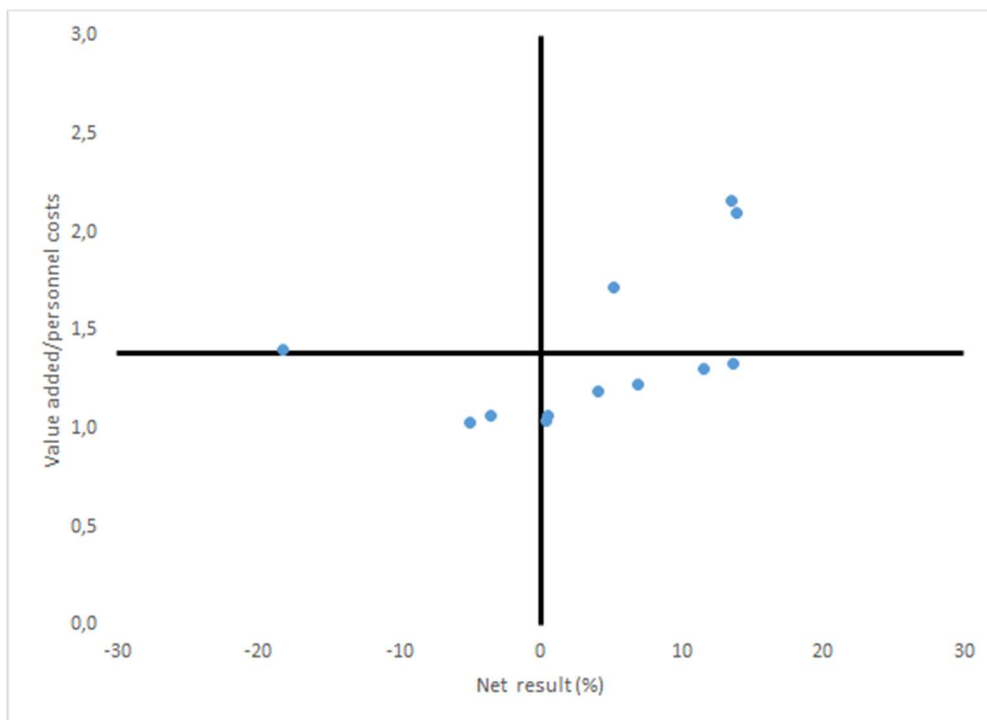


Figure 20. Productivity-profitability matrix of CAROs (2018) (n=16)

The business class companies in both 2017 and 2018 comprised Adroit Science AB (Sweden), Centrum Innowacji Stb Sp. z o.o. Sp.k. (Poland), Inphotech Sp. z o.o. (Poland), Mated S.R.L. (Italy) and Pro Novum Sp. z o.o. (Poland). Centrum Badawczo-Rozwojowe Glokor Sp. z o.o. (Poland) and Microbion S.R.L. (Italy) advanced to the business class in 2018.

4.2.4 Financial performance of “Secondary” CAROs in Europe

In this chapter, the same key financial figures are presented for the group “Secondary” CAROs, as were presented for “Core” CARO in the previous chapter. For the explanations of the financial figures, please refer to the previous chapter (4.2.3.)

In our figures (Fig. 21), the number of employees includes all temporarily employed and part-time employed persons for each given year in full-time units converted into full-time employees. In the past years, the median number of employees in “Secondary” CAROs has

been declining. In 2018, the median number of employees of the European “Secondary” CARO companies) was 17.

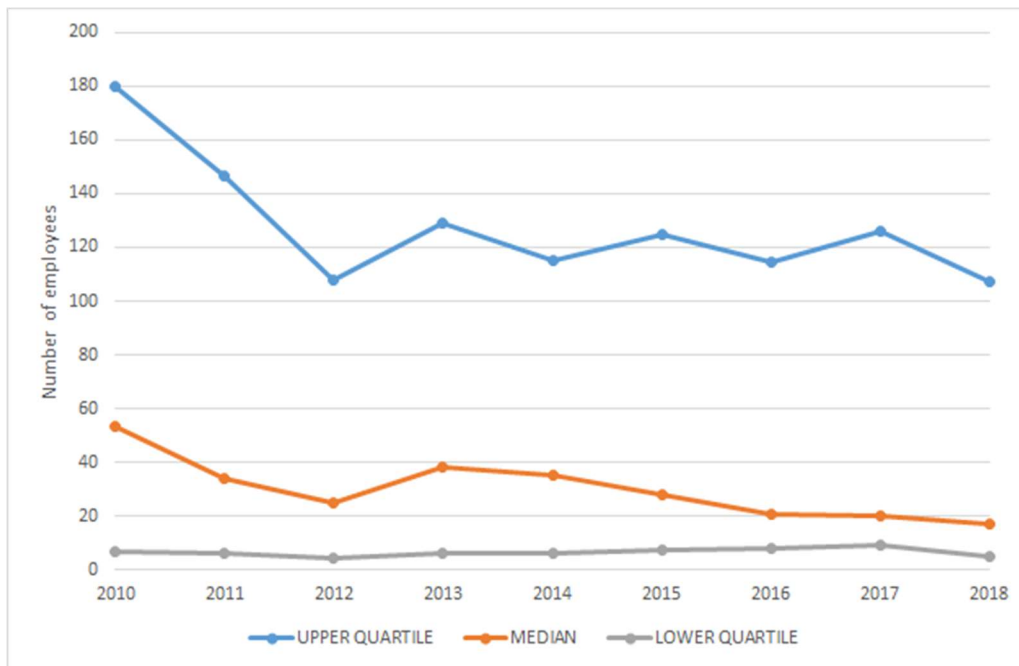


Figure 21. Number of employees in “Secondary” CAROs in 2010 - 2018

Since the mid-2010s the median turnover of European “Secondary” CAROs showed a slightly increasing trend until 2017, when it was approximately 1.3 million euro (Fig. 22). However, in 2018, it declined to approximately 0.7 million euro.

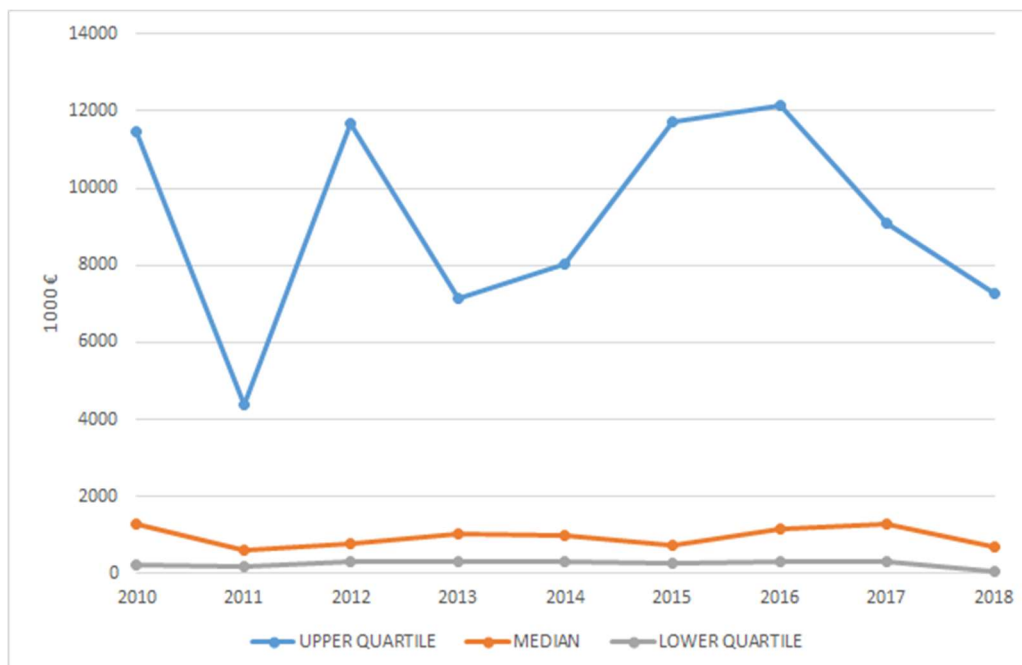


Figure 22. “Secondary” CARO turnover in 2010 - 2018

Median EBITDA margin of the “Secondary” CAROs has been declining since the mid-2010s when it was 16.9% (Fig. 23). In 2018, the median was 12.9%. However, there is quite a big

difference in the operating profitability among the “Secondary” CARO companies. The upper quartile of the EBITDA margin in 2018 was 17.3%. At the same time, the lower quartile of the EBITDA margin was negative (-1.4%).

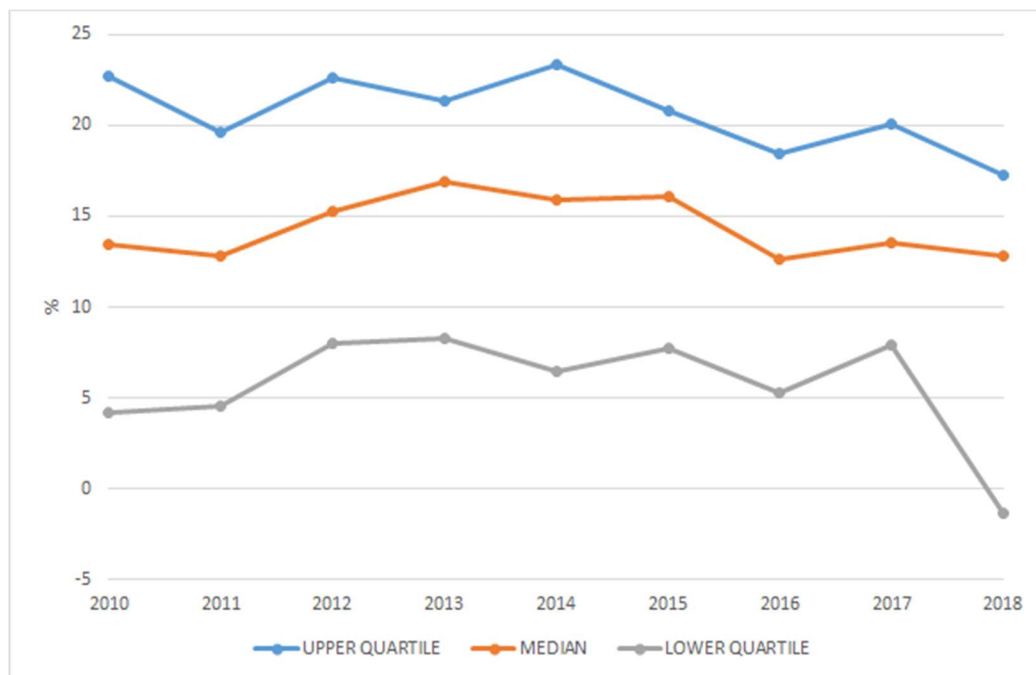


Figure 23. EBITDA (%) of “Secondary” CAROs in 2010-2018

The median net result margin of “Secondary” CAROs during the 2010s varied between 5.9% and 3.1% (Fig. 24). In 2018, the median net result margin of “Secondary” CARO companies was 5.8%. However, despite relatively good mean profitability approximately one quarter (25.6%) of the analysed “Secondary” CAROs were unprofitable in 2018.

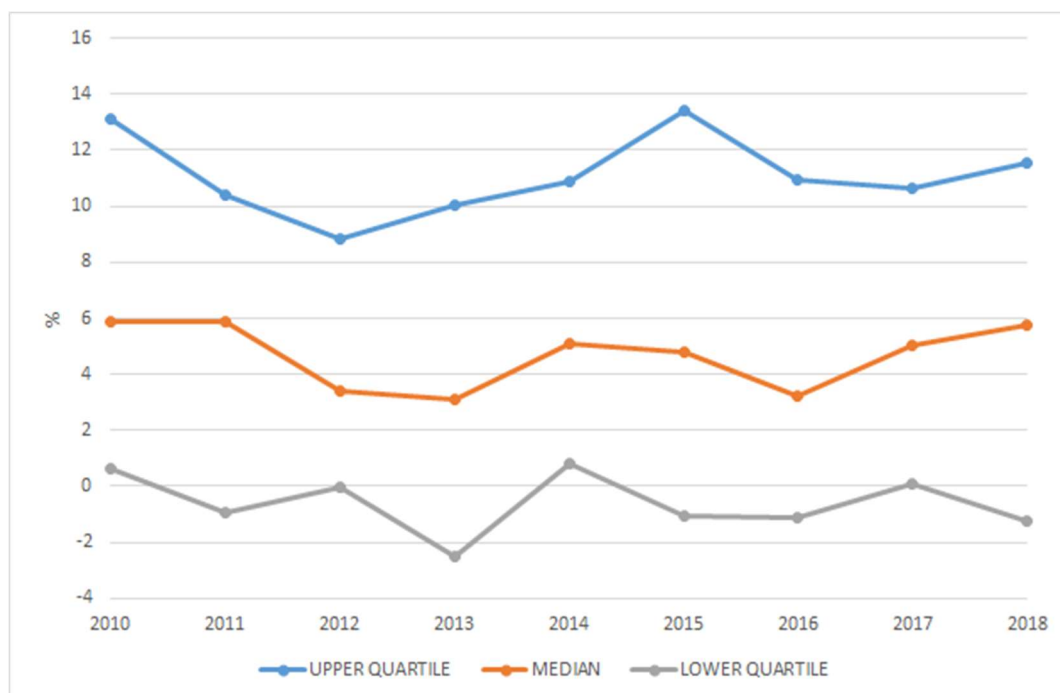


Figure 24. Net result (%) of “Secondary” CAROs in 2010-2018

After the mid 2010's, the median ROI of European "Secondary" CAROs has been on below satisfactory level (Fig. 25). In 2012, it was still 10.4% but in 2018 only 5.7%. One quarter of the analysed "Secondary" CARO companies had ROI that was below zero percent.

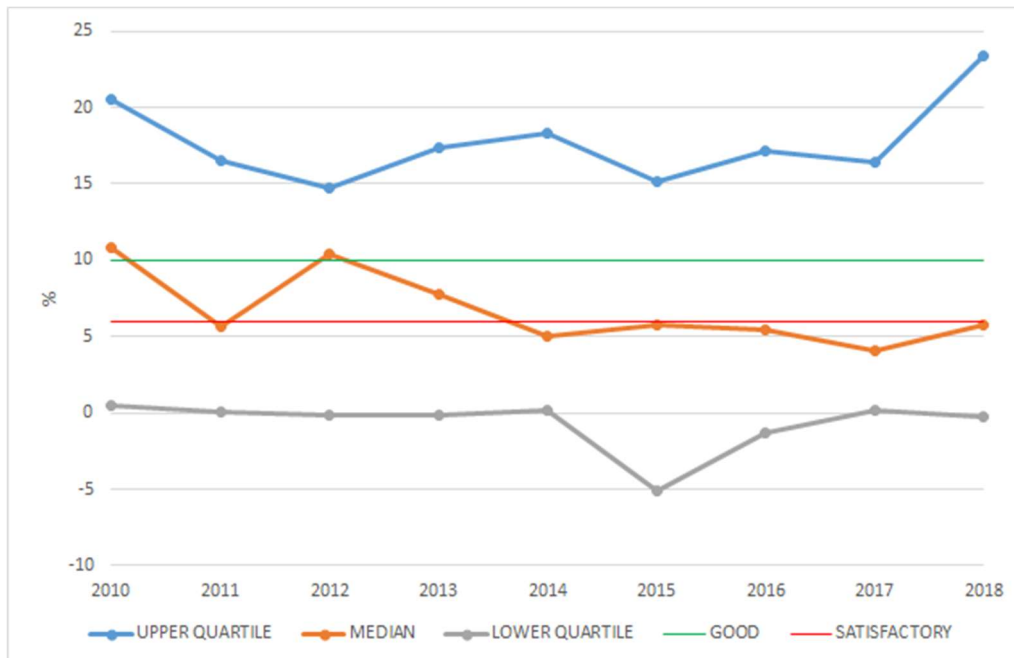


Figure 25. Return on investment in "Secondary" CAROs in 2010-2018

During 2010s, median equity ratio of the "Secondary" CARO companies has remained well above 40% (Fig. 26). However, almost one of six (16%) "Secondary" CARO companies had a low equity ratio, i.e. less than 15%. Such a low equity ratio weakens their loss tolerance and opportunities to cope with challenging economic conditions.

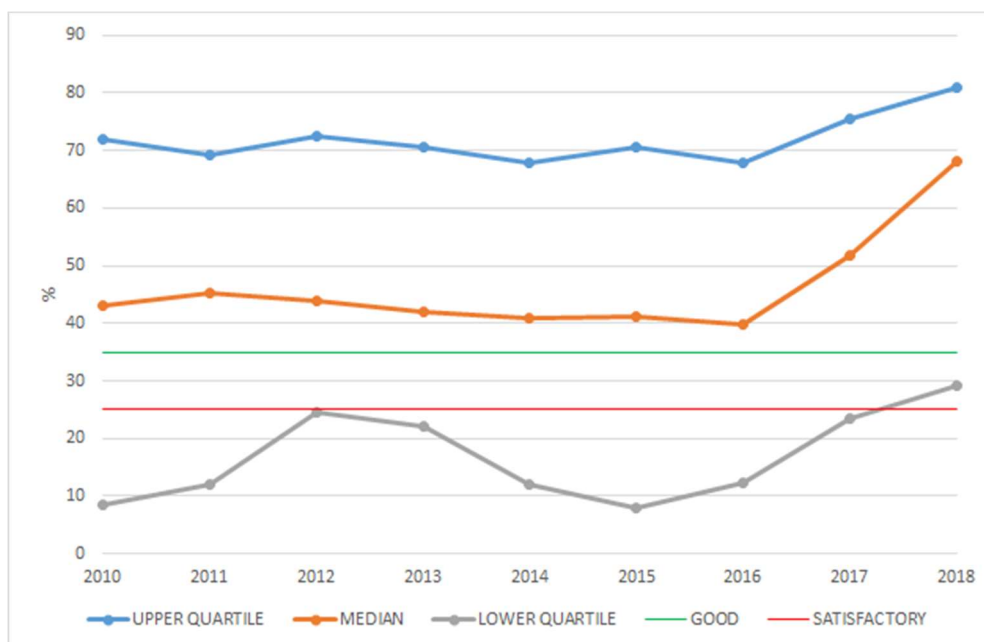


Figure 26. Equity ratio (%) in "Secondary" CAROs in 2010-2018

During the past decade, the median quick ratios of the “Secondary” CAROs have been varying between 1.6 and 1.8 (Fig. 27). In 2018, the median value in this group declined to 1.4 but was still on a good level.

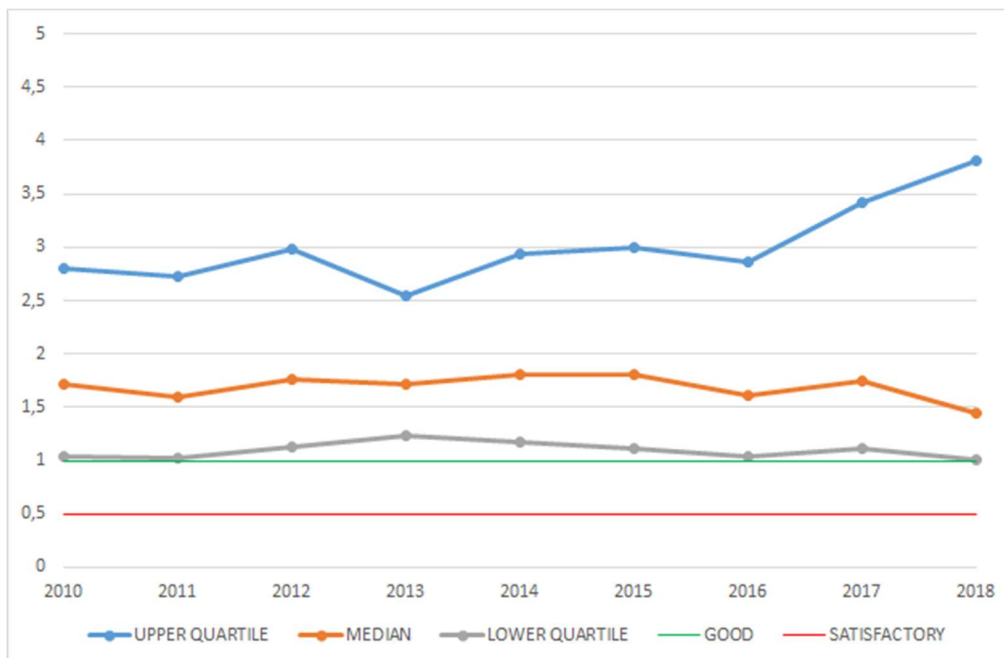


Figure 27. The quick ratio of “Secondary” CAROs in 2010-2018

The value added/personnel costs ratio of European “Secondary” CAROs has during the past decade varied between 1.41 and 1.25 (Fig. 28). In 2018, the median value added/personnel costs ratio was 1.25. One out of four (27%) of the “Secondary” CAROs had a value added/personnel costs ratio under the critical value of one. This meant that the value created in those “Secondary” CAROs did not cover the employment costs.

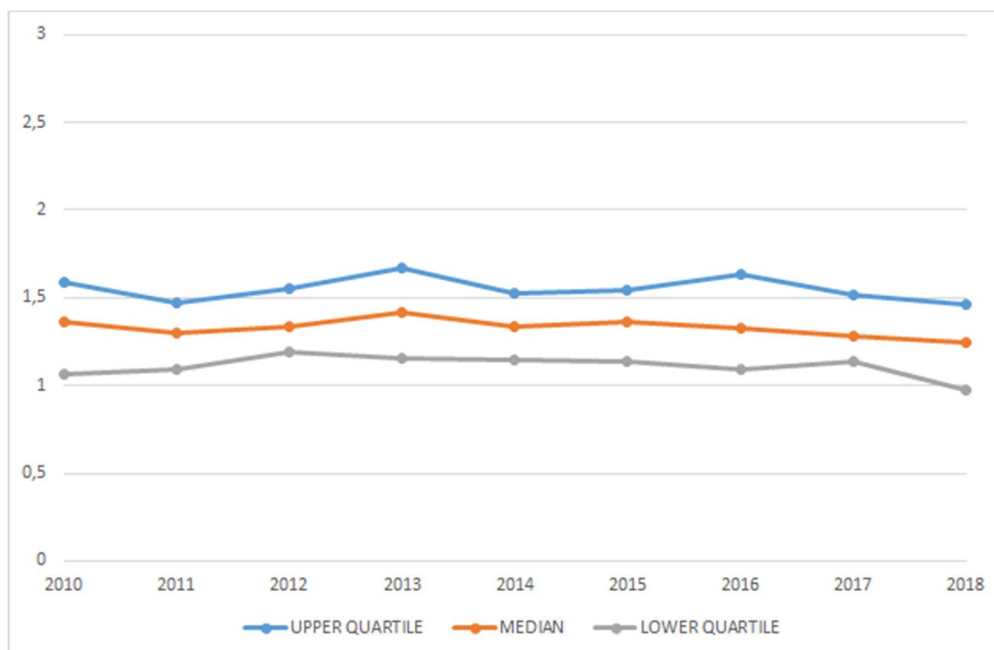


Figure 28. Value added/personal costs in “Secondary” CAROs in 2010-2018

In the productivity-profitability matrix presented in Figure 29 (see also chapter 4.2.3.) illustrating the CARO “Secondary” companies, the X axis is drawn at the median value added per personnel costs of that group of companies, 1.25 [2018], and the Y axis is again drawn at the net result percentage of 0. As stated earlier, unprofitable companies with low productivity are placed in the swamp. Of 30 European “Secondary” CAROs, 9 (30%) were situated there in 2018. The capital graveyard contains firms that are unprofitable, despite better than average productivity. None of the “Secondary” CAROs falls into that category.

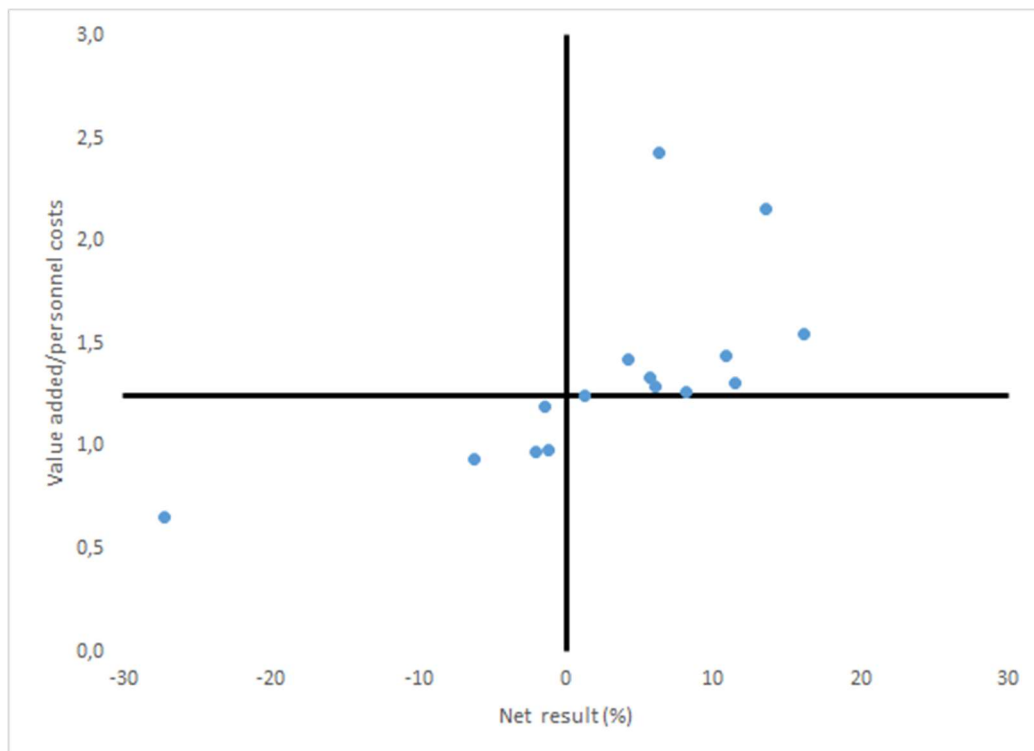


Figure 29. Productivity-profitability matrix of “Secondary” CAROs (2018)

Companies located in the kindergarten quadrant have low productivity, but are still profitable. Five (17%) of the analysed European “Secondary” CAROs belong to this quadrant. The last quadrant, business class, consists of elite companies of the industry: they are profitable and their productivity is high. Of the “Secondary” CAROs analysed, 16 (53%) are classified as business class companies based on their 2018 economic figures.

4.2.5 Comparison of the financial performance of “Core” and “Secondary” CAROs

In this chapter, the comparisons of the median values of key financial figures are presented between the groups “Core” and “Secondary” CARO (Figs. 30-37). For the explanations of the financial figures, please refer to chapter 4.2.3. Comparison of the performance of “Core” and “Secondary” CAROs in terms of the productivity-profitability matrix is presented in Table 3.

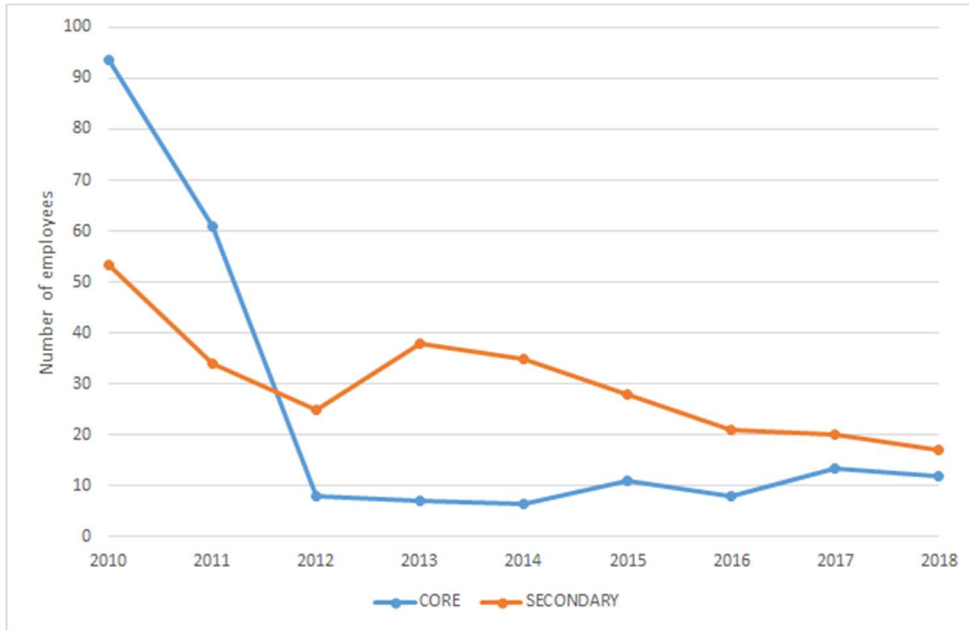


Figure 30. Comparison of the median numbers of employees in “Core” and “Secondary” CAROs in 2010-2018

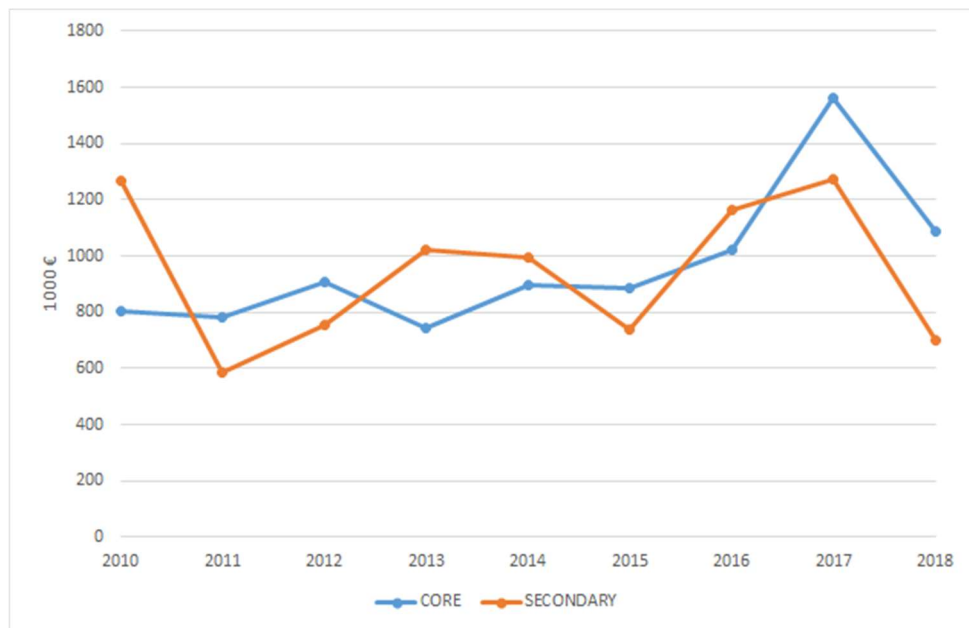


Figure 31. Comparison of the median turnovers of “Core” and “Secondary” CAROs in 2010-2018

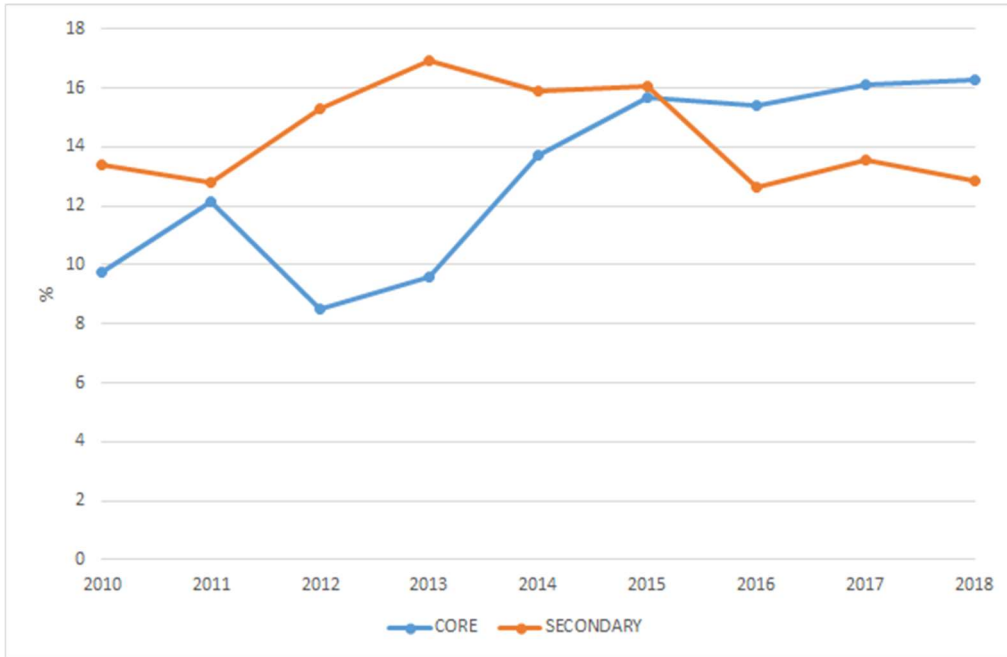


Figure 32. Comparison of the median EBITDA (%) of “Core” and “Secondary” CAROs in 2010-2018

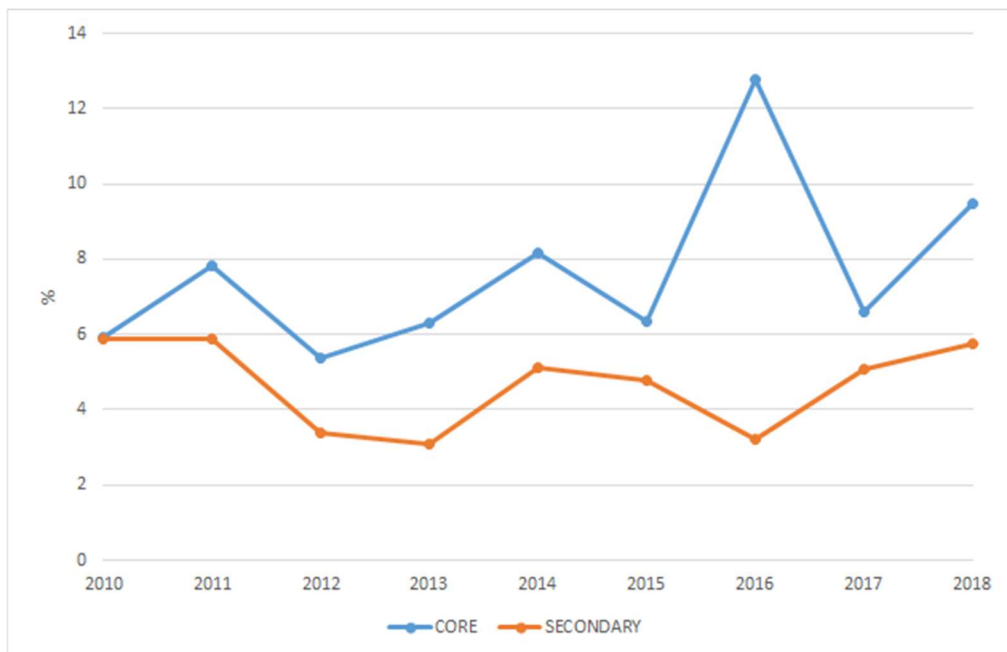


Figure 33. Comparison of the median net results (%) of “Core” and “Secondary” CAROs in 2010-2018

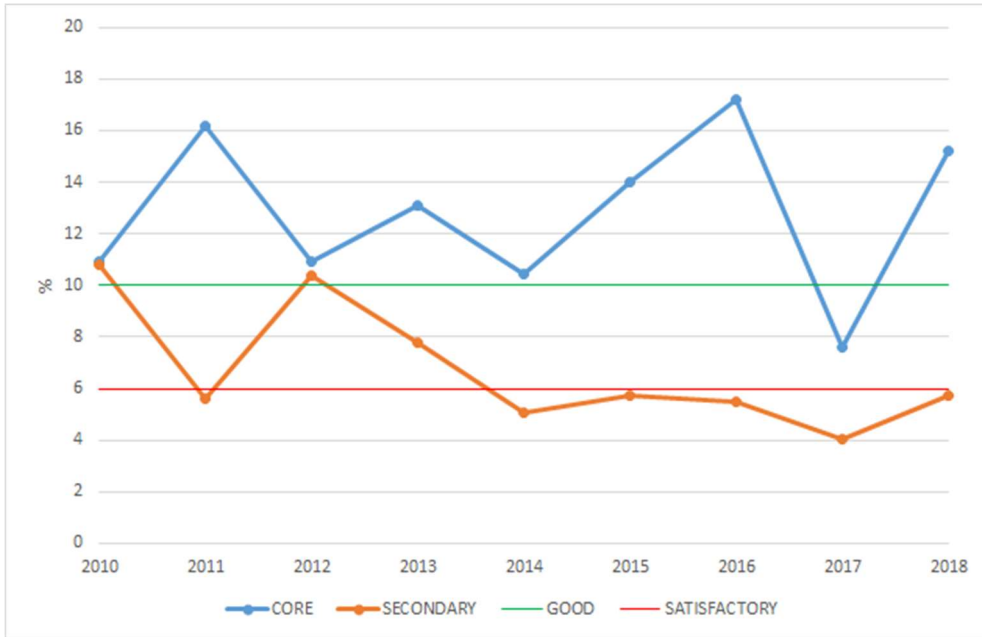


Figure 34. Comparison of median returns on investment (%) in “Core” and “Secondary” CAROs in 2010-2018

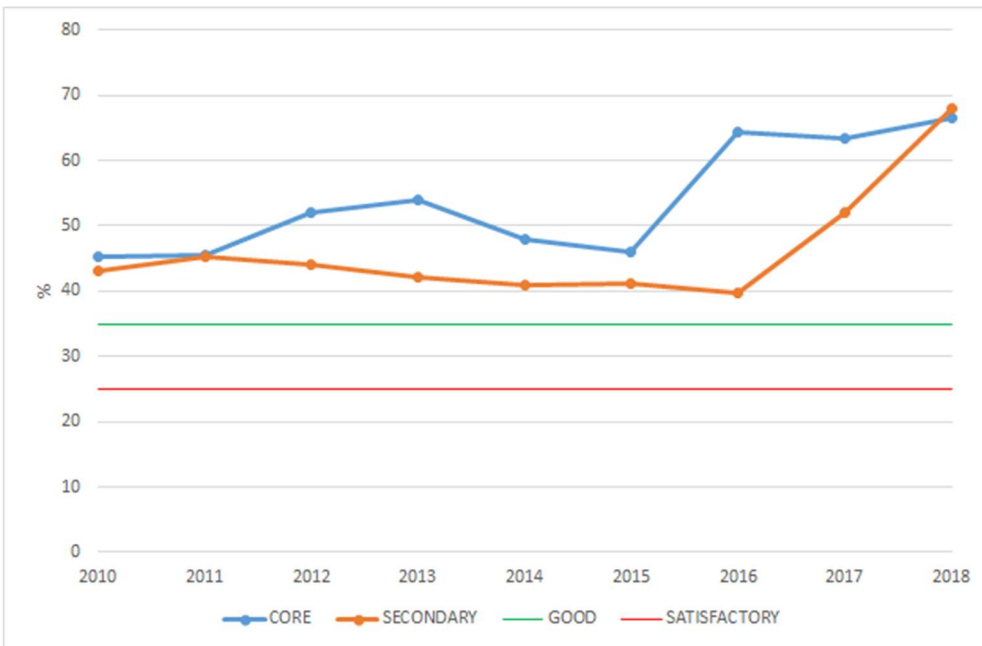


Figure 35. Comparison of median equity ratios (%) in “Core” and “Secondary” CAROs in 2010-2018

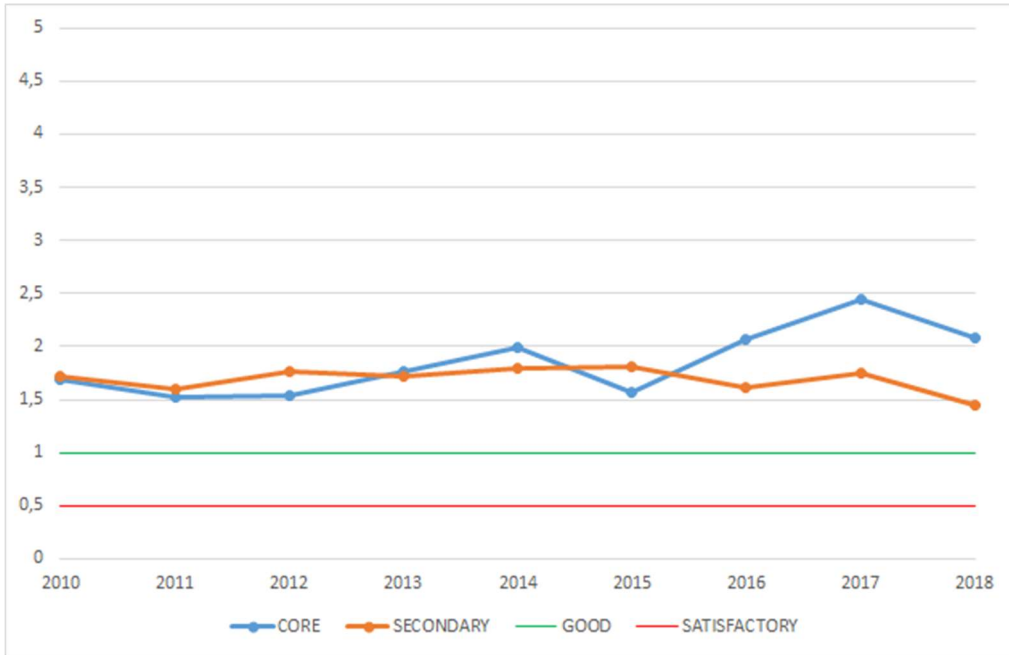


Figure 36. Comparison of median quick ratios of “Core” and “Secondary” CAROs in 2010-2018

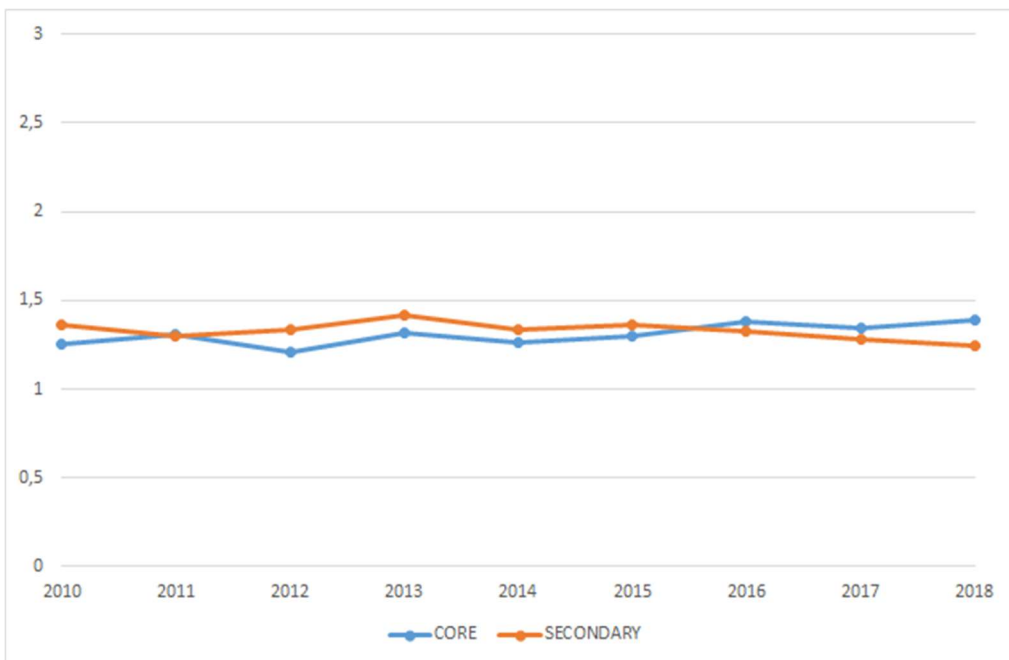


Figure 37. Comparison of median value added/personal costs in “Core” and “Secondary” CAROs in 2010-2018

Table 3. Comparison of the performance of “Core” and “Secondary” CAROs in terms of the productivity-profitability matrix (see chapter 4.2.3.)

	“Core” CAROs (n=16)	“Secondary” CAROs (n=30)
Business Class	44%	53%
Kindergarten	38%	17%
Capital Graveyard	6%	0%
Swamp	13%	30%

5. CARO markets - Investigation on materials research usage and needs

Materials research includes basic research and combines science and technology of materials. It may deal with solids, liquids and gases as well as organic and inorganic materials. Materials research belongs to the starting point for the R&D process in every manufacturing industry. One may say that commercial success in any industrial field requires combining the talents of software coding, materials science and market research.

5.1 Examples of utilizing materials research on different industrial fields

Finnish operators offering research, laboratory and other support services for different industrial fields are presented as an example.

5.1.1 Geology and the exploitation of minerals

The Geological Survey of Finland (GTK) is a leading European competence centre for the assessment and sustainable use of geological resources. Their services support the competitiveness of business, provide public administration with background information, and supplement the service range in the sector.⁶ GTK has a versatile collection of materials research equipment for their studies.

Mineralogical analyses are an essential tool for the mining industry. For example, several mineral features (particle size, liberation, association, refuse minerals and the chemical content of particles) essentially affect ore enrichment. Different materials research methods like Mineral Liberation Analyser (MLA) and X-Ray Diffraction (XRD) are used at GTK to find the reasons for problems in mineral enrichment, to further develop traditional enrichment techniques, to create innovative methods suitable for the utilisation of different industrial by-products and slag, and for the purification of contaminated soil.⁶

Modern industrial society consumes an increasing amount of metal and energy and unfortunately produces many types of waste and waste effluents that end up in landfills. The methods used in GTK's ore enrichment are also suitable for utilisation and recycling studies on different materials. These technologies help in the safe utilization of industrial waste and waste effluents more effectively as raw material or products, while minimising emissions caused by the materials in the location of use and, when necessary, contributing their disposal to a landfill.⁶

5.1.2 Natural resources and bioeconomy

Natural Resources Institute Finland (Luke) is an expert organization for utilizing natural resources. Luke's vision is a sustainable future and well-being from renewable natural resources and their mission is to create value and solutions for their customers by solving local

⁶ The Geological Survey of Finland, <http://en.gtk.fi/> (2.1.2020)

and global challenges through research.⁷ Luke brings together experts in natural resources and sustainable food production. Their researchers and specialists provide new solutions towards the sustainable development of bioeconomy and promotion of new biobased businesses. Luke's research is divided into four research programmes: 1) increasing productivity by digitalization, 2) supporting regional vitality by circular economy, 3) creating well-being from immaterial values, and 4) supporting the profitability of healthy food production. Through academic research and product development, Luke supports sustainable businesses in creating new services and benefits from renewable natural resources.⁷ One example of materials research at Luke is their research related to the usability of side-streams as soil improvers and recycled fertilizers. Researchers at Luke study and develop new solutions for the side or waste streams. For soil improvement, one can use materials like gypsum, structural lime, and paper mill sludge. Nutrient recycling and carbon sequestration into agricultural soils is vigorously evolving part of bioeconomy. Luke provides an analytical framework to characterize recycled fertilizer products in terms of nutrient composition, availability and fertilizer value, as well as absence of undesirable properties and contaminants by doing laboratory analysis, greenhouse experiments, and field scale experiments.⁷

5.1.3 Food industry

The Finnish Food Authority (Ruokavirasto) works for the good of humans, animals and plants, supports the vitality of the agricultural sector, and develops and maintains information systems. Furthermore, it promotes, monitors and studies the safety and quality of food; the health and wellbeing of animals; plant health; fertiliser products, animal feeds and plant protection products that are used in agricultural and forestry production; and propagating materials i.e. seeds and planting materials.⁸ Finnish Food Authority's laboratories are a good example of food-related materials research. Their laboratories have national reference laboratory nominations in 45 different areas of analytics and diagnostics.⁸

5.1.4 Shipbuilding

The association Finnish Marine Industries (Meriteollisuus ry) promotes cooperation within the industry, represents its members at international forums for RDI and participates in launching new RDI projects and programs. The objective of research coordination is to follow and to influence national and international research activities together with other actors of the maritime cluster, the scientific community and the authorities. Finnish Marine Industries takes part in defining the future RDI themes and informs its members about current developments concerning the operational environment, funding channels, research needs and ongoing projects. Global megatrends have a crucial influence on marine businesses. Factors affecting marine industry are growth of the world economy, population growth and unexpected changes in economy, political situation and nature. Climate change, availability of raw materials, food and water create demand for new solutions.⁹

New building processes in cruise and ferries are based on modularity in design, and production is developed more efficiently by automation and robotics. In addition, advanced and lightweight materials and the development of new efficient and lightweight structures (e.g.

⁷ Natural Resources Institute Finland, <https://www.luke.fi/en/> (2.1.2020)

⁸ The Finnish Food Authority, <https://www.ruokavirasto.fi/en/> (2.1.2020)

⁹ Finnish Marine Industries, <https://meriteollisuus.teknologiateollisuus.fi/en/node> (2.1.2020)

steels and composites and related cost-effective production methods) are an important part of making the products more efficient. The utilization of new materials requires new approaches for the manufacturing process, as well.⁹

Clean energy solutions have become important subjects that consider shipbuilding, too. Ship systems should be optimised for minimum energy usage and emissions. Initiatives toward a zero-emission and self-contained ship mean that the ship's energy usage and emissions should be constantly decreased through the development of its transport efficiency by minimizing its own weight and resistance to waves and ice (hull surface and shape, propulsion systems); enhancing energy production systems (diesel engines, fuel cells); storage (fuels, batteries) and recovery systems; improving waste material treatment and recycling on and off-board; and by reducing NOX, SOX and CO₂. Furthermore, recycling is becoming more important and should be taken into account in the design and building processes when materials and producers are selected. Better materials are needed in critical components to lengthen their lifetime and make them resource effective.⁹

5.1.5 Health and wellbeing

The Technical Research Centre of Finland Ltd (VTT) offers services of cross-disciplinary technological and business expertise, unique research infrastructure and comprehensive partnership networks. VTT creates customised solutions in close cooperation with their customers.¹⁰

VTT offers a broad array of contract R&D services for developing health and wellbeing-related businesses. One example of this kind of research at VTT is their materials research on molecular diagnostic applications. They focus on novel reagents and assays, sensor technologies, computational tools, and data mining. The need for sensitive molecular measurement is becoming increasingly important in industrial processes in the healthcare sector, but also in many other sectors like environmental detection and food safety. VTT develops, pilots and tests analytical devices and sensors in their pilot processing facilities and in their micro and nanotechnology clean room laboratory.¹⁰

Researchers at VTT help their customers develop new technologies and service concepts in the area of digital health. The results can be seen as improvements in preventive healthcare, predictive diagnostics and care, as well as health care process optimization. Turning opportunities into a success requires a combination of high-quality R&D in medical sciences, ICT, wearable sensors and in diagnostics technologies together with top-level research and science-based results. VTT also offers early-stage clinical validations of developed technology solutions.¹⁰

Materials research is also needed in creating wearable technology such as clothing, sports trackers, headsets, watches and glasses. Challenges of combining form, function and integration with novel sensing capabilities, energy harvesting technologies and software algorithms need to be solved. VTT develops wearable technology from concept through pilot production. They have pilot production environments for both microelectromechanical (MEMS) and printed electronics (PE) components and systems. They combine expertise in optical engineering, instrumentation and measurement science with deep application knowledge to

¹⁰ Technical research centre of Finland Ltd, <https://www.vttresearch.com/> (2.1.2020)

solve challenging technical problems. The result is effective new products and solutions for next generation wearable devices.¹⁰

5.2 Trends in development of medicines and medical instruments

Drug development is the process of bringing new medicines to the market. The process starts with the discovery of new compounds to be used in the medicine. After that comes preclinical research on microorganisms and animals, filing for regulatory status, clinical trials on humans, and obtaining regulatory approval to market the drug¹¹.

A considerable number of contract research organizations (CROs) specialised in drug development are operating worldwide to support drug development through the various phases of drug discovery from the very beginning to the final product on market. One of the biggest operators is the American corporation Charles River Laboratories International Inc. According to them, over the last 20 years, the landscape of drug discovery has changed dramatically. The situation used to be such that research and development activities were conducted within large pharmaceutical companies, while a range of smaller biotechnology companies would be carrying out the innovating, and often they would end up being acquired by larger companies. Today, a dynamic mixture of big pharma, biotech companies, and virtual organizations occupy the operating environment. As a trend, the pharmaceutical industry is reducing spending in internal research and development, along with purchasing more external research services. This development has made it possible for the pharma companies to reach benefits such as a reduction in their fixed cost-base, and greater capital flexibility¹².

During the co-operation between CRO and pharmaceutical company, the project leader at CRO is responsible for all elements of project management, operating a single point of contact policy with his or her counterpart in the partner company. This ensures clear communication, efficient delivery of objectives and prompt data sharing through. This way CRO can also coordinate the contracting process for potential partners. The trust is developed through regular face-to-face meetings, supplemented with regular teleconferences and email communication¹².

According to WHO (World Health Organization) governments and pharmaceutical manufacturers are the main funders of the R&D of new medicines and other health products, and investment in health R&D is concentrated in the industrialized economies. The Global Forum for Health Research identifies five principal content areas and resource flows in its analysis of global funding for health research, and they are:

1. Basic research
2. Research into health conditions, diseases or injuries
3. Exposures or other risk factors that impact on health (determinants)
4. Health systems research
5. Research capacity building.

¹¹ Wikipedia https://en.wikipedia.org/wiki/Drug_development (2.1.2020)

¹² Drug Discovery & Development <https://www.drugdiscoverytrends.com/the-new-age-of-drug-development/> (2.1.2020)

Data of the major pharmaceutical companies (from the year 1998) shows the following segmentation for the money used for R&D budget on the different stages of clinical evaluation of new products: clinical evaluation 40%, basic research 27%, development of production process 19%, implementing regulatory requirements 7%, and other 7%. In the second half of the 20th century, rapid progress has been made in developing powerful new medicines¹³.

Trend in the medical and healthcare sector is a shift in emphasis from treatment to early diagnosis and prevention. Overall future trends in the medical sector are for example sustainability, digitalization, artificial intelligence, robotics, miniaturization, preventive health care and 3D printing. All this needs materials research. There will be a special need for methods for analysing and evaluating nano-structures: nano-simulation, nano-creations and nano-measurements (for example nanoscale visualization).

Major new medical device technological advances, developments and innovations might include¹⁴.

- Surgical robotic systems.
- Mobility and cloud access.
- Nuclear medicine imaging devices.
- 4k ultra-high definition medical imaging technologies.
- Telemedicine.
- Augmented, virtual and mixed reality devices.
- 3D printing technologies.
- The advent of artificial intelligence (AI) in healthcare.
- Wearable medical device technologies and the Internet of Things (IoT).
- Radio frequency wireless technologies.
- Bio-printing (artificial organs).
- Clustered regularly interspaced short palindromic repeats (CRISPR).
- Bluetooth-enabled medical devices.

5.3 Future needs of materials research on different industrial fields

In total, the material usage is expected to increase hugely. Now for high-income countries, the per capita material footprint, the quantity of materials that must be mobilised to meet the per

¹³ World Health Organisation (WHO) <https://apps.who.int/medicinedocs/en/d/Js6160e/4.html> (2.1.2020)

¹⁴ Cision Communications Cloud, <https://www.prnewswire.com/news-releases/latest-innovations-in-medical-device-technologies-2019-global-analysis-report-300936723.html> (3.1.2020)

capita consumption of an individual country, is 60% higher than for upper-middle-income countries and 13 times that of the level of low-income countries.¹⁵

Materials research have methods to help in tackling the biggest global challenges of the 21st century, climate change, increasing CO₂ emissions, depleting energy resources, sustainability, pollution, labour change by automatization & robotics, global health, food and water security¹⁶. Future trends in the manufacturing industry sector are new energy technologies, biobased materials, recycled materials and quality products.

5.3.1 Environmental materials

Environmental materials can be divided into three types: resource-saving materials, low environmental impact/environment-purifying materials and clean energy materials¹⁷.

Resource saving materials are those that help preserve energy or natural resources. Transportation of raw materials and products forms a big share of all manufacturing industries. One method for resource saving is to improve fuel efficiency and decrease CO₂ emission of transportation vessels. In order to improve fuel efficiency, it is necessary to reduce the weight of materials used in transportation vehicles without sacrificing their safety, and to improve thermal efficiency of the engines. Thus, it becomes very important to develop new materials, which are higher in specific strength and specific elasticity, thinner, more heat resistant and so on, when compared to present-day materials.¹⁷

Concrete is the most produced material in the world at 4.2 billion tons per year, with most of the demand for construction projects in fast-growing and emerging economies. Conventional Portland cement is made by heating ground limestone and clay at 1400°C and 1500°C to produce nodules of clinker, which are then ground and mixed with other materials to produce cement. Production of clinker is energy and CO₂ intensive. The high volume of production makes the global cement industry one of the largest producers of CO₂, accounting for five to ten percent of global emissions. In addition, the CO₂ embodied in limestone is released during production¹⁵. Manufacturing of sustainable cement from for example fly ash produced in biomass combustion is possible, but research on that and on other alternatives is needed.

One possibility for resource saving is prolonging the usable life of new products and thus materials. That helps to utilize natural resources more effectively and to reduce energy consumption in the manufacturing processes. Therefore, it is highly important to research new materials that offer greater longevity, and new methods for inspecting materials deterioration by time are needed.¹⁷

Low environmental impact materials are those, which have comparatively small impact on the environment through their life, from production to scrapping. In view of our limited and valuable natural resources and the constraints on the environmental capacity to receive waste, low environmental materials are designed so that they can be recycled. In addition, they are manufactured using processes, which have minimal impact on the environment.¹⁷

¹⁵ Global Sustainable Development Report 2019: The Future is Now – Science for Achieving Sustainable Development, Independent Group of Scientists appointed by the Secretary-General, United Nations, New York, 2019.

¹⁶ Royal Geographical Society, <https://21stcenturychallenges.org/challenges/> (3.1.2020)

¹⁷ A Vision of Materials Science in the Year 2020 (Excerpts from the "2020 NIMS Policy Paper"), Independent Administrative Institution National Institute for Materials Science, June 2007.

Plastic is quite a controversial material from this point of view. Plastic packaging can increase resource productivity by extending the shelf life of food, and because it is light, less fuel is consumed during transportation. However, the volume of plastic-waste production is expected to grow from 260 million tons per year in 2016 to 460 million tons by 2030 and nearly half of that comes from packaging materials. Unfortunately, close to half of single-use packaging ends up in landfills or leaks out of formal waste collection systems, with devastating consequences for the environment.¹⁵

Clean energy materials are materials related to renewable energy. For example from the standpoint of promoting solar power generation by using solar cells, it has become necessary to improve the energy transformation efficiency of existing silicon based semiconductors and develop low-resistance materials. It is also important to cut their costs and develop an effective method for storing surplus electricity. High-performance secondary batteries that can be charged and discharged repeatedly are widely used in cars, cell phones, computers, etc. For these products, it is important to develop new materials, which offer higher performance and longer life.¹⁷

5.3.2 Global health

The global health context has changed dramatically, and the change is supposed to continue. Advancing human well-being, including material wellbeing and health, as well as other aspects of life that people value, like education, access to a clean and safe environment and resilience, is at the core of transformations towards future sustainable development¹⁵. Countries spend more on health, as the population is ageing and the burden of chronic diseases is growing; novel and expensive medicines and health technologies become available; and demand for better health is increasing as people's income grows. The Lancet Commission on Investing in Health estimated that an additional 70 billion euros is needed annually to make basic services available worldwide.¹⁸

5.3.3 Food safety

The Centre for the Development of Industrial Technology (CDTI) and the European Environmental Bureau (EEB) underline that over exploitation of water and fertile soil combined with an already decreasing availability due to the effects of climate change and intensive management practices, groundwater and soil pollution resulting from badly managed bio-waste and pharmaceuticals entering the water supply from faeces, urine and washing, as well as an existing and rising demand for food, could undermine world food security¹⁹.

To achieve a sustainable bio-economy, there is a strong consensus for need of support for basic and applied research, technological development, demonstration projects, translational research infrastructure creation and training activities, involving all actors (including farmers, foresters, fishermen, advisory services, industry (all involved in the supply chain), consumers and society at large), and the support should reach local, regional, national, European and global level¹⁹. The German Bio-economy Research and Technology Council argues that in

¹⁸ World Economic Forum, <https://www.weforum.org/agenda/2018/01/how-to-overcome-global-health-challenges/> (9.1.2020)

¹⁹ Bio-based economy in Europe: state of play and future potential - Part 2: Summary of the position papers received in response to the European Commission's Public online consultation, Publications Office of the European Union, Luxembourg 2011.

order to meet the desired product and production standards, biogenic raw materials (made by or of life forms) must be adapted. Production of foods produces added health-boosting benefits, which may counteract nutrition-related health deficiencies throughout the world. Targeted breeding and modification of the appropriate genes can influence flavour, nutritional characteristics and the content of desired ingredients. Animal health will be an essential requirement in the future production of animal-based foodstuffs. Animal health and welfare will be the cornerstone of the essential link between animal protection and health-related consumer protection.¹⁹

6. SWOT analysis of CAROs

6.1 What constitutes a SWOT analysis

SWOT analysis is a strategic planning technique used for identifying strengths, weaknesses, opportunities, and threats related to business competition. It is designed for use in the preliminary stages of decision-making processes and can be used as a tool for evaluation of the strategic position of organization. The SWOT analysis uncovers both internal and external factors that influence a company's performance and goals, and it is suitable for use in different types of companies and organizations. The analysis may concern either the company as a whole or, in more detail, some part of the business. The detailed examination is more limited; the subject can be, for example, markets, products or personnel. At its best, SWOT analysis is a simple method that can be used in a company or industry level. Threats and opportunities are considered external factors, while strengths and weaknesses are internal factors. Instead of a company-level SWOT, we have in this case opted to create a SWOT analysis of a group of companies, namely the group of CAROs.

Like said, the SWOT analysis aims to identify the key internal and external factors seen as important to achieving an objective. One of the key principles of conducting a useful analysis is that it should be as simple and practice-oriented as possible. The SWOT analysis groups key pieces of information into two main categories:

- 1) Internal factors: the strengths and weaknesses internal to the organization or the industry. These factors represent the current state of affairs.
- 2) External factors: the opportunities and threats presented by the environment external to the organization. These factors will potentially affect the success of the business in the future.

Once the aforementioned issues have been identified, they will be used as a basis for defining concrete operational courses of action. On a general level, one should strengthen the current strengths and continue to leverage them. Any weaknesses found should be corrected. Not all vulnerabilities can be eliminated, but efforts should be made to mitigate their effects. One should take advantage of opportunities within the boundaries of resources available, and prepare for threats with good planning so that things do not come as a surprise.

In this chapter, we assess the strengths, weaknesses, opportunities and threats characteristic to the CARO industry. The term "industry" is being used here to describe the group of CAROS. CAROs do not actually constitute a separate industry by themselves, as CAROs function in various industries. The results are first and foremost based on thematic company interviews conducted in various European countries during the CAROTS project. The interview results were collected through an online survey with the CAROTS project partners and associated partners. The partners sent eight responses, consolidating the results of interviews conducted by them in various European countries. The survey was carried out in May 2020 and the responses cover all participating countries. The results are qualitative in their nature, and have not been subjected to quantitative methods of analysis.

6.2 Results of the SWOT analysis

6.2.1 Strengths

In SWOT analysis, strengths form the other one of the internal factors under scrutiny in addition to weaknesses. This part of the analysis assesses the strengths of the firms in the CARO industry. The strengths are distinctive assets of the firms, such as a resource or a skill that grants them a comparative advantage in the market²⁰. Based on our analysis, we have identified five main strengths of CARO companies (CAROs).

The CAROs display a high level of competence in the areas of analytical methods, specialised technical expertise, as well as having a general understanding of materials and production. CAROs are typically run by some of the leading experts in the specific field, possessing unique competences and scientific knowledge within the area of the services offered. Because of the high competence in a very specific field of expertise, some CAROs operate as Research & Development departments for industrial companies on a long-term basis. This kind of a continuous relationship is mutually beneficial, and brings stability for CAROs.

The financial situation of the CAROs is good. Typically, they have not had to resort to getting external funding from the market. Instead, they are able to finance their operational business through sales. The CAROs have typically reached the break-even point quickly after having established their businesses, and are thus in general profitable. The CAROs display financial management strategies that can be characterised as risk-averse. This manifests itself e.g. through buying second hand equipment. The fact that some CAROs are affiliated to a specific research infrastructure enables a constant flow of commissions, and reduces the pressure on new customer acquisition, which can consume a great deal of financial resources. There are also public funding programs designed to foster collaboration with research institutes.

The product (the service offering) of the CAROs meets well the needs of their target customers, typically filling the gap between industrial and academic research. The CAROs are able to offer added value through offering tailored solutions to problems, instead of mere measurement results. Overall, the CAROs provide a wide variety of research and development services. Most of the CAROs having been interviewed provide services through their internal capabilities, and are not forwarding any activities to other research organizations. The success of the CAROs is mainly based on their own research and development capacity, including unique technologies, expertise, and data analysis approaches. The CAROs also are able to fill niches, where there otherwise would be no or limited other provision of analytical services. In addition, some CAROs even have patented intellectual property that grants them protection of expertise, and an additional cash flow.

CAROs are many times organisationally light, in general not owning their own research infrastructure, but outsourcing it, which grants them an opportunity to be agile. This means that they can reach their customers in a nimble manner, and make adjustments into their service offering in order to be able to meet the specific needs of various customers.

²⁰ Pearce, John A. & Robinson, Richard B. (1991). Strategic Management, (4th Edition), USA: Irwin, Inc.

As the fifth strength, the CAROs are well connected on the other hand to customers, as well as to the providers of research infrastructure. CAROs have typically been able to establish close relations and confidentiality with their customers. Therefore, the customers are less tempted to use a different provider of CARO services. The CAROs are well acquainted with the way large facilities function, and are thus able to provide their customers with smooth access to those. The networks of CARO entrepreneurs facilitate access of CAROs to advanced research infrastructures and to scientific expertise that their customers demand. On the other hand, CAROs have good relationships with regional public authorities. They support innovative enterprises that advance the business climate and stimulate labour markets locally.

CAROs have recognised the benefits of organising B2B (business-to-business) events. They appreciate the important role of companies in organising networking events, which serve as an effective tool for establishing new contacts and exchanging experiences between entrepreneurs. In terms of reputation, when creating networks, CAROs can benefit from the fact that their core staff often consists of scientists who came from research institutions that allowed them to create a reputation as scientists before starting their CARO, and that reputation was transferred with them to the CARO industry. This also makes it possible for CAROs to utilise their network of colleague scientists in a specific field to invite colleagues to projects to solve problems arising from the point of view of branch-specific expertise.

6.2.2 Weaknesses

One of the primary reasons why small businesses fail is a lack of funding or working capital and sufficient funding is crucial for a successful business²¹. However, sourcing enough money to operate, especially in the early stages of the business creation, can be difficult. In this sense, the CARO companies are no exception. The lack of capital and financing to support the development and growth is a challenge for many CARO companies. Additionally, especially relevant for companies in the start-up phase, fragmented and volatile demand causing instability and volatility of revenue flows. These weaknesses are interlinked with the low recognition and challenging market access. However, our interviews indicated that many of the CARO companies have been able to establish their businesses even with relatively low dependence on external funding. In the starting phase, founders have had a good degree of knowledge about the potential target market and its needs, along with personal connections to the clientele. This has enabled CAROs to grow their businesses gradually, within the boundaries of their financing available. CARO founders have in many instances preferred gradual organic growth to giving up any ownership to their company in return for receiving external investments into their CARO. Still, the issue of financing of CAROs is controversial especially if faster growth were desirable. If the founders of CAROs were more interested in more aggressive growth strategies and granting ownership to investors in return for investments, the societal significance of CAROs e.g. in terms of employment could potentially be larger. With regard to public funding, many CAROs take pride in declaring that they have not needed nor asked for such. However, in reality, many customer projects are in some form supported by public funding. Therefore, if financing through public funding programs were reduced, it would conceivably also end up affecting negatively the income of CAROs.

²¹ Cunningham, B., Nikolai, L.A., Bazley, J., Kavanagh, M., & Slaughter, A. (2018). Accounting : Information for Business Decisions, (3rd edition), Australia: Cengage Learning Australia

In addition, CARO companies and their services have low recognition and visibility in the market. The fact that they are not known makes it difficult for them to reach and gain new customers. This is especially challenging for newly established small companies. When a company enters a market, eventual customers may be sceptical and cautious. Many customers favour companies that they have already worked with. Likewise, it is more expensive to acquire new customers than to keep existing ones. Without a current customer base, understanding market needs is also challenging. Companies in the start-up phase have short market experience, building a customer relationship that is based on trust, and cooperation takes time.

One further evident shortcoming of the newly established CAROs is the lack of necessary business skills. Scientists/members of academia, who often lack experience in running a business, often establish CARO companies. It is often challenging for people coming from academia to adapt their mind-set to the business environment and some of them have shortcomings for example in their day-to-day management and marketing skills. As a new entrepreneur, they might also have a lack of perspective that can be achieved only by doing business for several years, the company operates without valuable points of reference, and many mistakes are made in learning by doing process. At the same time, businesses in the early stages are often too dependent on the owner or one key person. This may be, at least partly, due to absence of well-established procedures or lack of delegation. In addition, safeguarding knowledge from inadvertent disclosure or its unauthorized use by competitors has become increasingly critical for developing and retaining competitive advantage. The intellectual property (IP) protection system provides a key tool for successful business and some of the CAROs do not pay enough attention to securing their IP and expertise.

Finally, the European CARO companies have problems in recruiting skilled scientific personnel with relevant expertise. CARO companies have problems in recruiting qualified employees with relevant competencies. Therefore, companies have to employ people with less competence and put a lot of effort in training them. This is expensive and there is no guarantee that investment will pay off and trained employees are loyal and stay in the company.

6.2.3 Opportunities

Because CAROs offer their services for various industries, it is somewhat challenging to raise specific themes as common opportunities for all CAROs. However, we will present examples of various phenomena that can manifest themselves as potential opportunities, but their relevance will depend on the specialisations and focus areas of each CARO. Of the different areas of CARO specialisation, it was especially noticed as a general trend that there would be growing demand for the expertise of CAROs operating within materials science.

In terms of growth potential, the market for intermediary services is largely underdeveloped and it can be considered to have a large potential to grow. Large-scale promotion is many times too expensive for CAROs and the potential market thus stays largely untapped until potential customers start looking for research and development capabilities more seriously, or until they manage to establish contacts with CAROs during research and technology conferences and events. The research and development investment capacity of many

companies is too small for survival and successful future operations, and many of them will thus have to find their way to CAROs if they desire to be successful business entities.

Networking provides an opportunity for CAROs to increase awareness about them. Through networking and collaboration, competence gaps of individual CAROs can be filled. That allows them to perform at a higher level and to offer industry or other institutions cutting edge solutions, and e.g. participation in large Horizon projects. Through networking, CAROs can be more prominent in various industry arenas and conferences, and establish contacts to R&D processes. There are large unused opportunities to develop cooperation with research and scientific organizations, technology transfer centres, and involving researchers in business as co-owners, and promoting the development of joint ventures with an entrepreneur.

One aspect is that scientists in research institutions have many good ideas that could be commercialized, but they have no interest in developing them into a business. Researchers write articles, participate in conferences and this way share expertise, which can boost the CARO industry. Improved collaboration between scientists on the level of ideas could bring increased economic prospects to both sides. In order to grasp the opportunities, it could also be beneficial to provide basic training in areas such as shared business services and marketing. This could enable CAROs to quickly get support and improve in those areas.

New sources for financial support can also represent an area of untapped opportunity. Policy makers can potentially create favourable business conditions for CAROs and innovation organizations e.g. through evolution in state procurement regulations. Furthermore, there may arise new support ecosystems with communication events/platforms for collaboration of innovative CAROs and academia. There could as well be state policy instruments fostering collaboration between research institutions and CAROs on university infrastructure and the commercialization of scientific expertise. The availability of support instruments across borders can foster international cooperation by creating new competitive businesses that are able to access available funding. On the other hand, bureaucratic hurdles of public research facilities to provide industry service do not apply in the same way for CAROs, which can represent an opportunity for CAROs. In addition, CAROs can potentially benefit from state grants for patent processes, state and EU grants for research, and state innovation support in the form of incubators and business consulting for CAROs, and ultimately, calls for research in the institutions like NASA, CERN, and ESA.

6.2.4 Threats

One of the threats to the development of the CAROs is that the strategies of potential customers are not supporting the outsourcing of analytical and intermediary work. This means that companies would have to become more aware of CAROs and the benefits that they could bring to them, which could consequently make them realise the value of incorporating CAROs in their business strategy. In addition, a further threat might be that existing customers change their practices to increase their own in-house analytical work or reduce their R&D investments.

In terms of funding, the fact that the possibilities for CARO companies to get private funding from commercial banks, investment companies, and venture capitalists are limited can be a threat. Furthermore, many of the already existing public financial instruments and support mechanisms are rather rigid, and encompass many rules and guidelines having been set for

the duration of the financing instrument (e.g. a financing programme). Therefore, these instruments do not optimally cater to the needs of companies like CAROs. Additionally, at least in some countries, bureaucracy or legislation makes it challenging to get access to national public support programs suitable for CAROs.

Falling prices and intensified competition in the market caused by new CARO companies and other research facilities or labs offering services directly to industry without CARO like intermediaries creates a threat to the development of the branch. Furthermore, the extensive physical distance of European CAROs from their main industrial markets, for example in East Asia, makes at least to some degree difficult to know and be aware of all technological needs of the customers. In addition, in some markets industry espionage is a relevant threat.

Third-party dependence can cause problems because delivery of the CARO depends on the availability of external instrumentation. Additionally, the period to access large-scale research facilities/infrastructures can be too long with respect to industry requirements. Furthermore, relatively high costs in particular for advanced measurements services at large scale research infrastructure is challenging. In addition, it is good to consider that a number of CARO companies are not interested in working with large-scale research infrastructures.

Overall, there are uncertainties that may turn out to be either advancing or braking the growth of CAROs. The general trends of consolidation in the high-tech sector, and challenges in SME sector R&D resources can pose additional challenges for smaller CAROs. Depending on the development of information technology, it might be possible that the CAROs role could be replaced by IT solutions, which could pose a threat if CAROs were not able to react quickly and e.g. focus on IT expertise in order to maintain their market position. On the other hand, larger industry players can deploy CARO-like activities, which can again reduce the demand of CARO services. It is a fact that technological trends are many times unclear. CAROs are therefore forced to take decisions under uncertainty and often concentrate on one or few technology areas, because of their limited resources. Only time will then tell if their decisions were correct.

6.3 Conclusions of the SWOT analysis of CAROs

As a result of the SWOT analysis (see figure 38), we can say that the results of the SWOT analysis of CAROs manifest similar characteristics and phenomena as are common with companies offering other types of expert services to business customers. Some of the most central challenges of CAROs revolve around demand-related uncertainties. Potential customers may not be aware of the existence of CARO services, they may produce such functions in-house, or their strategies are not compatible with the outsourcing of intermediary expert services. Through an increased focus in marketing and networking activities, for instance, in industry events, CAROs can strive to improve their presence on the market.

Figure 38: A summary of the results of the SWOT analysis

INTERNATIONAL	<p>Strengths</p> <ul style="list-style-type: none"> High level of competence Stable financial situation through service sales Relevant product and service offerings Agility of the companies Own network of customers and research infrastructures 	<p>Weaknesses</p> <ul style="list-style-type: none"> Low visibility Lack of business expertise Lack of private funding Dependence on public funding Difficult to attract skilled workforce
EXTERMINAL	<p>Opportunities</p> <ul style="list-style-type: none"> Growing demand for expertise in materials science Growth potential in intermediary R&D services Industry-wide business networks bringing awareness New sources for financial support 	<p>Threats</p> <ul style="list-style-type: none"> Company strategies not aligned with purchasing of CARO services Competitive situation becoming tougher Accessing financing and support mechanisms to enable faster growth can become increasingly challenging for companies Uncertainty in trends of technical development Low availability of skilled workforce

7. The networking of CAROs

CAROs represent a type of company that does not yet have a widely agreed definition, and even the term CARO is not yet widely known in the market. In order to grow their business, CARO companies (CAROs) need to assess carefully what kind of business models would be most suitable for them. On the other hand, networking can potentially be as crucial a part of growing their business as the business model.

7.1 Characteristics of CAROs

CAROs form a heterogeneous group of companies. Some of them are very small and have only a few employees. At the other end of the spectrum, the biggest CAROs have hundreds of employees. At the same time, the identified CARO companies are in very different stages of business development/business lifecycle. Some of the companies could be classified as start-ups that are only a couple of years old, while others have decades of business experience. Currently, most of the identified CAROs are not limited to one service, instead offering a range of different services. On the other hand, there are also some examples of CAROs that are focused on a narrower service range, focusing successfully on serving niche markets. Based on our analysis, the vast majority of CAROs are international by nature with most of them operating in international markets. Therefore, it is very challenging, if not impossible, to develop one business model that would fit for all CAROs.

7.2 Building foundations for market entry

A company builds its business idea usually around its core competences. In order to have a possibility to succeed on the market, it must know its business and competitive environment. An example of this is a great number of Swedish CAROs providing services for the steel industry. In order to succeed, a company also needs to be able to make appropriate decisions in terms of marketing strategy and competitive strategy. Since CAROs do not necessarily have measurement instruments of their own, cooperation with other service providers is essential. CAROs often cooperate closely with local universities. Hence, the focus areas and measurement equipment of local universities are also determining the target market of each individual CARO. Due to the heterogeneity of the typical markets for CAROs, and their demands, it would seem plausible that small and medium-sized CAROs should strive not to employ a one-size-fits-all business model. Instead, they could benefit from the development of e.g. various pricing and service delivery options, and the introduction of modularity in their service offering. By modularity, we mean in this case the productization and classification of the expertise that the CAROs have. This way, CAROs could offer their services and expertise in a mass-customised manner, being able to tailor their service offering according to the needs of each particular customer, at the same time making it possible to target a wide range of customers.

In terms of networking, it would seem recommendable for CAROs to strive to assess objectively their core competencies. Based on that, they should adjust their strategy to offer services in knowledge areas where their comparative advantage is highest, and then strive to

collaborate with best possible providers of complementing expertise. This applies especially to smaller CAROs with limited financial resources to insource expertise.

7.3 What is a business network?

According to the definition by ECORYS (2014)²², *a business network is a form of inter-firm cooperation that allows companies, located in different regions or countries, to collaborate on a basis of common development objectives expressed in a cooperation agreement. The companies decide to join their strengths, share information and create synergies to become more innovative and competitive in domestic and international markets, while keeping their autonomy, not creating a separate legal entity. This cooperation model is suitable for any kind of business activity or sector.*

Business networks usually have both strategic and operational objectives. The strategic objectives of the networks focus on longer-term activities that help the members of the network, for example, to strengthen their innovation capabilities, become international, or enhance their capabilities to find foreign business partners. The operational objectives of business networks are more diverse and include, for example, collaboration in larger national and international projects.

7.4 The key benefits of networking for CAROs

The goal of business networking is to increase business revenue in one way or another. The increase of the bottom line can be immediately apparent, as in developing a relationship with a new client, or developing over time, as in learning a new business skill. Business networking can also be described as a process of establishing a mutually beneficial relationship with other businesses. The benefits of business networking is a widely discussed topic and several different actors²³ have presented lists of the key benefits of business networking. Potential benefits of networking have also been mapped in the Baltic TRAM project where a network of Industrial Research Centres (The IRENet) was established. We present here benefits that can be considered to be of particular relevance for scaling up the businesses of CAROs.

7.4.1 Generating new leads, business opportunities

One of the obvious benefits of networking is to identify opportunities for partnerships, joint ventures, or new areas of expansion for your business. Therefore, networking might open up new opportunities also for European CARO companies. These new opportunities can range from business partnerships to client leads, and from joint ventures to asset or business sales. It could help especially newly established CAROs in growing their business. However, it is up to each individual CARO how to utilise these opportunities. Whether it is a referral, a partnership offer or a request for the company's service, it is important to be ready to seize opportunities when they appear.

²² ECORYS (2014) Business Networks Final report DG Enterprise & Industry

²³ For more information, see for example <https://www.woveon.com/business-networking-and-its-benefits/>, <https://smallbusinessbc.ca/article/five-benefits-networking/>,

New CAROs will become a part of an existing innovation ecosystem, which now consists of analytical research infrastructures and universities. The Baltic Sea region has several important existing large-scale infrastructure installations: the high-energy PETRA-III storage ring at the German Synchrotron Research Centre in Hamburg, the European XFEL in Hamburg and Schleswig-Holstein, MAX IV and the European Spallation Source (ESS) in Lund, Helmholtz-Zentrum Berlin and Helmholtz-Zentrum Geesthacht in Schleswig-Holstein, and the synchrotron SOLARIS in Cracow. CAROs can act as a partner for easier and faster access to these large-scale research infrastructures.

7.4.2 Visibility and marketing

As mentioned earlier, CAROs represent a type of company that is not very well known yet. Therefore, business networking could provide an efficient way for a CARO to gain initial visibility and increase the awareness of its services among relevant target groups, such as other CAROs, or research infrastructures. Being part of a wider network of companies can generate more visibility for an individual CARO. Members of a network can appear under a common “umbrella”, with e.g. a shared visual identity, and thus increase the visibility of the whole network towards targeted customers. Such a shared public identity of the network companies can also contribute to reduced marketing costs. For example, some case examples of already conducted research can be utilised by all CAROs of the network. By attending the events of the network, other members of the network will begin to recognise the company and get to know its core competences. This kind of recognition can help the company to build its reputation as a knowledgeable, reliable and supportive company. A well-known and reliable company is also more likely to be able to generate more leads and referrals.

7.4.3 Credibility

When CAROs need equity financing for the start-up phase or at some other stage of business development, it may be able to find an angel investor or venture capitalist through a network of CAROs. On the other hand, being a part of a network of European CAROs may increase the company's credibility and attractiveness to financiers and angel investors. Once a company's reputation and credibility grow, it will likely be able to get better business opportunities and support. Companies may also be able to help other companies in the network with valuable sources, ideas, and information. This will further enhance the credibility of the company.

7.4.4 Shared knowledge and access to complementing expertise

There are CAROs of different types. CAROs may specialise in certain measurement techniques or technology challenges, or they may operate as brokerage companies. However, the different types of CAROs still have much in common. For a CARO, being a member of a network of companies with similar characteristics in their business can be important for the sharing of ideas and knowledge. Within a group of similar companies, it is likely that there are companies that have already been where some CAROs are today. This provides CAROs with many opportunities to learn, and to avoid some of the common pitfalls that others may have experienced. For example, if a CARO is considering launching its services onto a new market, it could receive valuable advice from another company that has conducted similar business in

that particular or comparable market. Being able to take advantage of the experiences of other CAROs having invested time and money in a particular venture can be of great value.

In strategic alliances with other companies, knowledge sharing is even more important and deeper-going. Forming strategic alliances with companies of complementing expertise can enable especially smaller CAROs to be more competitive on the market, and expand the scope of their activity.

The network of European CAROs provides an opportunity for companies in different stages of the business life cycle to exchange knowledge about, for example, specialised methods and processes, best practices, possible new emerging markets, and the trends of the established markets. A network with interconnected and well-informed representatives of CAROs might work as a gateway to a wider access to valuable and novel information. In a business network, members can receive valuable advice and support from experienced peers. A functional and reliable network can provide a platform for member companies to discuss opportunities and challenges, and open doors to valuable guidance and suggestions.

In addition to internal capacity-building activities, the members of the network may also provide joint training for industrial users, clients and multipliers (e.g. regional development organisations) as part of their own responsibility to promote the network's offering. This kind of training activities could also contribute to increase the quantity of potential customers and revenue generated by the network.

8. Conclusions

The identified 45 European “Core” CARO companies are located in fourteen different countries around Europe. However, more than one fourth of them were German companies. A good tenth of them were located in either France, the United Kingdom or Poland. According to Eurostat, in 2017, the EU’s (EU 28) business economy was made up of almost 27.5 million active enterprises. Therefore, the identified European Union “Core” CARO companies represent a negligible proportion of the total European Union business.

Our analysis revealed that the average age of “Core” CARO companies was higher than expected at the start of the research project. The average age was close to twenty years and even the median age was fourteen years. The companies identified were therefore not as young as anticipated. However, approximately one tenth of the “Core” CARO companies were five years old at maximum, and a good third were ten years old at maximum.

In our analysis, we divided the CARO services in five different categories: consultancy, testing, analysis, equipment, and other services. The category “Other services” included, for example, training, seminars, and software. Almost all “Core” CARO companies offer consultancy services, and a vast majority offers testing and analysis services. Most of the “Core” CARO companies are not limited to one service, but offer a wide range of different services. Three quarters of them provide services in at least four of the above mentioned service categories. Only a handful of “Core” CAROs have specialised in one service category only. Almost all “Core” CAROs operate in international markets, with only a few “Core” CAROs concentrating merely on their domestic markets.

The profitability of the actual operations (EBITDA margin) of the “Core” CARO companies has increased during the 2010s, and in 2018, it was approximately 16 percent. The median net result margin of “Core” CAROs has displayed some volatility in the past couple of years, ending up at close to ten percent in 2018. Despite favourable profitability development on the industry level, approximately one fifth of the “Core” CARO companies were unprofitable in 2018. However, there is significant polarisation in the profitability of the companies because one quarter of the “Core” CAROs had a net profit margin of over 20 percent in 2018.

The solidity of the “Core” CAROs, as measured in terms of the median equity ratio, has been on a good level ever since the beginning of the past 10-year period, and on an excellent level during the past three years, rising to almost 67 percent in 2018. In 2018, approximately one out of eight of the “Core” CARO companies had poor solvency.

A further analysis of the “Core” CARO companies on the productivity and profitability axes revealed that, in 2018, only one out of them could be classified as a “Swamp” company, which implies an unprofitable company with low productivity. On the other hand, approximately one third of the “Core” CARO companies are “Business Class” companies that are profitable and their productivity is better than average.

In general, new materials research services can create added value and novel solutions for the client industries and the society by solving local and global challenges through research. As a conclusion of this study, the rapid technological development of the modern world, and the importance of materials research in different industrial fields, together with a small number of existing CAROs, give a strong indication for the need of new CAROs especially in the

various fields related to materials research. Examples from the medical sector show that the outsourcing of research activities can have a remarkable positive influence for the companies operating in the medical industry. Based on that, one could anticipate that there could be market opportunities for new commercial CAROs also when they are operating in other sectors besides the medical sector.

According to the financial analysis of a small number of already operating CAROs, there is a good possibility of new CAROs becoming profitable companies. New CAROs could take inspiration from the service categories of older profitably operating CAROs and provide expert services related to consultancy, testing, analysis, equipment, and training activities. Our study also reveals that almost all “Core” CAROs operate in international markets, so that would also appear to be key for profitable operations.

Despite their heterogeneous nature, the importance of networking is a thing that is common to all CAROs. Through networking, CAROs can leverage synergies with partner organisations, and get new business opportunities, gain visibility, build credibility, and get access to complementing expertise. It is therefore recommendable that networking activities for CAROs be developed and marketed to the stakeholders in the CARO industry.

Finally, the SWOT analysis conducted suggests that the CARO business reflects similar characteristics as the sales of other expert services. Demand-related uncertainties represent some of the most central challenges for CAROs, as CARO services are not yet known well among potential customers. Furthermore, the potential customers may be operating similar functions by themselves, or they may not be accustomed to outsourcing such services. It would seem to be recommendable for CAROs to strive to gain visibility on the market through increasing their focus in marketing and networking activities. This may necessitate the hiring of new staff that are knowledgeable in the areas of business, communications and public relations, but that could well turn out to be a profitable investment in the future performance of the CARO.