European Optical Society Coherence for Europe ®

Report on Swedish photonics industry

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1. Introduction and executive summary

The term photonics[1] was first coined by the French scientist Pierre Aigrain back in 1967. However, due to its horizontal nature, photonics has for a long time not been recognized as an independent research area and branch. Just recently, people have become aware that photonics is playing an increasing role in many key economic areas like manufacturing, information and communication technologies, life sciences and health etc. The photonics world market was worth EUR 228 billion in 2005, and it is expected to nearly double in the next ten years[2]. With EUR 43.5 billion, European photonics production is now equivalent to that of microelectronics, and is expected to exceed it soon[2].

As a consequence of this development, many countries in Europe and worldwide have started activities in the field of optics and photonics: Germany successfully set up a dedicated funding programme in photonics a decade ago; the United Kingdom defined a national photonics strategy in 2007, and the European Commission now regards photonics as one of the key strategic technologies for Europe. In 2006, an industry driven European association, called Photonics21 was established to make people aware of the overall impact of photonics on economy, and to create a comprehensive research strategy.

In this document, we present a survey on Swedish companies in the field of optics and photonics. The study was initiated by the Swedish Optical Society, Kista Photonics Research Centre (KPRC), Swedoptronics and Vinnova, feeling the need to make the Swedish photonics company landscape more transparent to policy makers and industry alike. Furthermore, the study attempts to estimate the impact of the photonics industry for Sweden including:

- number of companies present (in comparison with other European countries)
- employment structure and qualification of employees
- qualification level of workforce needed by industry
- turnover of industry (estimate)
- markets where Swedish companies are active in
- relevance of public funding for industry
- R&D activities and budget

The results may be useful for policy makers to adjust public funding strategies in this field but also for the photonics industry in Sweden.

246 companies were identified, which is higher than the expected goal of 150 companies. 234 companies answered the questionnaire, which corresponds to a response rate of 95%. It shows a high interest and commitment of the industry in the sector to support this study.

[1] Definition photonics: *"Photonics is the science of the harnessing of light. Photonics encompasses the generation of light, the detection of light, the management of light through guidance, manipulation, and amplification, and most importantly, its utilisation for the benefit of mankind."* [Towards a Bright Future for Europe - Strategic Research Agenda in Photonics, European Technology Platform Photonics21, 2006]

[2] Photonics21 study "Photonics in Europe-Economic impact"

Key results of the study are:

- the number of photonics companies is continuously growing: 34 % of Swedish photonics companies have been established in the last 8 years
- Sweden has the 2nd highest number of photonics companies/per capita in Europe
- Swedish photonics industry is mainly SME based
- engineers and scientists are the labour force mostly needed by the photonics industry
- the overall production volume of the Swedish photonics industry is estimated at EUR 2.5 billion
- the photonics industry is active in many different industry sectors with manufacturing, ICT, science and life sciences & health being the most relevant
- photonics is a highly innovative branch: 40% of companies spend more than 10% of their turnover on R&D
- the interest of companies in participation in the EC framework programme has significantly decreased from FP6 to FP7

The survey was carried out by the European Optical Society (EOS).

2. Methodology for selection of companies in the optics and photonics field

The OPERA2015 database (www.opera2015.org respectively: www.dynamo.tno.nl) served as an initial pool for companies in the field of optics and photonics, furthermore the internet was searched and professional experts in the optics / photonics field and experts of national agencies initiating research programmes (Swedoptronics, Kista Photonics Research Centre (KPRC), Swedish Optical Society, etc.) were consulted for their expertise.

To define the photonics industry, we have adopted the fields used in the OPERA2015 project. These are:

1. Photonic components and subsystems providers
2. Photonic systems and infrastructure providers
3. Providers of services based partly on photonic technologies
4. Distributors
5. Users (large) of photonic instruments and components
6. Consulting companies
7. Others (e.g. even opticians through their own databases and associations)

The companies working as opticians as well as the ones working as broadband suppliers have not been included in the survey. Preliminary tests have shown that the survey does not fit their field.

The information was collected by compiling a questionnaire (see annex I) which was send out to 246 companies which were identified as described above. The questionnaire was accessible and could be completed online. The addressed companies could also send the data back via mail and fax.

Out of the 246 addressed companies,

- 97 companies answered the survey
- 68 companies said explicitly that they don't want to answer

In total, 165 companies replied in the first attempt. The companies that did not want to answer were then asked why. They were given 4 options:

A) Don't have time.

B) The survey is irrelevant for our company.

C) We never answer surveys, for reasons of principle.

D) Other.

The result was as following:

16 did not have time, 36 did not think that the survey fit their company (here we lost some companies that are pure sales companies, and therefore considered most of the questions irrelevant for them, and some companies that are active in, for example, the fields of

displays, LCD, cameras, optical components, fiber optics, and IR-detectors, which still did not consider the questions relevant for them). 4 never answer surveys, and 6 referred to other reasons.

Finally, 7 companies just answered that they did not want to participate in the survey, no reason given.

The following listing shows the total number of companies in relation to the questions answered.

- 94 answered the questions on "Number of employees"
- 78 answered the questions on "Qualification of existing staff"
- 79 answered the questions on "Turnover"
- 73 answered the questions on "Optical market"
- 91 answered the questions on "Market field"
- 89 answered the questions on "Product groups"
- 78 answered the questions on "R&D budget"
- 89 answered the questions on "R&D Programmes"
- 86 answered the questions on "Number of employees in R&D staff"
- 57 answered the questions on "Qualification needed"
- 66 answered the questions on "Innovation strategy"
- 58 answered the questions on "In what field would R&D support be needed"

It should also be noted that this survey does not include research institutes or universities. The survey carried out by the OPERA2015 project on the European level shows an incomplete list of six research institutes in Sweden (see www.opera2015.org) and an additional national survey could be more detailed and would mirror a more complete figure on the number of people employed in the optics and photonics sector in Sweden.

Below, we present and discuss the results topic by topic. Wherever suitable, the results of the Swedish survey were compared to the results of the European survey carried out by the European project OPERA2015 as well as to the results of the report on Photonics in Europe – Economic impact published by the European Technology Platform Photonics21.

Within the project OPERA2015, 2019 companies in the optics and photonics field have been identified and analysed.

- 1927 companies in the 27 EU member states
- 92 companies in EU candidate countries and associated countries.

3. Analysis and results

The analysis is described along the questionnaire (annex II). We have tried to compile an "interested driven" interpretation on the results. When there were obvious deviations or similarities to the European survey, we raised this fact. The data of the European project "OPERA2015" is presented on a yellow background for easy differentiation and the data of the Photonics21 survey is marked as well.

3.1. Foundation date of company

The number of companies founded in the optics and photonics field in Sweden increased steadily by the years. In the last eight years 34% of the companies were founded while only 4% of the companies had started their business before 1970. This shows that the sector is very innovative and a lot of companies are young.

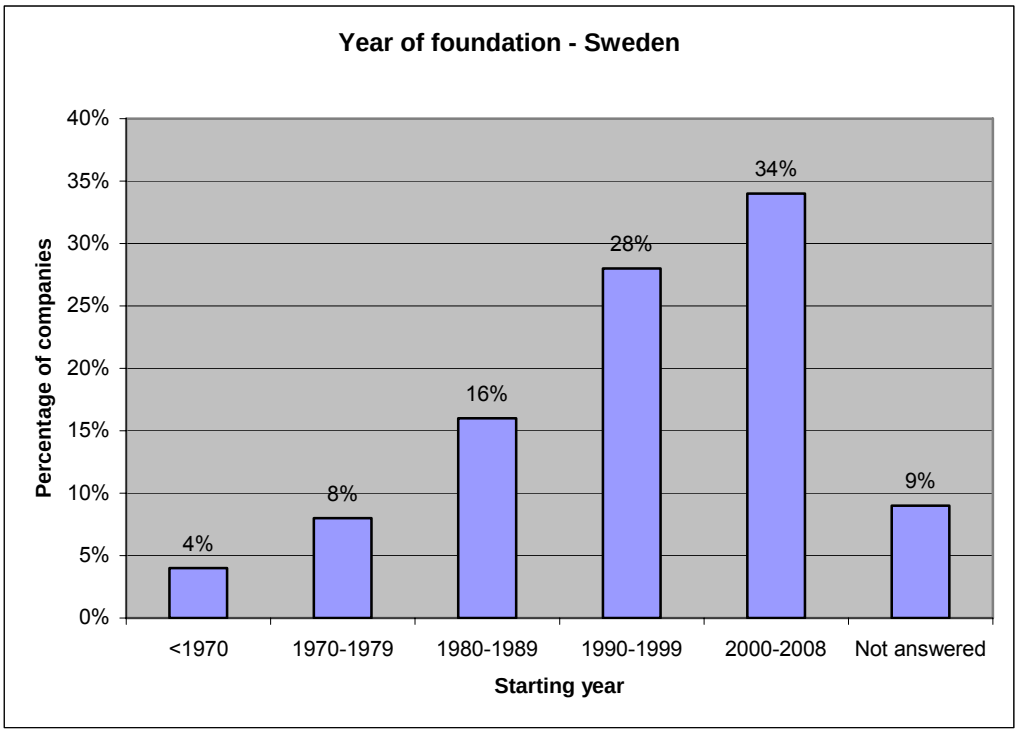

Figure 1: Year of foundation. The answering quotient (AQ) was 90/97 ≈ 93% (90 out of 97 companies answered this question).

3.2. Number of employees

It is noticeable that 50% of the companies have ≤10 employees. In comparison with Europe the situation is similar. 50% of the companies are small in terms of employees. The total number of employees in this sector is estimated to be 4200, which is 1.7% of the European labour force employed in photonics[3].

[3] Photoncis in Europe – Economic Impact: [Photonics employs 246,000 people in Europe…]

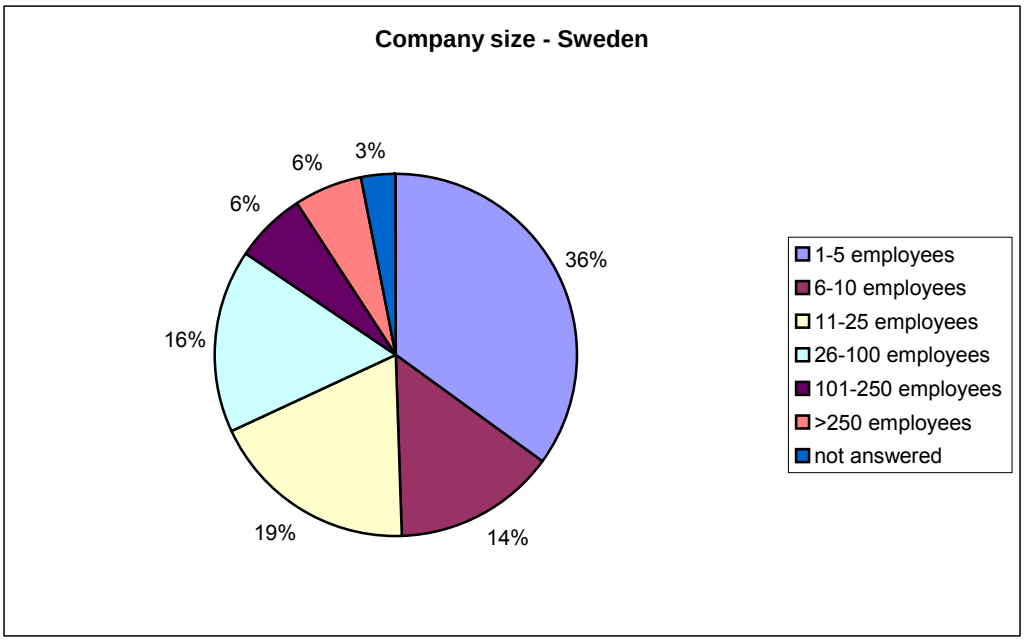

Figure 2a: Company size, in terms of number of employees. AQ: 94/97 ≈ 97%.

"In Europe just over half of the optical companies are micro-enterprises and almost 90% of the optical companies are SME (less than 250 employees). In Europe in general it is noticeable that the share of companies with size 250-499 employees is smaller (4 %) than the share of companies with 500 employees or more (9 %)" [OPERA2015][4]

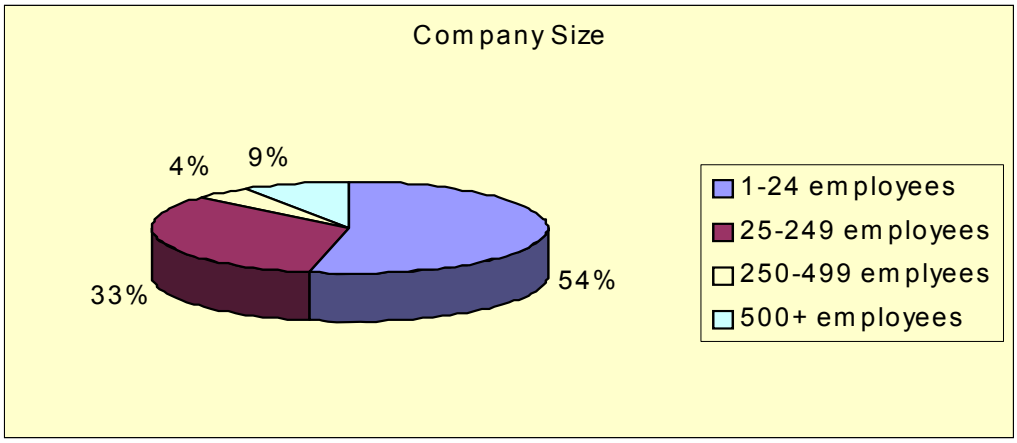

Figure 2b: Company size in terms of number of employees in Europe; OPERA2015[5]

[4] OPERA2015 report on workpackage 3, the Netherlands Organisation for Applied Scientific Research,TNO, 2008

[5] OPERA2015 report on workpackage 3, the Netherlands Organisation for Applied Scientific Research,TNO, 2008

3.3. Qualification of existing staff

Besides the size of a company the qualification level of the staff is an important description factor in the field. From the European perspective we know that the average of the qualification level in the photonics industry is relatively high. This reflects the complexity of the technology (like in the beginning phase of the "electronic age").

The qualification of existing staff was measured in number of employees within four different categories: *High skilled workers*, *Technicians*, *Engineers* and *Scientists* (see fig. 3a). An indisputable majority of the companies has 1-5 employees in all categories. Considering the company size (see fig. 2a) this is perfectly reasonable. Engineers are in a narrow majority. It shows that the field is an R&D intensive with highly qualified people employed.

Sweden's labour force had the 4th highest share of scientists and engineers in the EU (6.5%) in 2006. The highest share had Begium with 7.9%.[6]

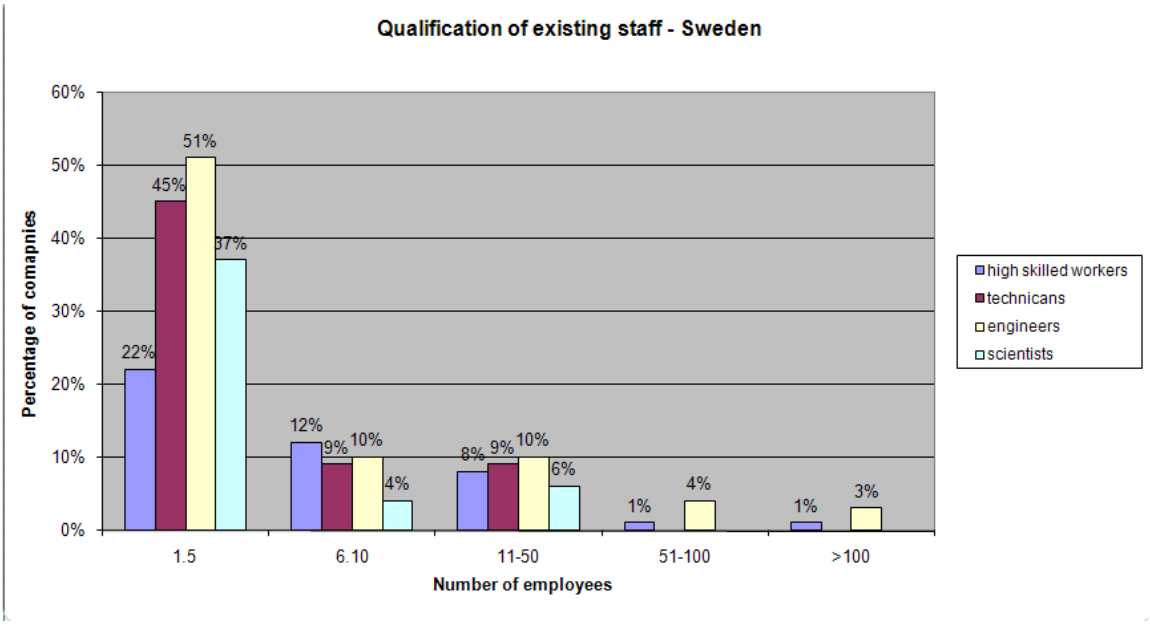

Figure 3a: Qualification of existing staff, in terms of number of employees within the different categories of qualification. AQ: 78/97 ≈ 80%.

The figures 3b-3f show the detailed allocation of the qualification of existing staff in the different sizes of companies. Only those who answered both "number of employees" and "qualification of existing staff" are included. When adding the number for all qualifications the total number doesn't equal the total number of employees. Hence, the remaining are summarized in "Other" in the chart. It is obvious that in the companies with less than 10 employees the percentages of engineers and scientists are higher than in bigger companies.

[6] Science, Technology and Innovation in Europe, Eurostat news release, 34/2008 – 10 March 2008

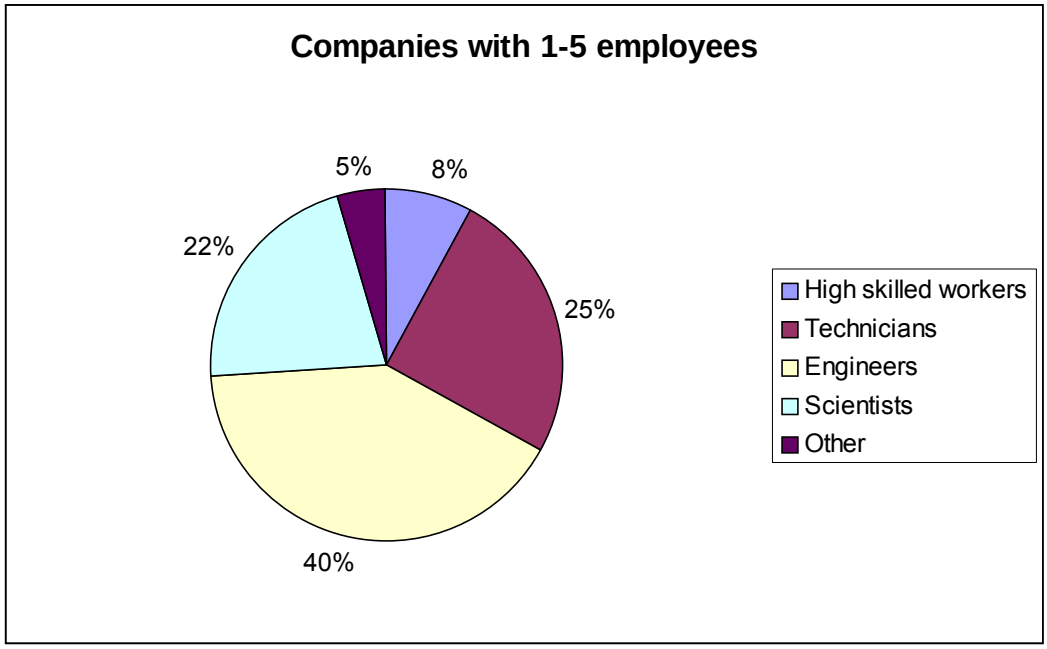

Figure 3b: Qualification of existing staff, in terms of number of employees (1-5)

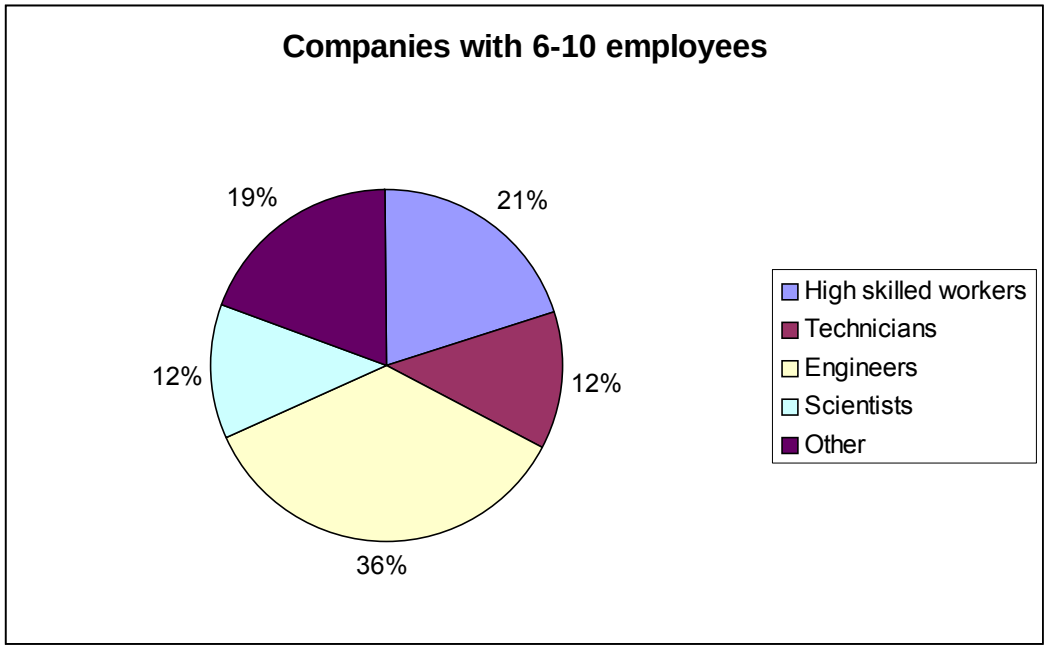

Figure 3c: Qualification of existing staff, in terms of number of employees (16-10)

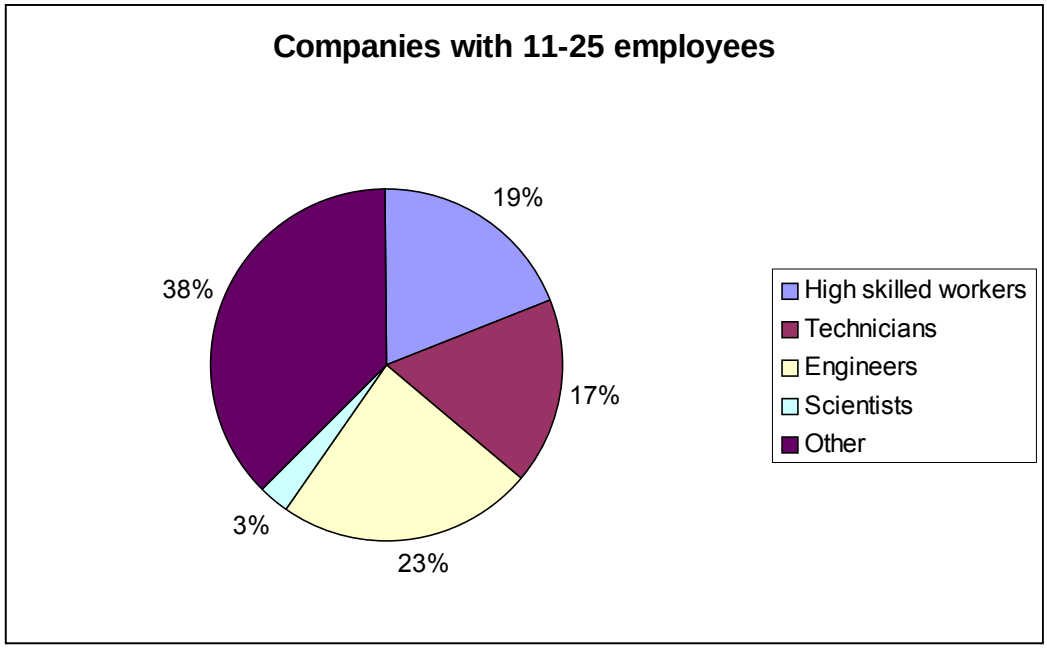

Figure 3d: Qualification of existing staff, in terms of number of employees (11-25)

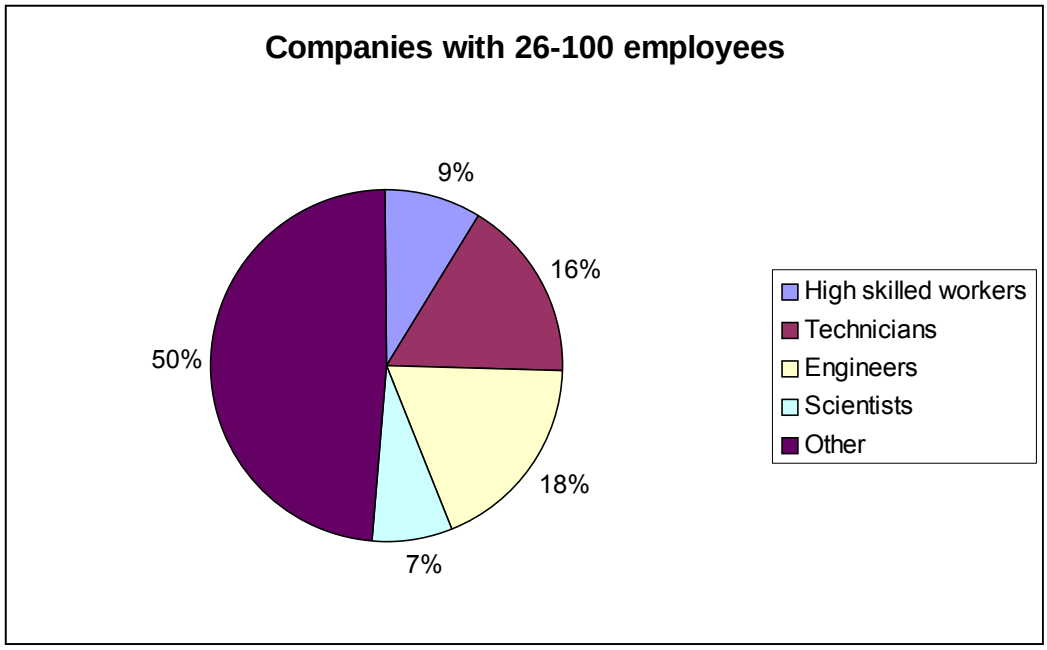

Figure 3e: Qualification of existing staff, in terms of number of employees (26-100)

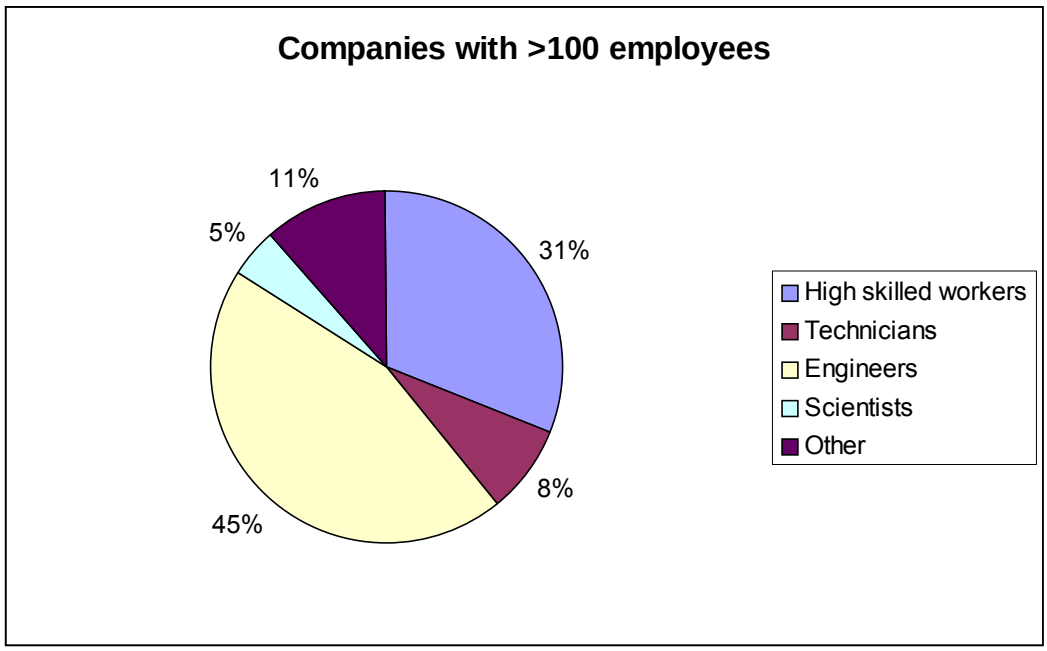

Figure 3f: Qualification of existing staff, in terms of number of employees (>100)

3.3.1. Qualification needed

Optics and photonics is an innovative industrial sector with a highly growing rate in respect of numbers of companies and employees. It has a considerable impact factor to the complete production technology of a country.

The need for qualified staff in this sector is evident. Scientists and engineers as human capital are essential for the success of a company.

In SMEs typically R&D and production go very close together. In larger companies we still see a higher degree of top qualified employees. In our survey the companies with more than 50 employees do not reflect the typical R&D rate like in the European survey. In Sweden, the SMEs are the main employers for high qualified people not the companies with more than 50 employees.

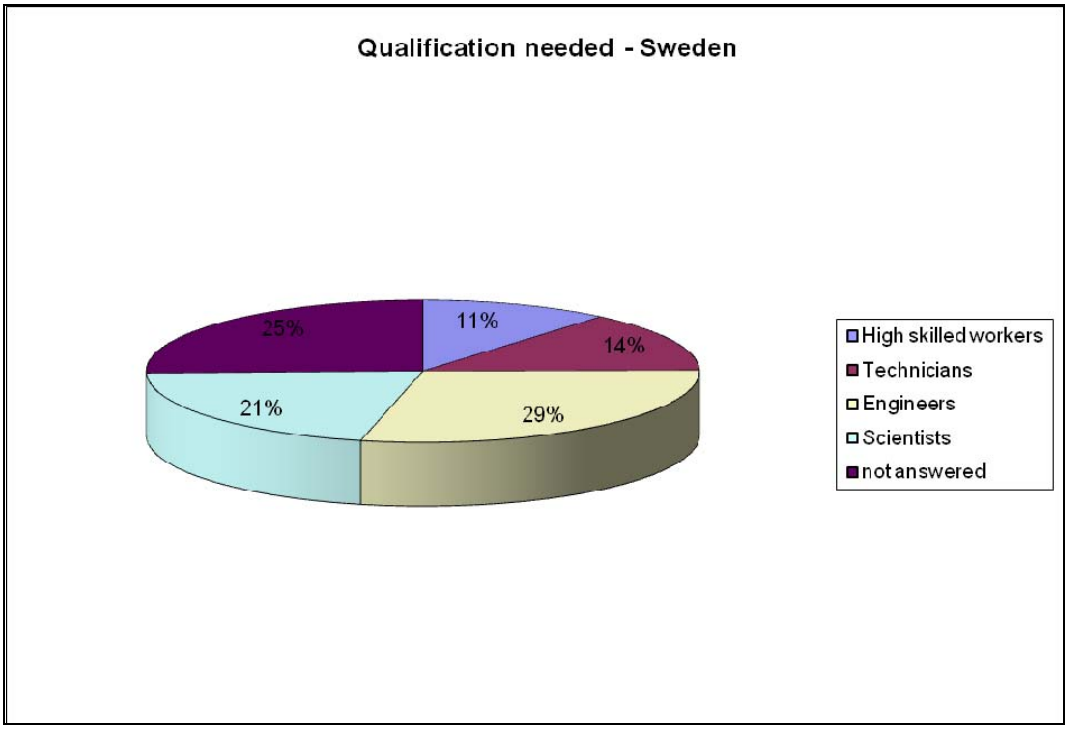

Figure 4: Qualification needed. AQ: 57/97 ≈ 59%.:[7]

To investigate what qualification is needed in Sweden, the four categories used to determine the qualification of existing staff were once again applied: *high skilled workers*, *technicians*, *engineers* and *scientists*. Engineers and scientists are the most sought-after qualifications. Noticeable is that engineers are the qualification most needed, even though the same is the most represented qualification of existing staff.

3.4. Turnover

About 50% of the companies show turnovers of ≤5 million Euros. This is compatible with the result from the company size diagram; there are most small companies and, reasonably, the turnovers are relatively small. The total turnover of the companies which answered the survey accounts 1.1 billion Euros. The total turnover for Sweden extrapolated accounts 2.8 billion Euros.

The turnover per employee can be estimated to be 269 thousand Euros which is comparable to the turnover per employee for other Western European countries.

[7] The percentage of companies which did not answer this question (29%) must be seen relative to the 22% of companies which do not have an R&D department.

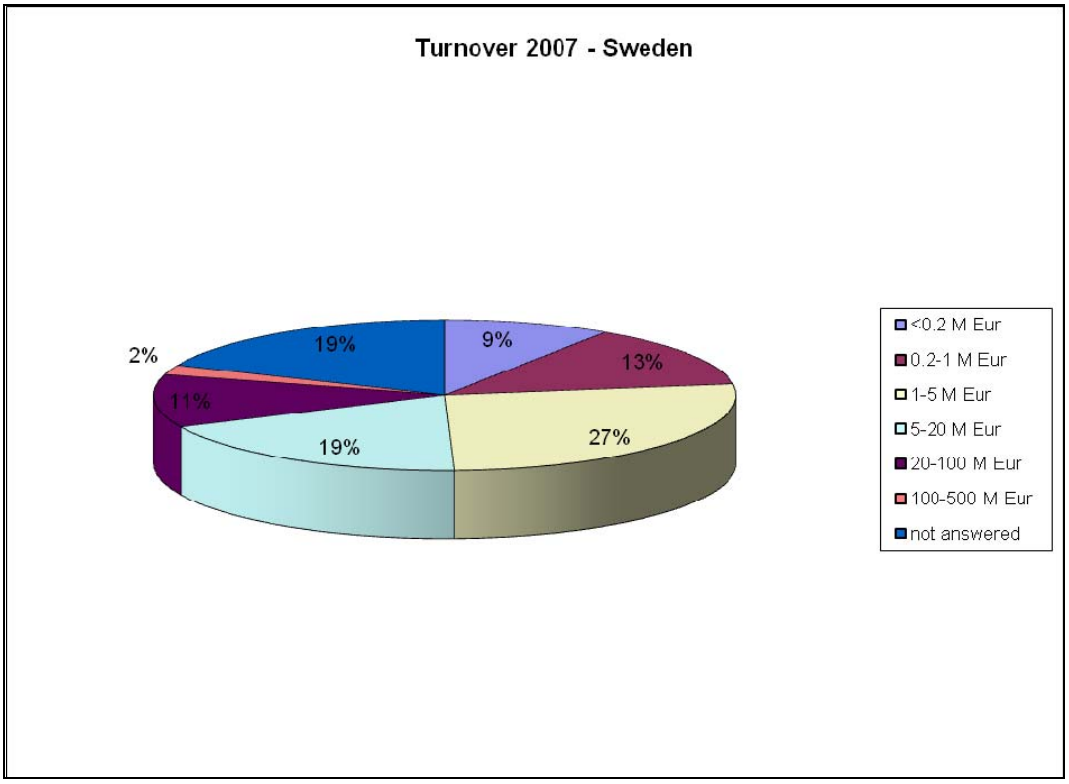

Figure 5: Turnover 2007 for Swedish companies in optics and photoncis, in terms of million euro. AQ: 79/97 ≈ 81%.

Production volume

Figure 5b shows the production volume of the photonics industry for Sweden. Therefore, the consultants and sales companies are taken out of the calculation of the turnover and extrapolated for the production volume.

The production volume of Sweden (2.5 billion Euros (see figure 5a)) has a share of 6% (see figure 5b) of Europe's production volume. This is a high number for a population of 9 million which is only 2% of Europe's population.

Figure 5b shows the production volume in the optics and photonics field for Europe for comparison (43.5 billion Euros)

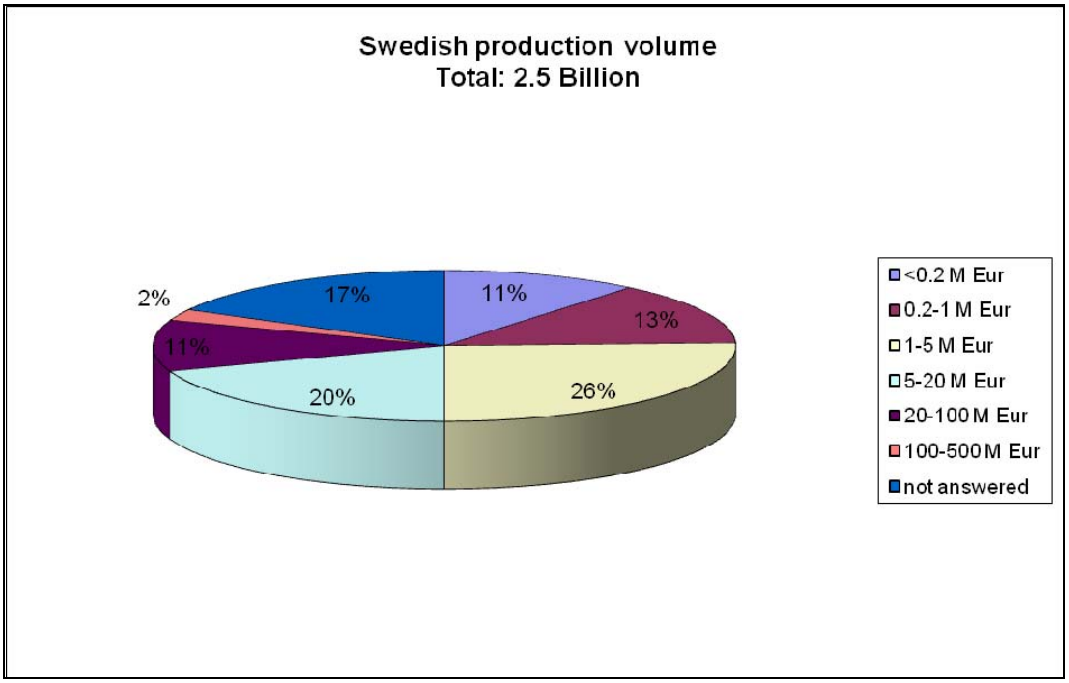

Figure 5a: Swedish production volume

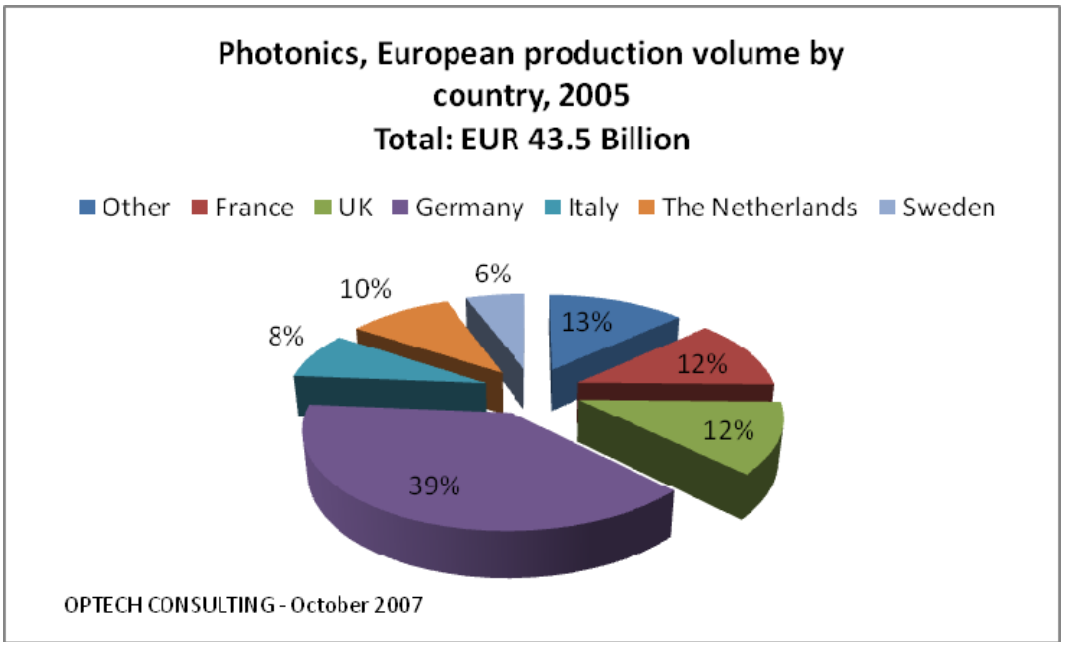

Figure 5b: Photonics, European Production Volume by country; data from Photonics21[8] and Swedish photonics industry data

[8] Photonics in Europe Economic Impact, European Technology Platform Photoncis21, 2007

4. Optical Market

4.1. Market scope

The market scope describes the regions where to optical companies in Sweden export their products. Most of the Swedish companies have a national market scope.

The optical market was estimated with the market scope (in rough numbers) for seven different regions:

- Sweden
- EU
- Europe without EU
- USA
- China
- Japan
- Elsewhere

It can be noted that Swedish companies have a low turnover in Japan, USA and China that means that they are not very active in these countries. Sweden has the largest market scope on the national market[9]. One reason for the low market scope in Japan, China and USA is the high number of SMEs (small and medium-sized enterprises) in this sector in Sweden and the that the majority of the companies are relatively young (see figure 1) and first try to get a market share on the national market before they can find their market elsewhere.

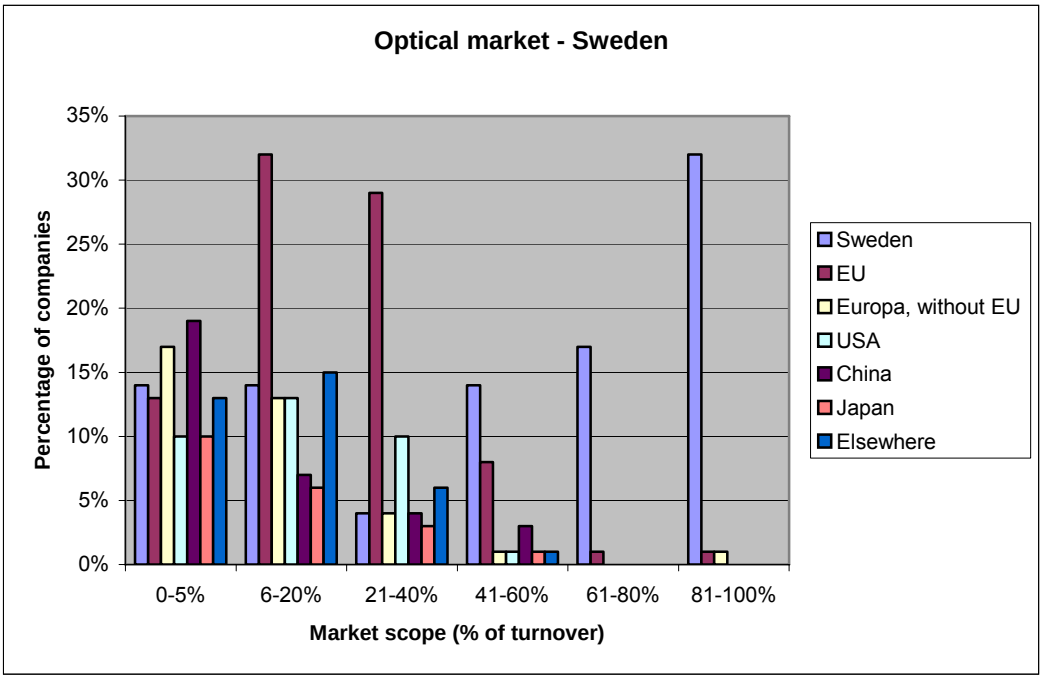

Figure 6a: The optical market as an overview of the market scope (% of turnover) for different regions. AQ: 73/97 ≈ 75%.

[9] Most of the larger companies did not answer this question which affects the percentage of the international turnover. The conclusion may be a bit uncertain in this respect.

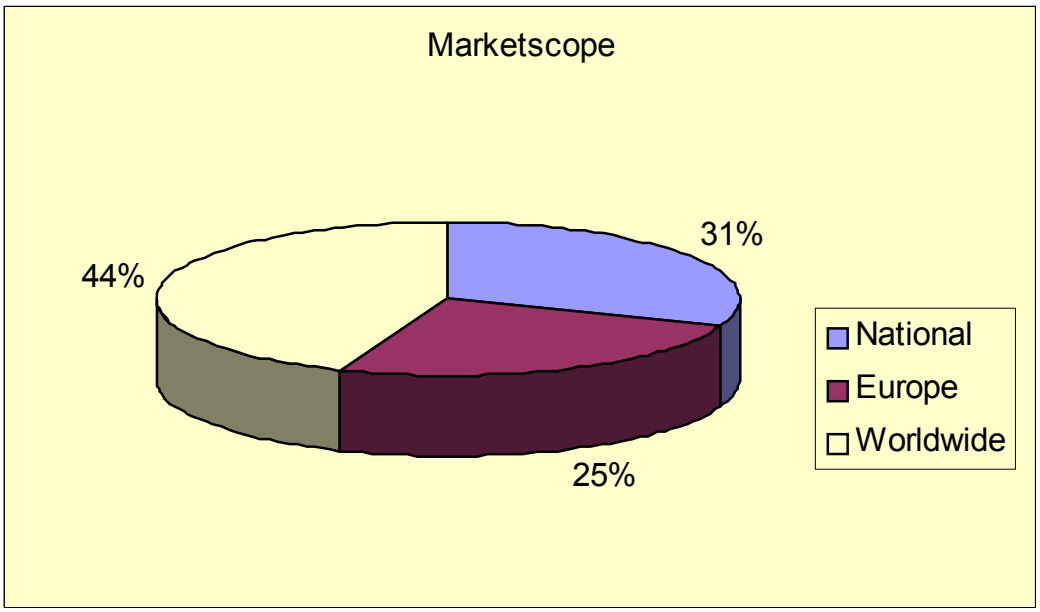

Figure 6b: The market scope for companies in Europe; OPERA2015

On the European level 44% of the companies indicated that their market scope is worldwide followed by 31% of companies whose aim is the national market.

"The market scope for European optical companies is for roughly one third at the national level, one third at European level and one third at worldwide scope. For French optical companies the main scope is at the national level (57 %). UK optical companies concentrate on the national level and worldwide, and less on the European market (16 %). German and Dutch optical companies focus on European and worldwide market, and less on national market (Germany 15 % and Netherlands 10 %). For Italian optical companies the market scopes national, Europe and worldwide are more or less equally important." [OPERA2015][10]

4.2. Market field

The photonic industry is a widespread area and more, it is an enabling and a cross-disciplinary field.

In this study we have divided the fields into 8 sectors to have convergence with the European studies:

- Manufacturing & Quality
- Defence
- Education
- Life science & Health care
- Science (safety & security)
- ICT & Imaging

[10] OPERA2015 report on workpackage 3, the Netherlands Organisation for Applied Scientific Research,TNO, 2008

- Telecommunication
- Lightning & Displays

The market field that is most often linked to the optical companies in Sweden is *Manufacturing & Quality 23%*, followed by *Life science & Health care 17%* . Here, the sizes of the companies are not taken into account the result is based on the number of companies within each sector only. The companies can also be active in more than one market field.

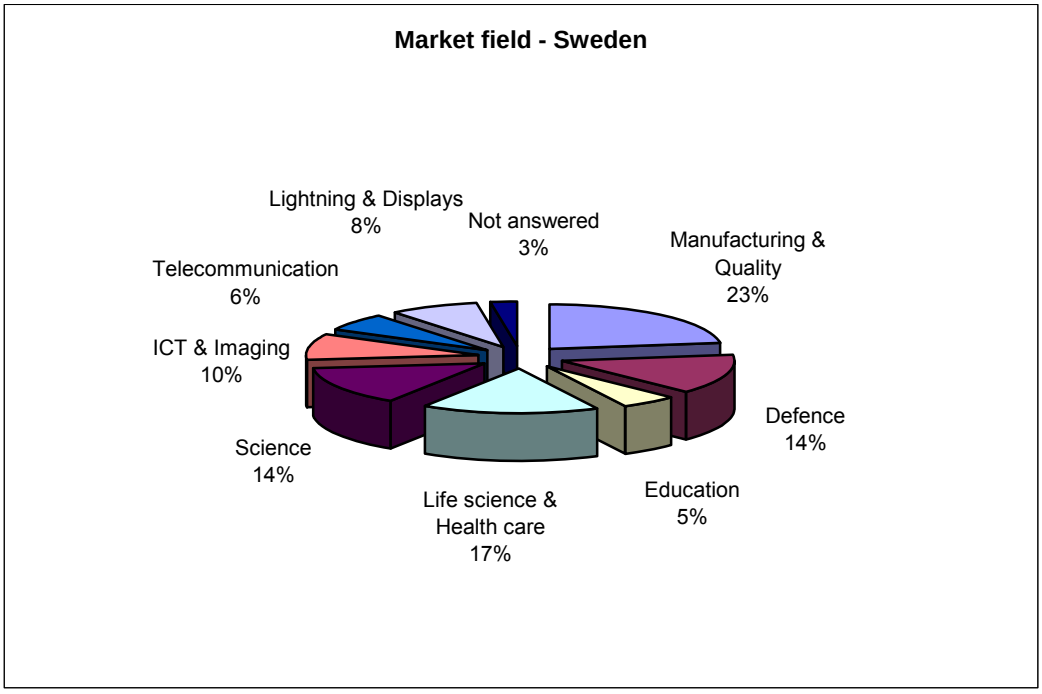

Figure 7: Market field, based on the number of companies within each sector. AQ: 91/97 ≈ 94%.

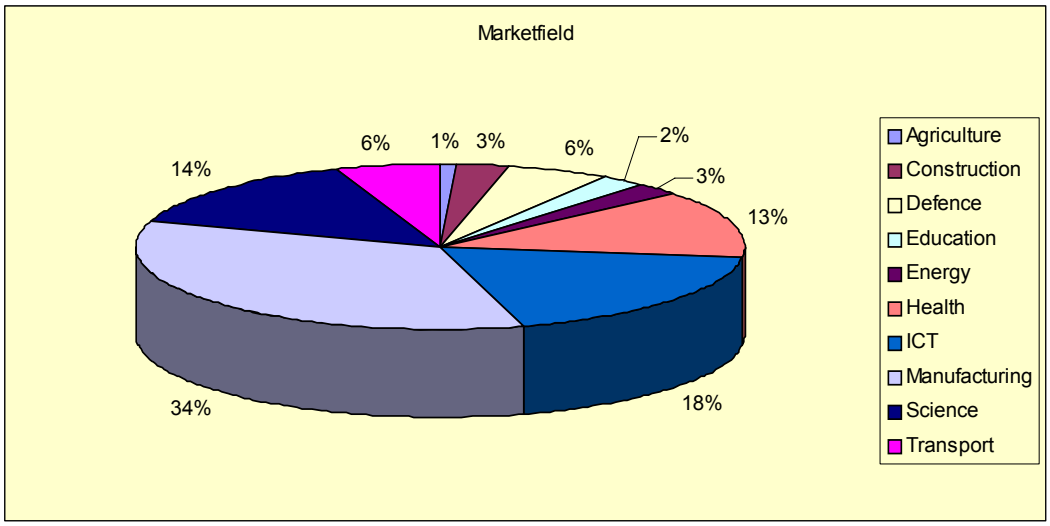

Figure 7a: European market field, based on the number of companies within sectors; OPERA2015

As in Sweden, the largest market field for European companies is manufacturing followed by ICT and science. Also life science and health care are an important market field.

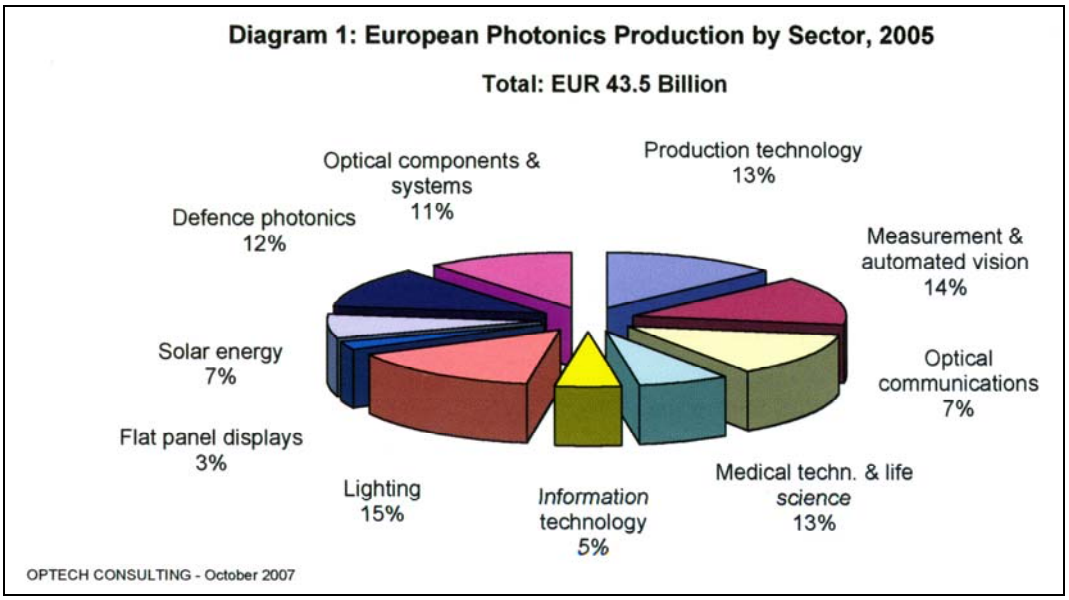

Figure 7b: Market field diagram for the European survey, Photonics21

The market field diagram for Europe is shown in fig. 7b. The result is from the Photonics 21 survey – Photonics in Europe – Economic impact

For comparison with the European study, Photonics in Europe – Economic impact, which applied a division of the market field in10 sectors, the table below shows the correspondence between the two studies.

Photonics in Europe	Swedish survey
Production Technology	Manufacturing & quality
Measurement & Automated Vision	Manufacturing & quality
Optical communications	Telecommunication
Medical techn. & life science	Life science & health care
Information technology	ICT & imaging
Lighting	Lightning & displays
Flat panel displays	Lightning & displays
Solar energy	
Defence photonics	Defence
Optical components & systems	ICT & imaging
	Education
	Science

Table 1: Comparison/connection between the division of market fields in the Photonics in Europe study, and this survey.

By using fig. 7b and table 1 some comparisons can be made. First, by adding the two fields *Production technology* and *Measurement & automated vision* in fig. 7a they correspond to the Swedish sector *Manufacturing & Quality*. The European sector has a share of 27% and the Swedish sector has a share of 24%.

Additionally, the European defence sector counts 12%, while the Swedish counts 14%. This kind of comparison is made between all sectors. The result is shown in table 2.

Market field	Swedish share	European share
Manufacturing & Quality	23 %	27 %
Defence	14 %	12 %
Education	6 %	-
Life science & Health care	17 %	13 %
Science	14 %	-
ICT & Imaging	9 %	16 %
Telecommunication	6 %	7 %
Lighting & Displays	8 %	18 %

Table 2: Comparison between the sizes of the sectors in Sweden and Europe.

The Swedish market seems to follow the European market well, with one exception, *Lighting & Displays*, where the difference is 10%. Also notable is the Swedish share of the *Life science & Health care* sector of 17% in comparison with 13% on the European side.

4.3. Product groups

To sort out the enormous amount of products within the photonic industry, they were divided into 18 groups (some quite extensive):

- Active optical devices
- Cameras
- Coatings
- Detectors
- Displays
- Fibre optics
- Glass & other optical materials
- Information storage
- Instrumentation
- Lasers
- Light sources
- Lighting
- Micro optics
- Nano photonics
- Optical components
- Optical manufacturing equipment
- Test & measurement systems
- Vision

Lasers and *Test & measurement systems* are the most often-mentioned product groups. Similar to the market field, this result is based on the number of indications within each product group, the company sizes are not taken into consideration, and the companies could mark more than one product group.

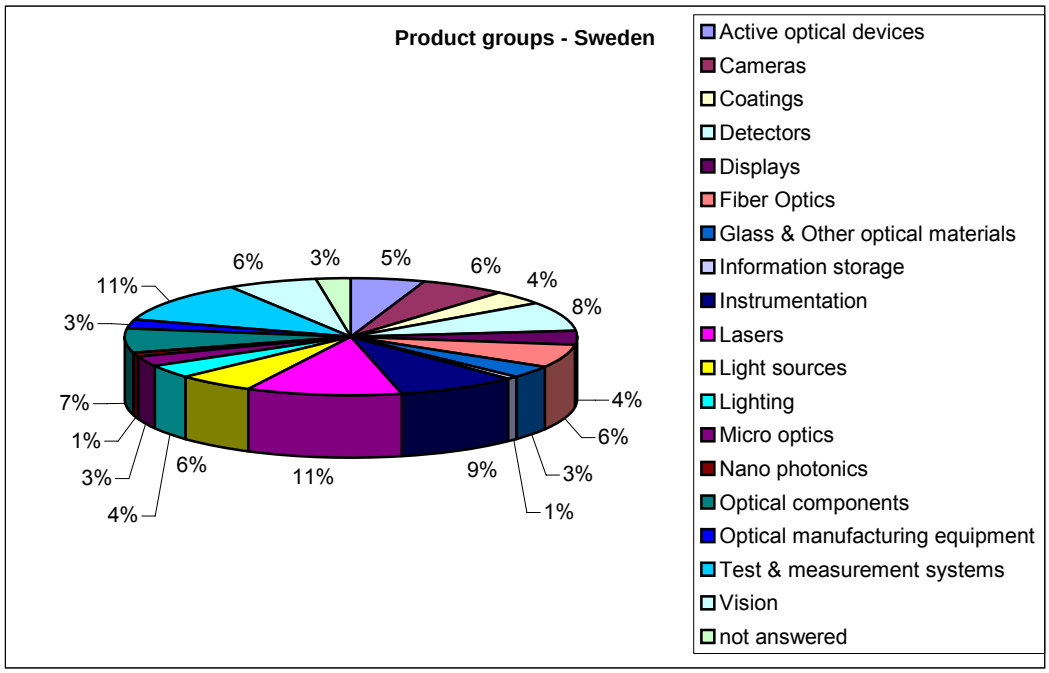

Figure 8: Product groups. AQ: 89/97 ≈ 92%

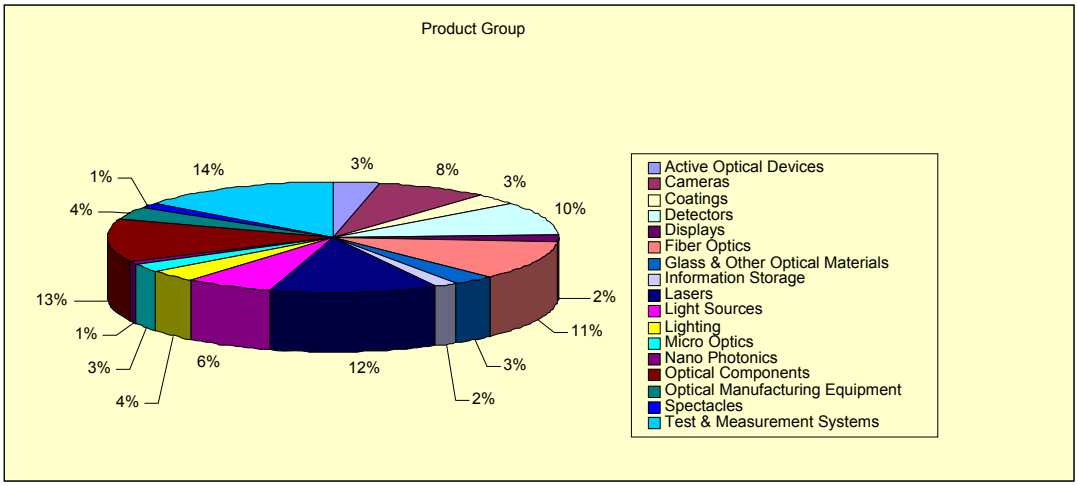

Figure 8a: Product groups of European Companies; OPERA2015

Like in Sweden, European companies are also very active in production of lasers and test and measurement systems. The reasons are obvious, lasers and measurement systems are most relevant for industrial use (e.g. automotive industry) and are best established in terms of years on the market.

4.4. R&D

The number of companies in the field of optics and photonics compared with the percentage of the turnover invested in R&D can also give an indication for the innovation in optics and photonics. The R&D investment generally reflects the willingness to go for future operations. Compared to Europe, Sweden is a highly innovative country in respect of their investments in R&D. According the final report of the OPERA project, only the Netherlands invest more in their R&D per capita.

The exceptional high investment in photonics research and development is in line with the overall R&D intensity (i.e. R&D expenditure as a percentage of GDP) in Sweden, which is - according to Eurostat - highest in EU27 (3.82%of GDP) [11]..

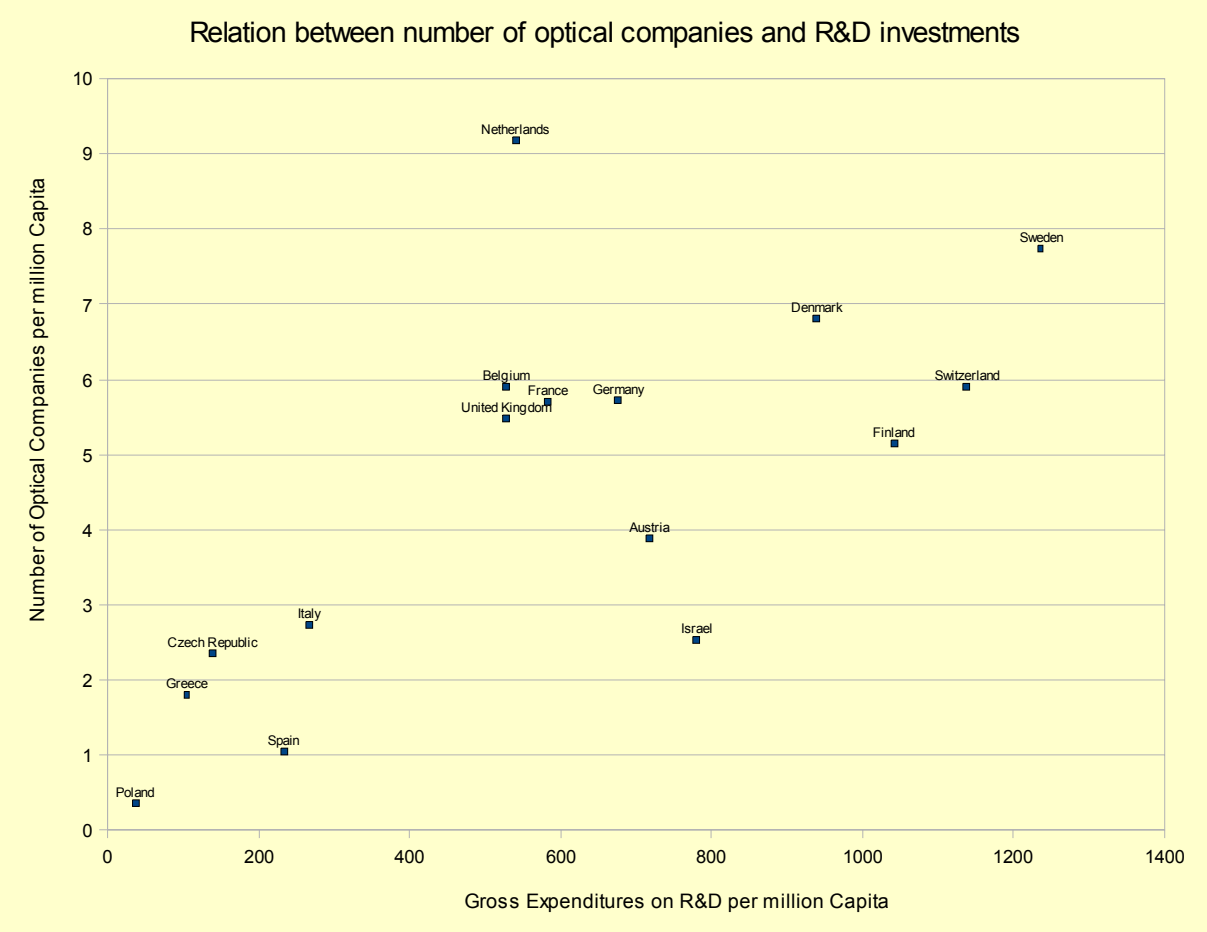

Figure 9: Total number of optical companies per million capita plotted against the gross expenditures on R&D per million capita. Note: countries with less than 20 optical companies have omitted from the graph. (Source: Opera Research 2008, Eurostat 2008, Eurostat 2007 and European Commision 2003) [12]; OPERA2015

[11] Science, Technology and Innovation in Europe, Eurostat news release, 34/2008 – 10 March 2008

[12] See: OPERA2015 report on workpackage 3, the Netherlands Organisation for Applied Scientific Research,TNO, 2008

4.4.1. R&D budget

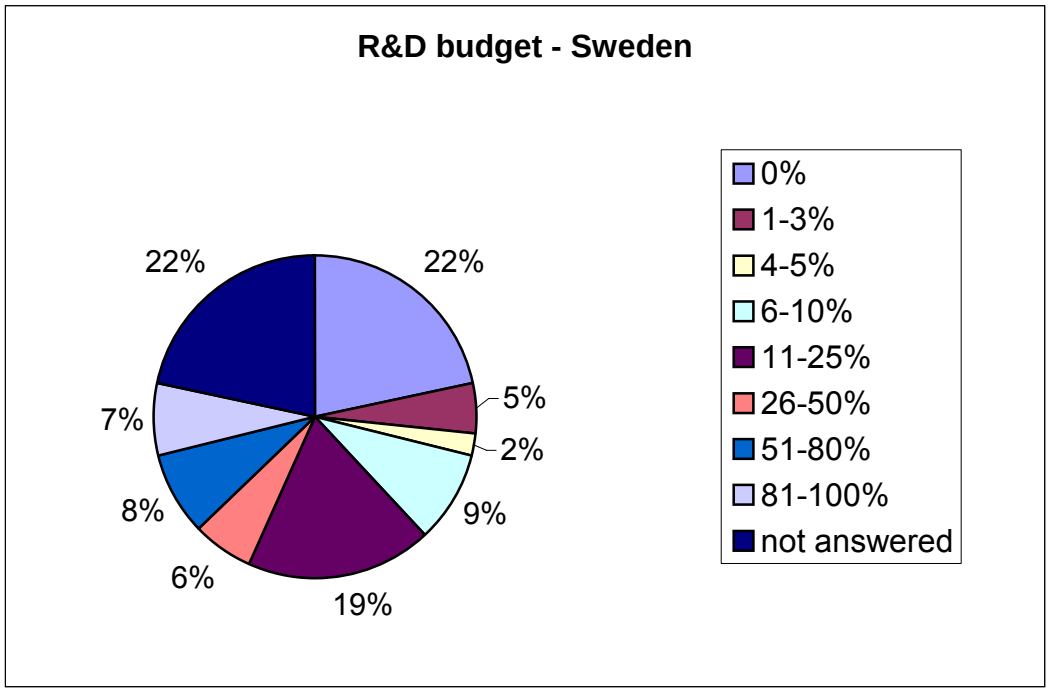

Figure 10: R&D budget, in terms of % of turnover. AQ: 78/97 ≈ 80%[13]

Most of the companies which have an R&D department spend 11-25% of their turnover for R&D (19% of the companies). Only 7 % of the companies spend less than 5 % on R&D. 9 % of the companies spend 6-10% on R&D, 6% spend 26-50% on R&D and 15% spend over 50 % of their turnover on R&D (see fig. 10).

Some of the companies which did not answer the question[14] do not have an R&D department they are for example pure sales companies or consultants. In the above figure these companies are included in the "*0%*" group, which means that the companies that are listed as "*not answered*" in this figure are the ones that have R&D, but did not answer. This share is 22%.

Most of the companies have 1-5 employees in R&D. Since more than 50% of the companies have ≤10 employees there is nothing remarkable with this result and just reflects the superior number of SMEs in this sector.

4.4.2. R&D programmes

Figure 11 shows the percentage of companies that have taken part (or will take part) in R&D support programmes. 37 % of the companies have received R&D support from Vinnova. 29% participated in EU FP6. Only 10 % of the companies have received R&D support from other programmes. For the companies that did not answer either "*yes*" or "*no*" on this question

[13] 22% of the companies do not have an R&D department (concluded from the information 0% of the turnover is spent on R&D budget).
[14] In total, 41% of the companies did not answer this question.

(programme), their lack of response is taken as a "*no*", but there are separate pillars for these anyway to make it clearer.

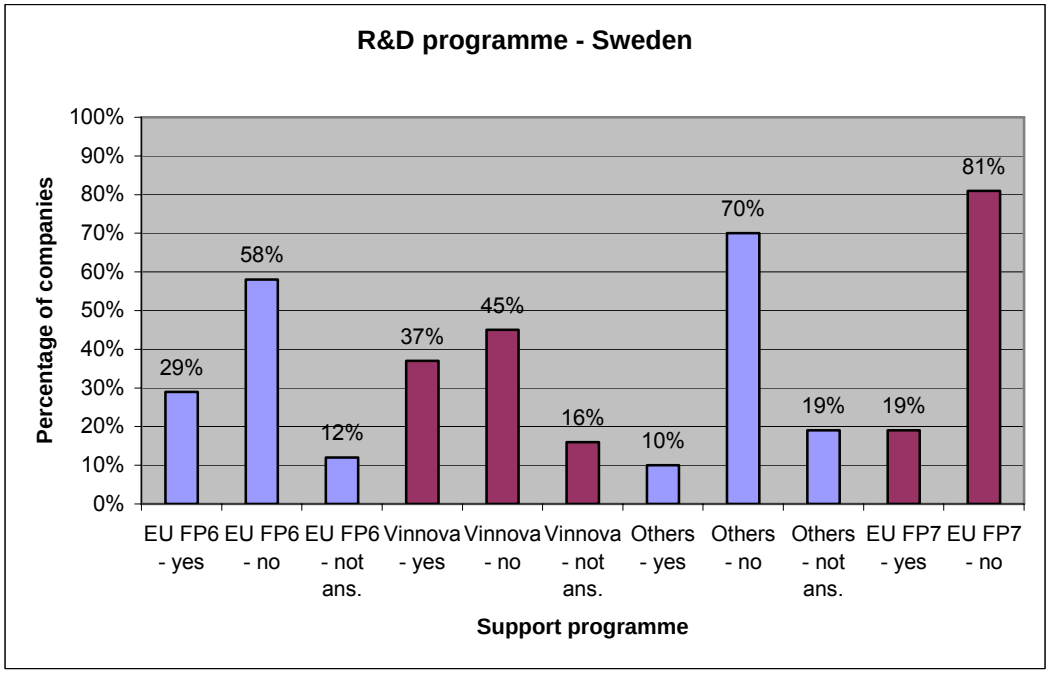

Figure 11: R&D programme: How many companies did/did not participate in EU FP6, receive R&D support from Vinnova, receive R&D support from other programmes and how many plan to participate in EU FP7[15]

Moreover, 75% (21 out of 27) of the companies that participated in EU FP6 also received R&D support from Vinnova. 61% of the companies that plan to participate in EU FP7 also participated in EU FP6, and 56% received R&D support from Vinnova. Only 22% of the companies have taken part of (or plan to) only one support programme, and 46% have not taken part of any programme at all (although, included here are the pure sales companies and consultants for example, which increases this percentage a bit). Hence, it can be seen that it is most common that companies take part of more than one of these support programmes, or none of them.

Further it shows that the companies in this sector barely have access to support from public funding. The consequence could be obstacles in the development of the sector. 29% of the companies participated in the FP6. Only 19% plan to participate in the FP7. It was also notable that several companies asked for more support from the public side e.g. in filing a project proposal, etc.

The companies that had not taken part in EU FP6 or in funding programmes of Vinnova were asked to answer why. The answers are summarized below:

- Bureaucratic processes are too long, cumbersome and complicated to file a proposal for the EU FP6
- Proposals were rejected

[15] The high percentage of companies which did not answer this question (47%) must be seen relative to the 22% of companies which do not have an R&D department.

- Swedish universities and government organizations are too slow and unefficient to cooperate with
- There is no market driven approach from Swedish institutes
- For small companies the application is too time consuming and costly
- In the US, the rules for applying for public funding are more adapted to industry and market demands
- Funding programmes are not known by the companies or the programmes are not suitable

4.4.3. Strategies for innovation

The eligible innovation strategies were:

- Co-operation in R&D
  - Co-operation with companies
  - Co-operation with institutes
  - Co-operation with universities
  - International co-operation
- Create spin-off or joint venture to realize innovation
- Outsourcing R&D
- R&D of innovation inside organisation
- Trading of licences

Co-operation in R&D (with sub-categories) and R&D inside organisation are clearly the innovation strategies most linked to.

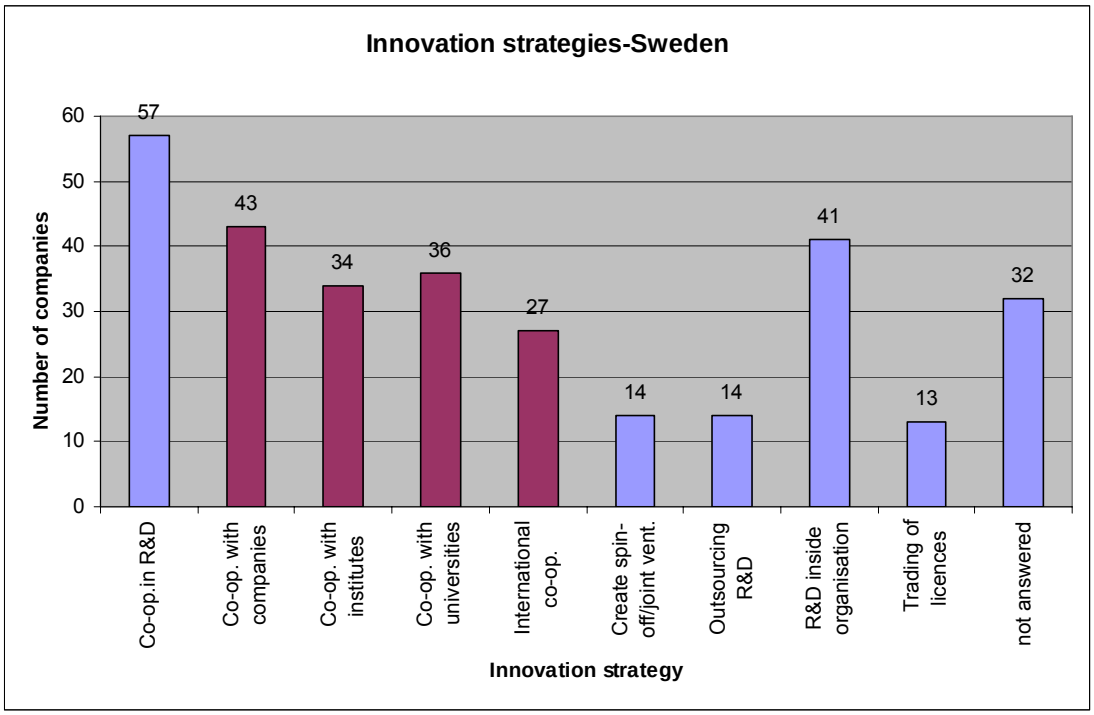

Figure 12: Innovation strategy. AQ: 66/97 ≈ 68%.

4.4.4. R&D support by fields

The figure 13 below shows in which areas the companies would like to see R&D support. There were six main areas to choose from, each with sub-categories. There was also one part left for the companies to include fields that were not already mentioned in the survey. These are collected under the title “Other”, with a more detailed summary in fig. 20.

The eligible innovation areas were:

- ICI (Information, communication & imaging)
- Life science & health care
- Lighting & displays
- Manufacturing & quality
- Optical instruments for science
- Safety & security (including defence)
- Other: this field is left for the companies to make some own choices.

R&D support in ICI is slightly more sought-after than the other areas, but this is only with a tiny margin. In practical it is not possible to extract one area, since the differences are too small.

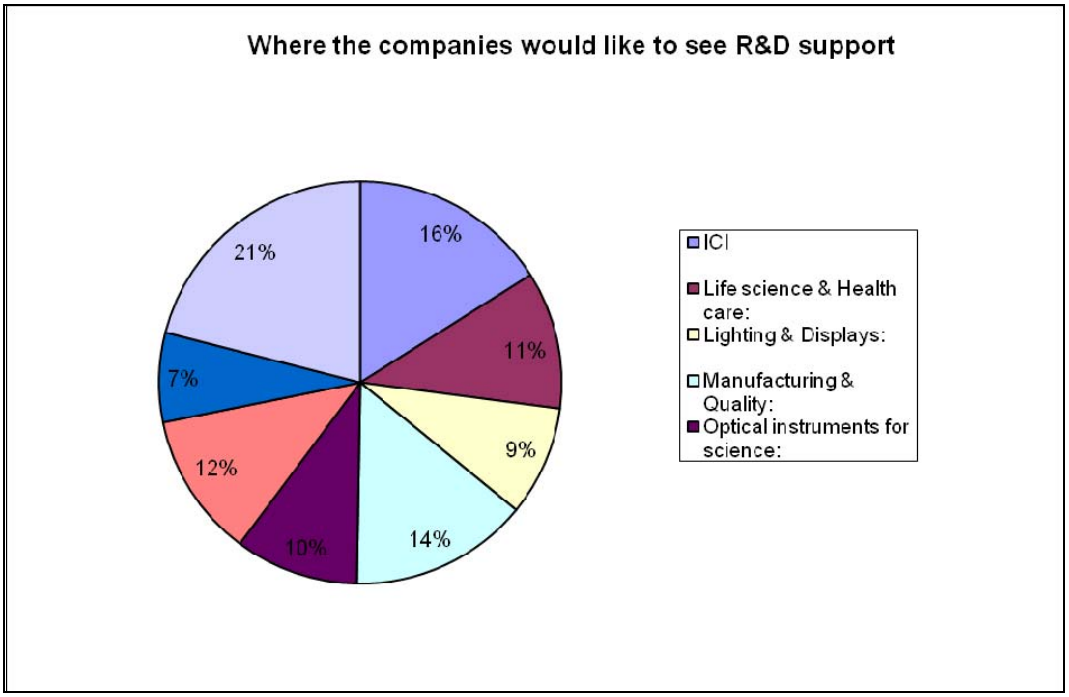

Figure 13: Innovations. Here it is indicated in which areas the companies would like to see R&D support. These are the main fields, which all are divided into sub-categories that are shown in figures below. AQ: 58/97 ≈ 60%...[16]

[16] The high percentage of companies which did not answer this question (22%) must be seen relative to the 22% of companies which do not have an R&D department.

In the seven following figures the innovation areas are shown more in detail, i.e. the sub-categories of each area are clustered. So, even though we cannot extract one or two main fields, core areas to be funded are indeed visible in the subcategories for the companies.

ICI (Information, communication & imaging)

Subcategories for ICI:

- Imaging devices & systems
- Optical communication in automobile & other transports
- Optical data storage
- Optical networks

Imaging devices & systems is clearly the most denoted category, while optical data storage seems to be of no interest at all.

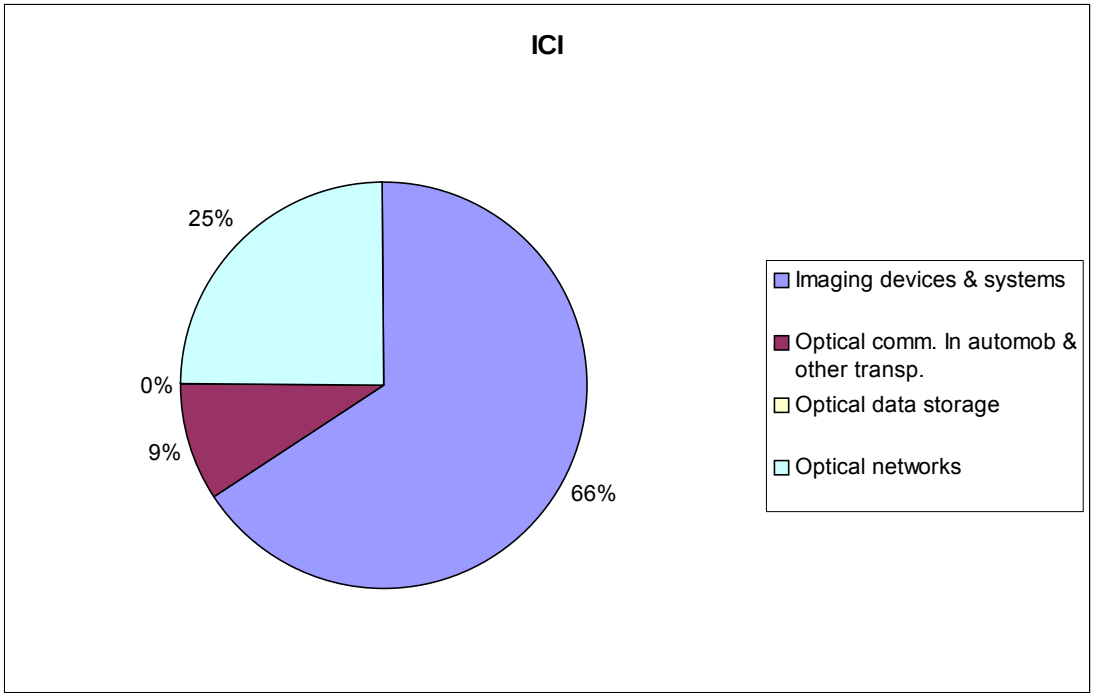

Figure 14: The sub-categories for *ICI n=28*

Life science & health care

Subcategories for Life science & health care:

- Bio-photonics & photonic markers
- Optical techniques for diagnosis in medicine
- Optical techniques for surgery in medicin
- Optical techniques for therapy in medicin
- Optical techniques in pharmaceutical industry

In this field 37% find *Optical techniques for diagnosis in medicine* to be the most important area to put R&D support, followed by *Bio-photonics & photonic markers* (24%).

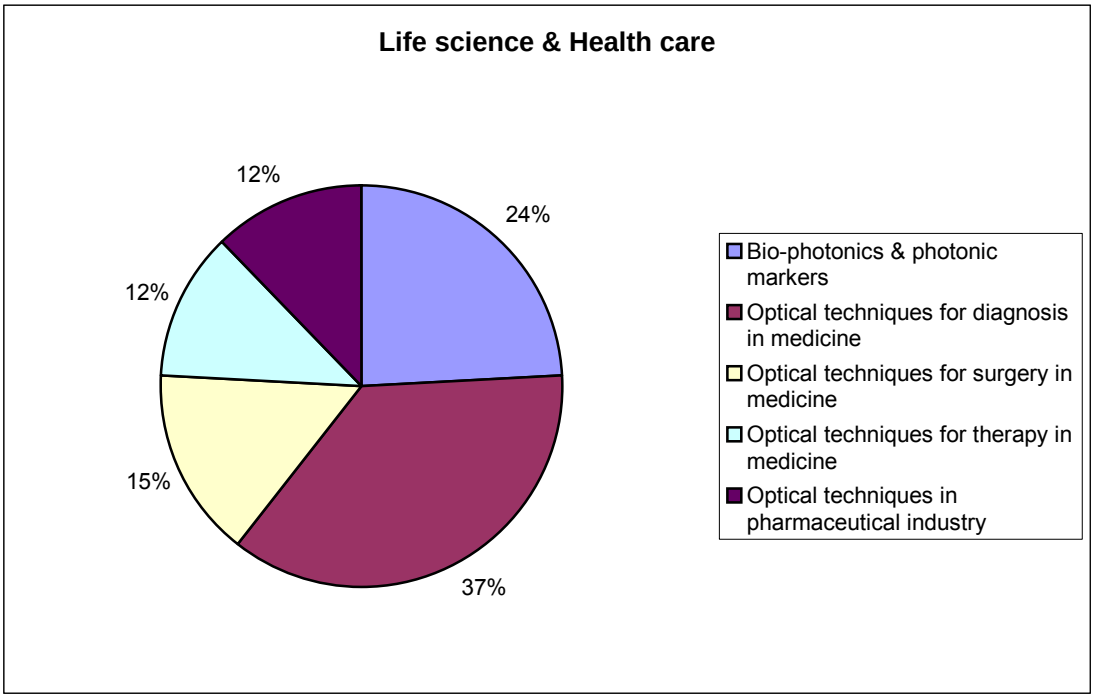

Figure 15: The sub-categories for *Life science & health care*. n=20

Lighting & displays

Subcategories for Lighting & displays:

- Displays based on OLEDs
- Displays based on solid-state lighting
- Solid-state lighting

In this field all sub-categories are, in principle, of equal interest.

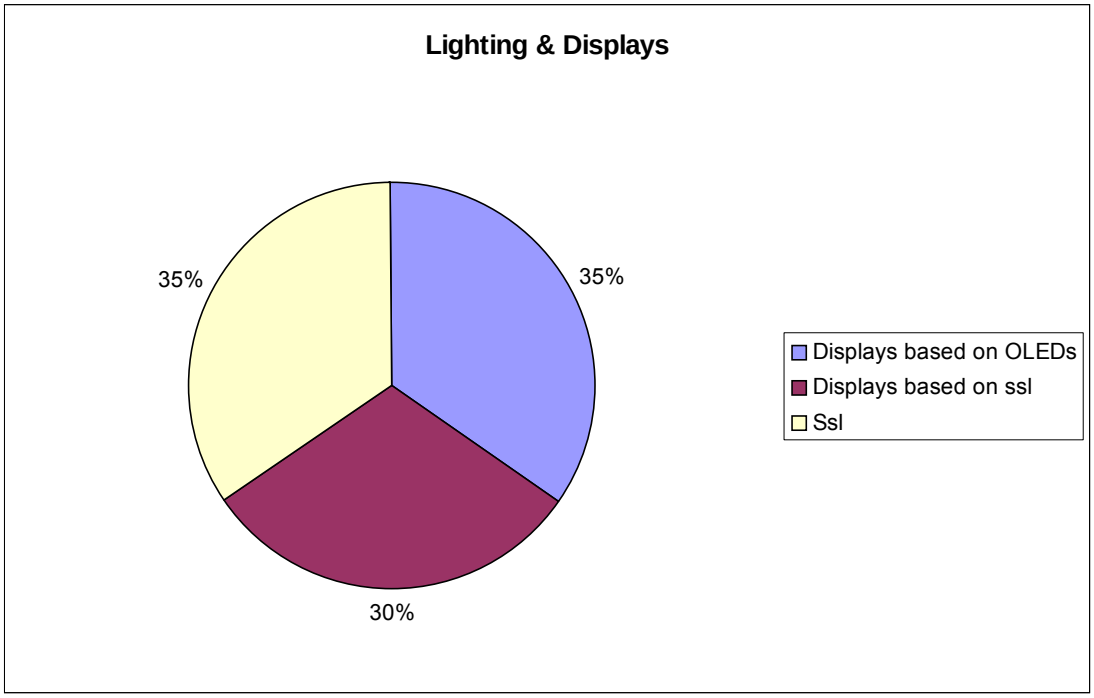

Figure 16: The sub-categories for *Lighting & displays*. n= 17

Manufacturing & quality

Subcategories for Manufacturing & quality:

- Laser-assisted macro manufacturing
- Laser-assisted micro manufacturing
- Machine vision
- Optical metrology

About 30% find *Machine vision* and *Optical metrology*, to be the most important areas in this field (together they reach >60%). Although, the remaining two fields totalled 18%, respectively, and therefore the differences are too small to extract one or two areas completely.

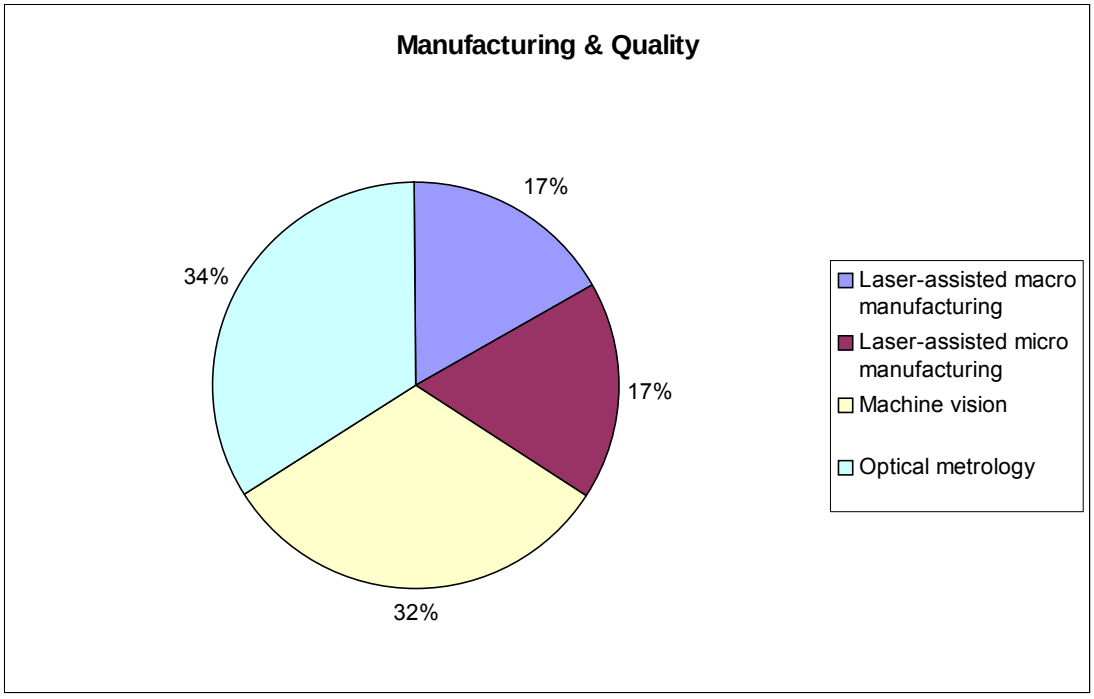

Figure 17: The sub-categories for *Manufacturing & quality*. n= 27

Optical instrumentation for science

Subcategories for Optical instrumentation for science:

- Instrumentation for physics & chemistry basic research
- Nanosciences, nano-photonics
- Nuclear energy research
- Optical instrumentation for ground-based astronomy
- Optical instrumentation for space

More than 50% chose *Instrumentation for physics & chemistry basic research* in this field, whereas *Nuclear energy* was of no interest.

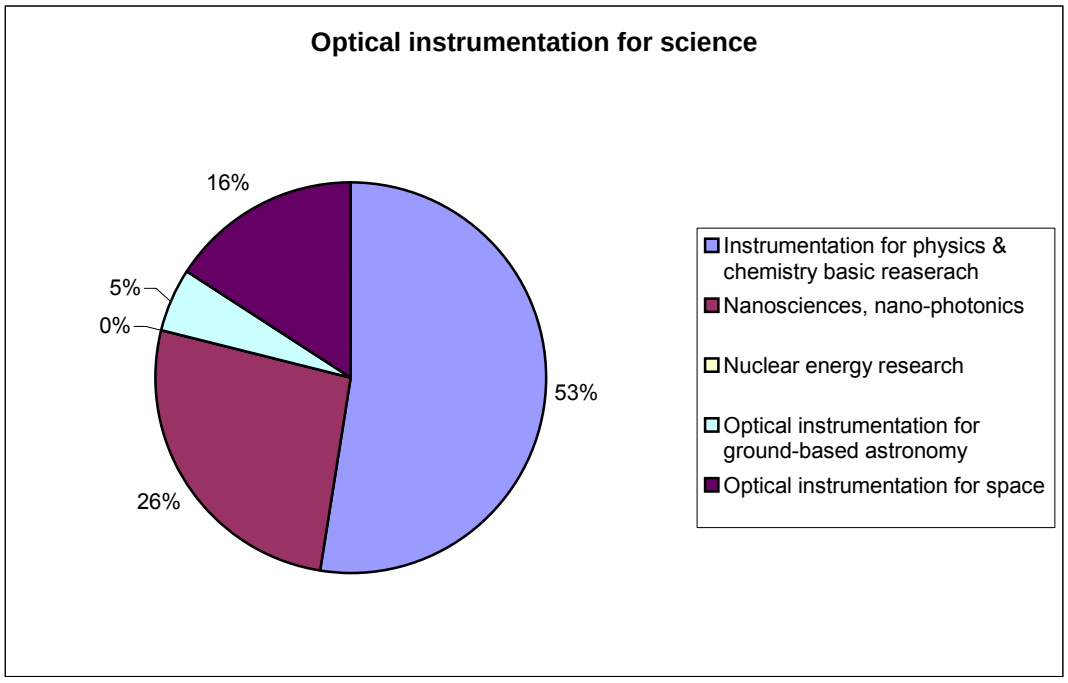

Figure 18: The sub-categories for *Optical instrumentation for science*. n= 18

Safety & security

Subcategories for Safety & security:

- Photonic identification & surveillance, terahertz imaging
- Photonic systems for defence
- Photonics for automotive & traffic

Similar to the field *Lighting & displays*, it is not possible to extract any field here, all three areas are of equal interest.

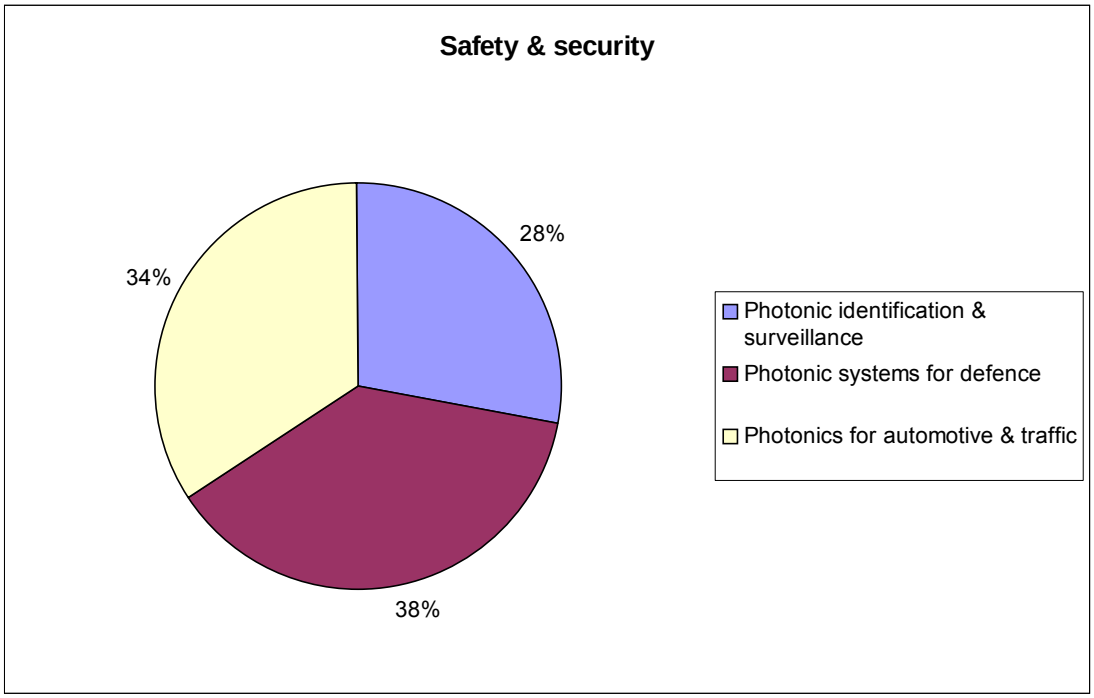

Figure 19: The sub-categories for *Safety & security*. n= 22

Figure 20 shows a summary of the innovation areas that was mentioned by the companies, besides the settled options.

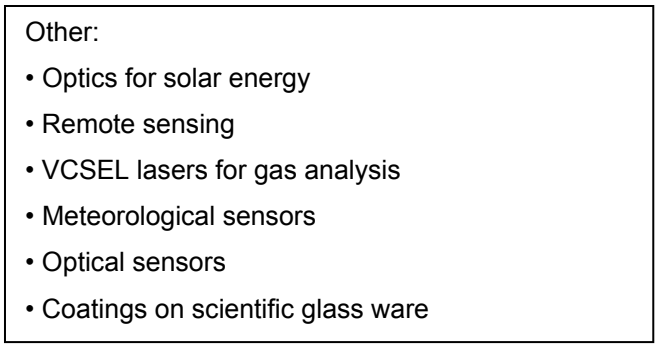

Figure 20: Some areas where companies would like to see R&D support, apart from the selections in the survey

Only 24 companies answered the question on “what photonic equipment was purchased annually”, which we believe is not enough to make any final conclusions about this. Although, from the answers we got, we can see that the most common photonic equipments purchased are different types of lasers, optical components (such as lenses, prosms, mirrors, and filters), and different types of measurement equipment/detectors.

5. Conclusions

Sweden's photonics industry has its basis in its SMEs. In general, SMEs are the strength of the economy of a country. The number of companies in the sector of optics and photonics is growing steadily. 38% of the companies active in the field have been established in the last 8 years.

The European survey (OPERA2015) also showed that Sweden has the 2nd highest number of photonics companies per capita in Europe.

It can be noted that Swedish companies have a low turnover in Japan, China and USA, which means that they are not very active in these countries. This can also be explained by the high number of SMEs, and by the high percentage of young companies in this sector, that first have to fight for a market share in Sweden and Europe before they are able to find their market elsewhere.

A very clear outcome was that engineers and scientists are the most needed work force, which shows how important human capital is for being successful on the market.

The total production volume of the Swedish photonics industry can be extrapolated to be 2.5 billion Euros. This is a share of 6% of the European production volume (43.5 billion Euros) in the sector, while Sweden only has 2% of the population of Europe. Hence, Sweden is contributing much to Europe's production volume compared to its size.

The total turnover for Sweden extrapolated accounts for 2.8 billion Euros. Here we included the consultancies and sales companies in the figure.

The turnover per employee is estimated to be 269 thousand Euros, which is comparable other Western European countries.

The sectors where the photonics industry is active in are widespread. However, the most relevant ones are manufacturing, ICT, science and life science & health. Unexpectately, telecommunication did not show up to be very important.

Regarding investments in R&D, Sweden is one of the top spenders in Europe in terms of percentage of GDP.

40% of the companies which have an R&D department spent more than 10% of their turnover on R&D. The figure reflects a highly innovative sector in terms of the willingness to invest in future operations.

It is remarkable that the companies in this sector barely have access to support from public funding. The consequence could be obstacles in the development of this sector. 29% of the companies participated in the FP6. Only 19% plan to participate in FP7. That shows that more support from the public side, more public awareness of the programmes, and more support in the bureaucratic procedure e.g. in filing the proposals is necessary.

On the other hand, the need for public funding was expressed clearly for certain areas. Core areas to be funded are indeed visible in the following categories:

- Imaging devices & systems
- Optical techniques for diagnosis in medicine
- Lighting and displays in general
- Machine vision and optical metrology
- Instrumentation for physics & chemistry basic research
- Safety and security in general

6. References

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7. Acknowledgements

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