

**Danish research and development within  
information and communication technology, ICT**

**R&D Statistics**

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## **Foreword**

This publication presents the results of the Danish Survey of Research and Development within Information and Communication Technology (ICT R&D) for 2005. The survey covers both the public and the business sector, providing a unique opportunity to match ICT R&D activities in businesses and public research.

The ICT R&D statistics are collected by the Danish Centre for Studies in Research and Research Policy (CFA) on behalf of the Danish Ministry of Science, Technology and Innovation.

The survey follows the OECD guidelines for R&D statistics, as described in the Frascati Manual. The Danish data is thus comparable with R&D data in other OECD countries.

CFA would like to thank all businesses and public institutions for their contribution to this survey.

Karen Siune  
Director  
June 2007

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### Read more on CFA's website:

[www.forskningsanalyse.dk](http://www.forskningsanalyse.dk)

The site contains a complete list of tables for the ICT R&D survey, a description of the methodology used, and ICT R&D questionnaires for both the public and business sector for 2005.

## Methodology

The survey covers Danish Research and Development within Information and Communication Technology (ICT R&D) in 2005. Responses to the public sector and business sector R&D statistics over 2003-2005 form the basis for the collected data. Businesses or public institutions that are either in the ICT sector or have reported conducting R&D within ICT have received a supplementary questionnaire dealing with ICT R&D.

The survey covers all institutions in the public sector and a sample of the population of businesses with ICT activity. Business sector data is grossed up based on industry and business size, thereby providing a representative picture of Danish ICT R&D in 2005.

The survey is conducted according to the OECD guidelines, as described in the Frascati Manual (2002). Businesses in the survey are classified according to the industry where their main R&D activity takes place. This is not necessarily the same industry where the majority of their economic activity is undertaken. For additional details, see [www.forskningsanalyse.dk](http://www.forskningsanalyse.dk) under "Forskning i IKT" (in Danish). The survey covers businesses with 2 or more employees, dependent on the industry.

Basic definitions – from the Frascati Manual:

**Research and experimental development (R&D)** comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

**Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

**Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

**Experimental development** is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

In defining information and communication technology, a fairly broad formulation was chosen in order to capture all ICT-related R&D:

*ICT comprises information technologies, communication technologies and related electronics. The area of ICTs consists of the group of technologies for the storage, processing, transmission and interpretation of information, also including the use, understanding and impact of these technologies.*

*ICT R&D includes both the development of technologies within ICT, and R&D that concerns the application, significance, comprehension and consequences of ICTs. ICT R&D does not include R&D where ICTs are solely used as a support activity or tool; ICT must be the object of the R&D activity.*

A central element in the survey methodology is the classification of types of ICT R&D. ICT R&D was classified along two dimensions, in terms of its use and in terms of research areas. Three main groups were identified according to its use:

- *Hardware*, including hardware used for communication and used for data processing
- *Stand-alone software*, both standardized and customized software
- *Integrated software*, which involve software that is embedded in other products

In all 16 research areas were identified for ICT R&D:

- *Software development tools*
- *Data storage*
- *Network management*
- *Instruments*
- *Security systems*
- *Business systems*
- *Process control*
- *Communication systems – mobile and wireless*
- *Communication systems – fixed line*
- *Microelectronics*
- *Image technology*
- *Language technology*
- *Usability*
- *Games*
- *Informatics*
- *E-learning*

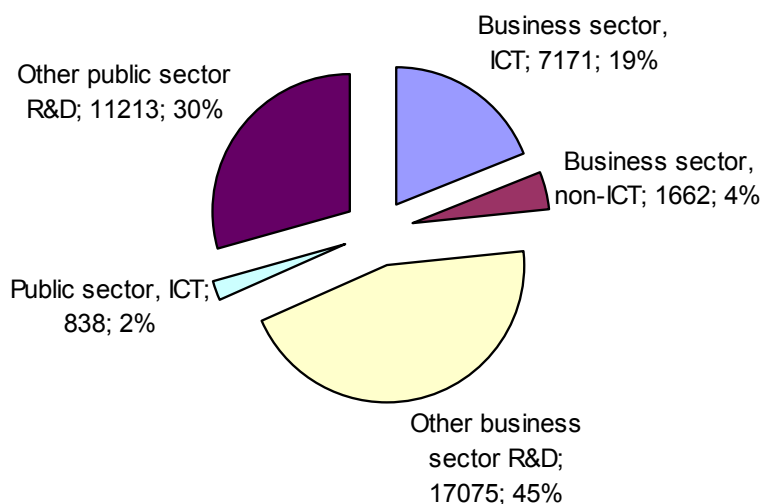
## 1. Intramural ICT R&D expenditures

Danish businesses and public research institutions spent 38 billion kr. (€ 5.1 billion) overall on R&D in 2005. Of this, 8.8 billion kr. (€1.2 bln) was spent on ICT R&D in the business sector and 0.8 billion kr. (€107 mln) on ICT R&D in the public sector. Hence, around a quarter of all R&D expenditures in Denmark for 2005 were conducted within ICT. See figure 1.

In the business sector, the 8.8 billion kr. amount to 34 percent of total R&D in for businesses in Denmark. This share is roughly the same as that for R&D in the health sector (32 percent of total R&D).<sup>1</sup> In the public sector, the 0.8 billion kr. amount to slightly less than 7 percent of total R&D in the public sector.<sup>2</sup>

ICT R&D is conducted both within the ICT sector and in other industries. In all, 81 percent of ICT R&D was conducted within the ICT sector in 2005.

**Figure 1. Total R&D expenditures in 2005, in mln kr. and percent.**



Source: Table 1 og 2.

Compared with figures from 2003, ICT R&D increased 1.1 billion kr. in fixed 2005-prices, or a total increase of 13 percent over the two years from 2003 to 2005. From 2003 to 2005, ICT R&D in the business sector increased 12.6 percent in the business sector and 18 percent in the public sector.

<sup>1</sup> See the publication, "Erhvervslivets Forsknings- og Udviklingsarbejde - Forskningsstatistik 2005" . [www.forskningsanalyse.dk](http://www.forskningsanalyse.dk)

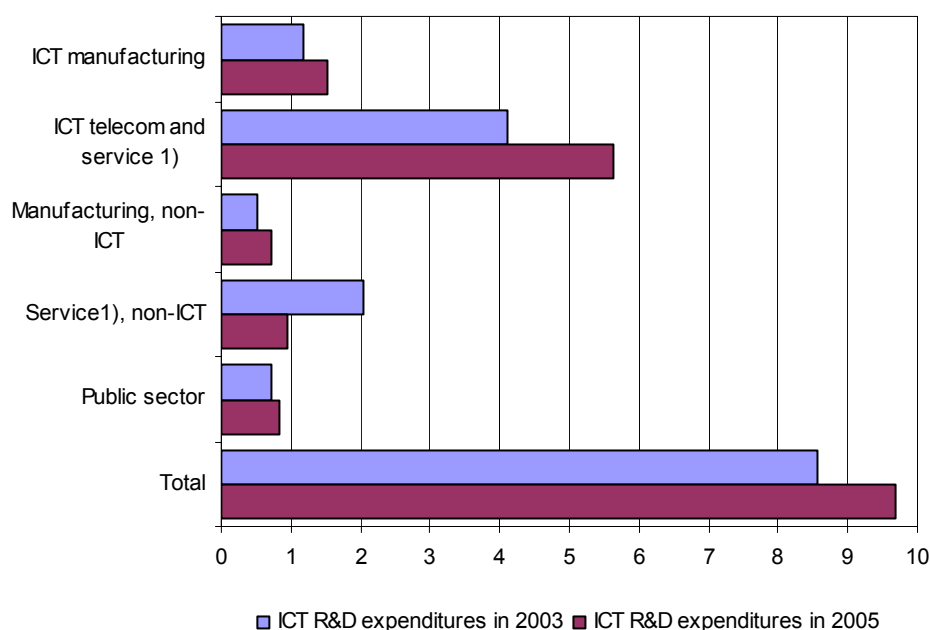
<sup>2</sup> See "Forskning og Udviklingsarbejde i den offentlige sektor - Forskningsstatistik 2005". [www.forskningsanalyse.dk](http://www.forskningsanalyse.dk)

As shown in figure 2, ICT services is by far the largest sector, with over half of total ICT R&D expenditures. This sector has also had the largest increase from 2003 to 2005, around 35 percent. ICT manufacturing has also experienced large increases in ICT R&D expenditures, with an increase of around 30 percent.

In contrast, ICT R&D expenditures in non-ICT services fell significantly in 2005, to around half their level in 2003. A possible reason for these developments is a concentration of ICT R&D in ICT businesses, either through outsourcing or sales of ICT related activities. However, it is not possible to confirm this based on the survey data. What the data does show is that a large number of ICT businesses have experienced increases in their ICT R&D activities.

In terms of percentage ICT R&D in the public sector has increased more than in the business sector. The increase is primarily due to increases in ICT R&D activity for a number of public research institutions, but also reflects ICT R&D from a smaller number of institutions that had not reported any ICT R&D in 2003.

**Figure 2. Business and public sector ICT R&D for 2003 and 2005. Bln kr.**

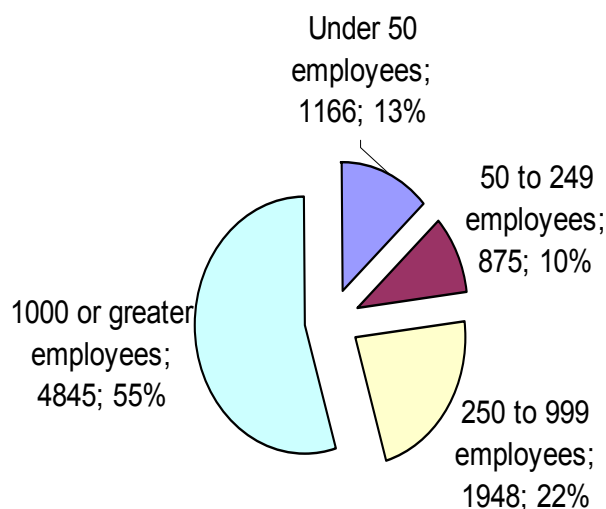
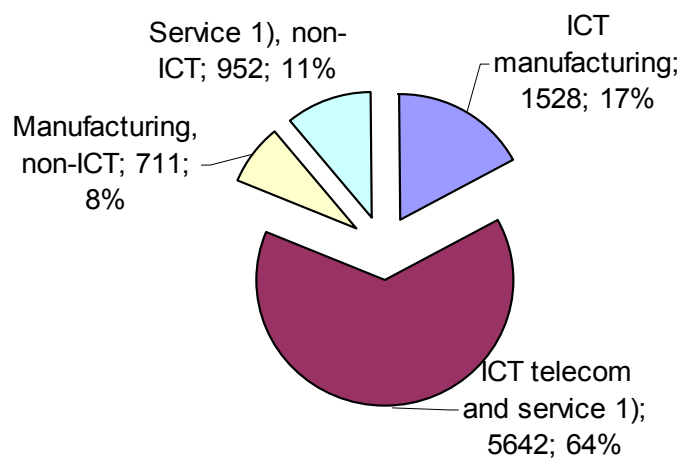


1) Service includes wholesale trade, financial intermediation, IT service, R&D service, other business service and telecommunications.

Source: Table 3 and 4.

Figure 3 shows business sector ICT R&D by industry groups and firm size. Just under 20 percent of ICT R&D was conducted outside of the ICT sector. ICT R&D is predominantly found in the service sector. Three quarters of business ICT R&D was conducted in the service sector, and two thirds within ICT services.

**Figure 3. Business sector ICT R&D by industry group and business size, 2005. Mln kr. and percent.**



1) Service includes wholesale trade, financial intermediation, IT service, R&D service, other business service and telecommunications.

Source: Table 1.

The majority of business sector R&D was conducted by businesses with over 1000 employees. Businesses with under 250 employees, ie. small and medium sized enterprises (SME) accounted for around 25 percent of ICT R&D expenditures. While a large number of small businesses (under 50 employees)

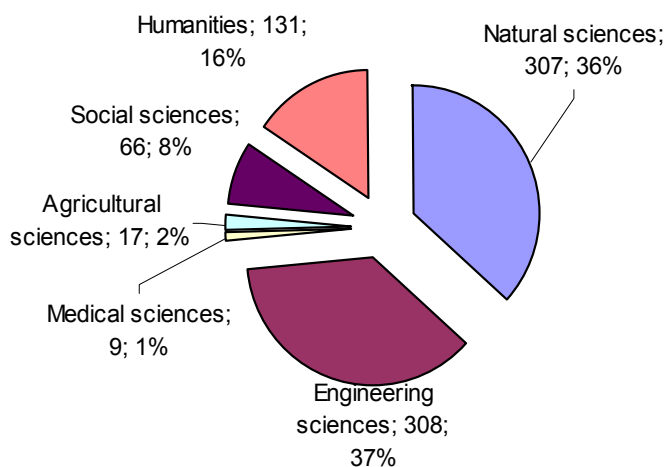


have conducted ICT R&D, particularly those in ICT services, they account for a very small share of overall ICT R&D expenditures.

In the public sector (higher education, government research and private non-profit institutions), ICT R&D was primarily conducted within two main fields of science, Engineering sciences and Natural sciences. As shown by figure 4, these two academic fields each accounted for around 40 percent of total ICT R&D in the public sector. The third largest field is Humanities, where around 15 percent of ICT R&D was conducted.

Looking at each academic field individually, Engineering sciences has the highest share of ICT R&D relative to total R&D. Around 20 percent of R&D in Engineering sciences was within ICT. Corresponding shares are 11 percent for Natural sciences, 8 percent for Humanities and 4 percent in Social sciences.

**Figure 4. Public sector ICT R&D by academic field, 2005. Mln kr. and percent.**

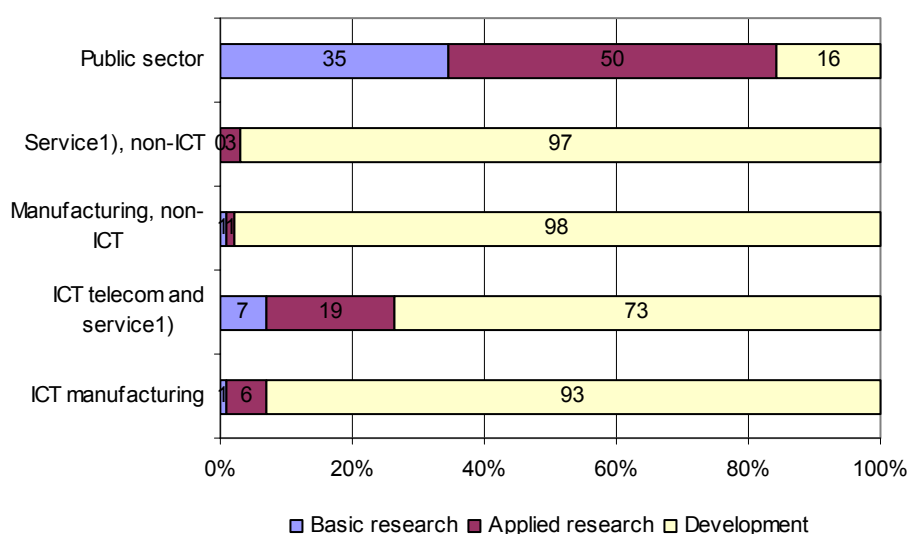


Source: Table 2.

As figure 5 shows, the far majority of ICT R&D was devoted to basic and applied research in the public sector, while the opposite is the case for the business sector. Around 35 percent of ICT R&D expenditures in the public sector were spent on basic research and 50 percent on applied research. In contrast, over 80 percent of business sector ICT R&D was devoted to development work, 14 percent to applied research and only 5 percent to basic research. The largest share of basic research in the business sector is found in ICT services. In

comparison with R&D expenditures as a whole in Denmark, public institutions with ICT R&D spent a smaller share on basic research (35% vs. 47%), a larger share on applied research (50% vs. 39%) and a similar share on development (16% vs. 13%).<sup>3</sup> For the business sector as a whole, 5 percent of R&D was spent on basic research, 23 percent on applied research, and 72 percent of development<sup>4</sup>. Hence, with the exception of ICT service, ICT R&D active businesses spent a much smaller share of ICT R&D on research than for business sector R&D as a whole.

**Figure 5. Basic and applied research and development expenditures with ICT, 2005. Percent.**



1) Service includes wholesale trade, financial intermediation, IT service, R&D service, other business service and telecommunications.

Source: Table 11 and 12.

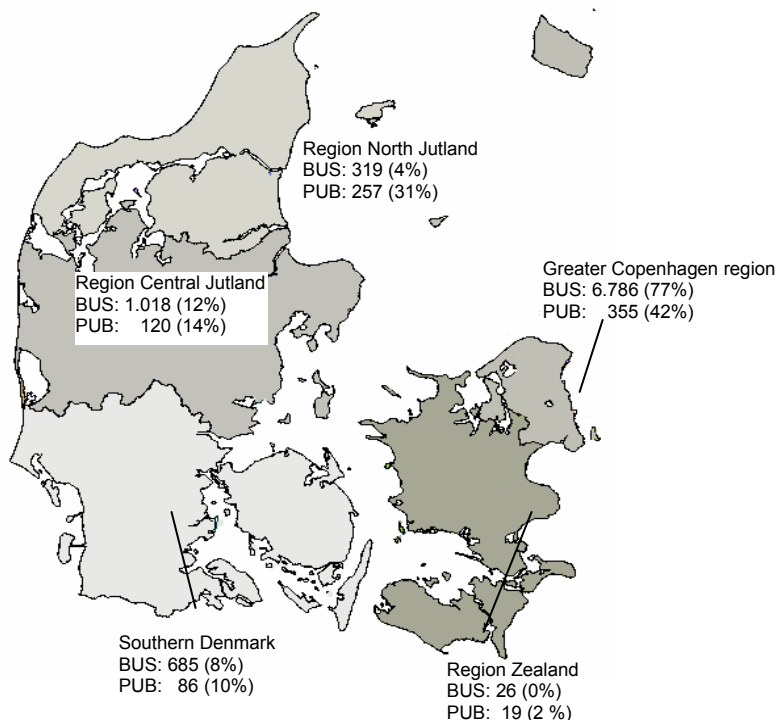
## 2. Regional ICT R&D

As is the case for total R&D expenditures in Denmark, the large majority of ICT R&D is conducted in the Greater Copenhagen region, namely 74 percent (see Table 18). There is however, a substantial difference in the regional distribution of ICT R&D in the public sector, where almost a third of ICT R&D was conducted in the Region North Jutland, which through Aalborg University has a strong national position within ICT R&D.

<sup>3</sup> See "Erhvervslivets Forsknings- og Udviklingsarbejde - Forskningsstatistik 2005". [www.forskningsanalyse.dk](http://www.forskningsanalyse.dk)

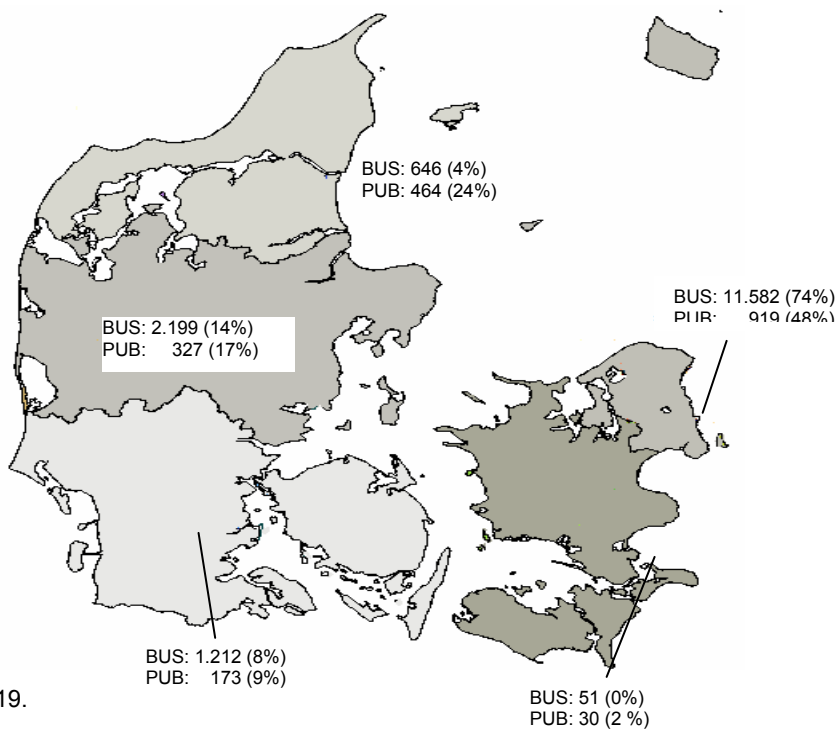
<sup>4</sup> See "Forskning og Udviklingsarbejde i den offentlige sektor - Forskningsstatistik 2005". [www.forskningsanalyse.dk](http://www.forskningsanalyse.dk)

**Figure 6. Business and public sector ICT R&D by region, 2005. Mln kr. and percent.**



Source: Table 18.

**Figure 7. Business and public sector ICT R&D personnel by region, 2005. Mln kr. and percent.**



Source: Table 19.

In terms of total ICT R&D, both Region Central Jutland and Southern Denmark have a greater share of ICT R&D expenditures, due to larger expenditures within the business sector.

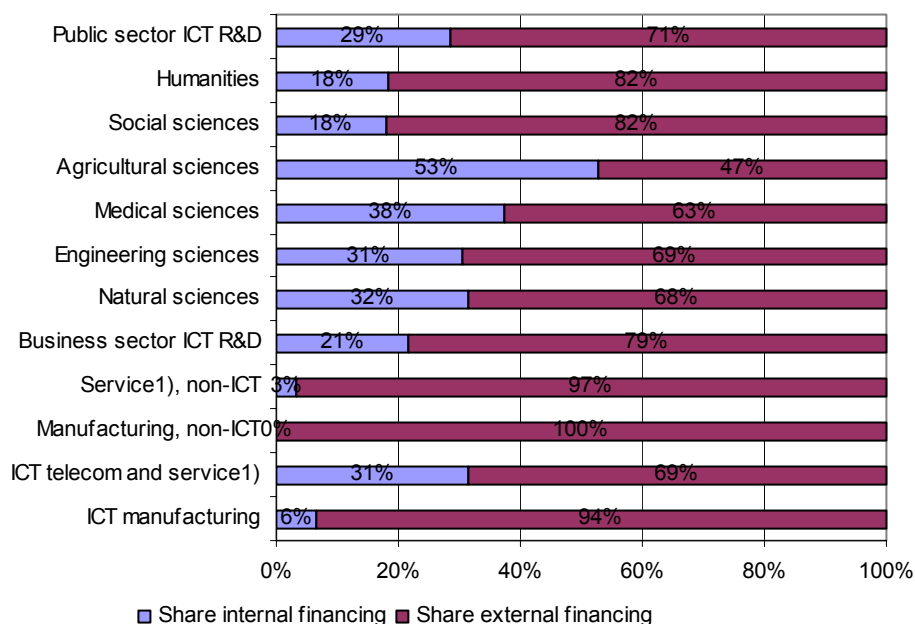
In examining the regional distribution of R&D personnel within ICT, the overall picture is very similar to that for R&D expenditures, as can be seen in figure 7. ICT R&D expenditures per R&D employee is thus relatively constant across regions.

### 3. Financing of ICT R&D

As figure 8 shows, around 30 percent of public sector ICT R&D was externally financed in 2005. The corresponding share for the business sector is around 20 percent.

Shares of external financing are particularly high within Agricultural sciences and Medical sciences, around 50 and 40 percent, respectively, while external financing is significantly lower in Humanities and Social sciences. Within Engineering sciences and Natural sciences, where the largest share of public sector ICT R&D is conducted, around a third of R&D expenditures are externally financed.

**Figure 8. Business and public sector ICT R&D by source of funding, 2005. Mln kr. and percent.**



1) Service includes wholesale trade, financial intermediation, IT service, R&D service, other business service and telecommunications.

Source: Table 9 and 10.

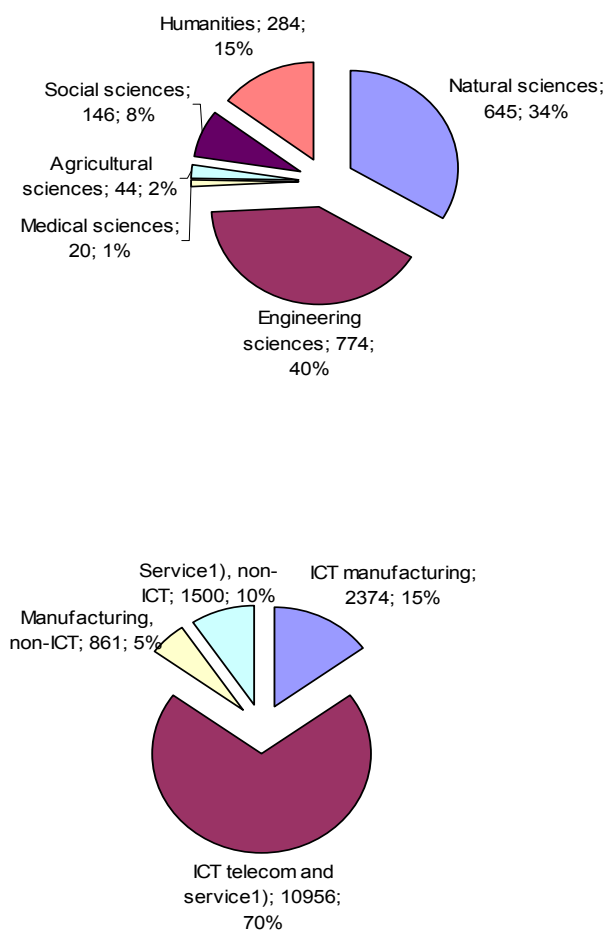
For the business sector, almost all external financing is concentrated in ICT services, where around 30 percent of R&D expenditures are externally financed. External financing of ICT R&D is very low in the other business sectors.

For comparison, 16 percent of total R&D in the business sector was externally financed, while the share was 37 percent for the public sector as a whole<sup>5</sup>.

#### 4. R&D personnel and Full-time equivalents within ICT

Figures 9 and 10 show the distribution of R&D personnel and full-time equivalents (FTE) within ICT. The distribution for R&D personnel and FTEs is very similar to that for expenditures.

**Figure 9. Business and public sector R&D personnel within ICT, 2005. Number and percent.**



1) Service includes wholesale trade, financial intermediation, IT service, R&D service, other business service and telecommunications. Source: Table 5 and 6.

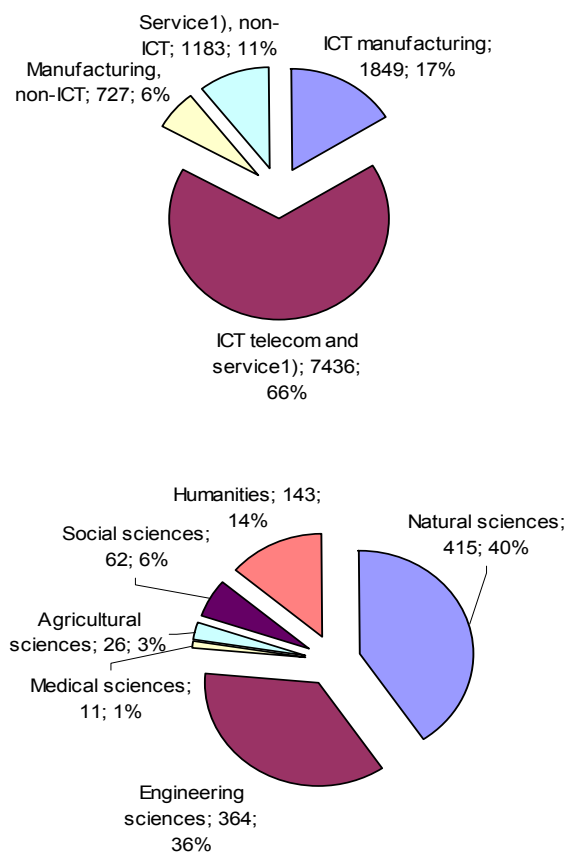
<sup>5</sup> See "Forskning og Udviklingsarbejde i den offentlige sektor - Forskningsstatistik 2005" and "Erhvervslivets Forsknings- og Udviklingsarbejde - Forskningsstatistik 2005".

The majority of R&D personnel within ICT are employed in ICT services in the business sector and in Engineering sciences and Natural sciences in the public sector.

Figure 10 shows the distribution of R&D FTEs within ICT, which gives the actual amount of time used by R&D employees on ICT R&D. On average ICT R&D personnel in the business sector spent over 70 percent of their time on ICT R&D. In the public sector, the share was around 50 percent.

Of the over 15,000 ICT R&D employees in the business sector, around two thirds are researchers, while three quarters of ICT R&D personnel are researchers in the public sector. For the public sector a large share of researchers within ICT are PhD students, around 25 percent.

**Figure 10. Business and public sector R&D FTE's within ICT, 2005. Number and percent.**



1) Service includes wholesale trade, financial intermediation, IT service, R&D service, other business service and telecommunications. Source: Table 5 and 6.

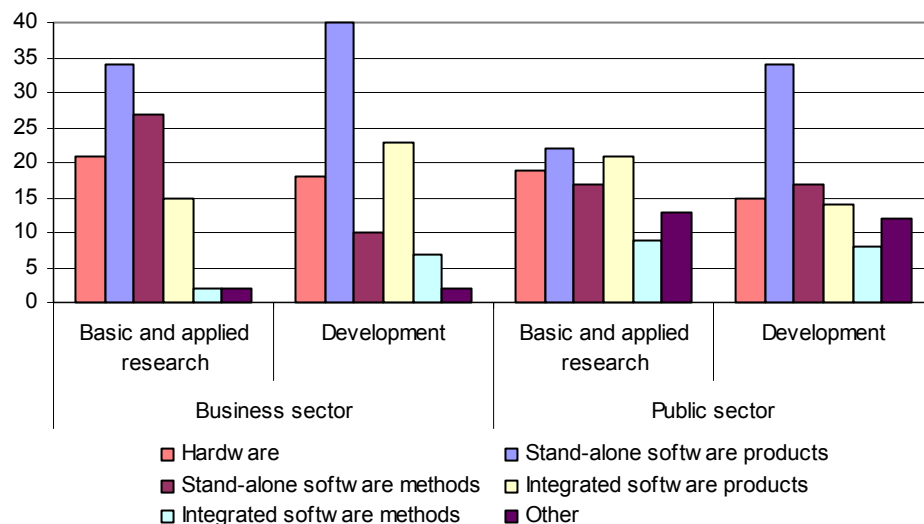
## 5. ICT R&D: Application and Research Areas

As noted above, three main areas for application of ICT R&D are identified: hardware, stand-alone software and integrated software. The latter two are further divided into R&D directed towards products and methods. Figure 11 shows the distribution of public and business sector ICT R&D expenditures according to area of application and whether expenditures were devoted to research or development.

In the business sector, the largest share of expenditures is within stand-alone software products, both for basic and applied research, and for development expenditures. Concerning development work, the next largest share is within integrated software products, followed by hardware. A large share of research expenditures in the business sector, around 25 percent, are devoted to stand-alone software methods. Little research is spent on integrated software methods, though a somewhat larger share is used in development work.

Expenditures in the public sector are more evenly distributed across application areas, in particular for research work. Note also that a higher share of public sector ICT R&D was not placed in any of the five application areas. This reflects in part the broader social and humanistic applications of ICT research in the public sector.

**Figure 11. Business and public sector ICT R&D by area of application, 2005. Percent.**



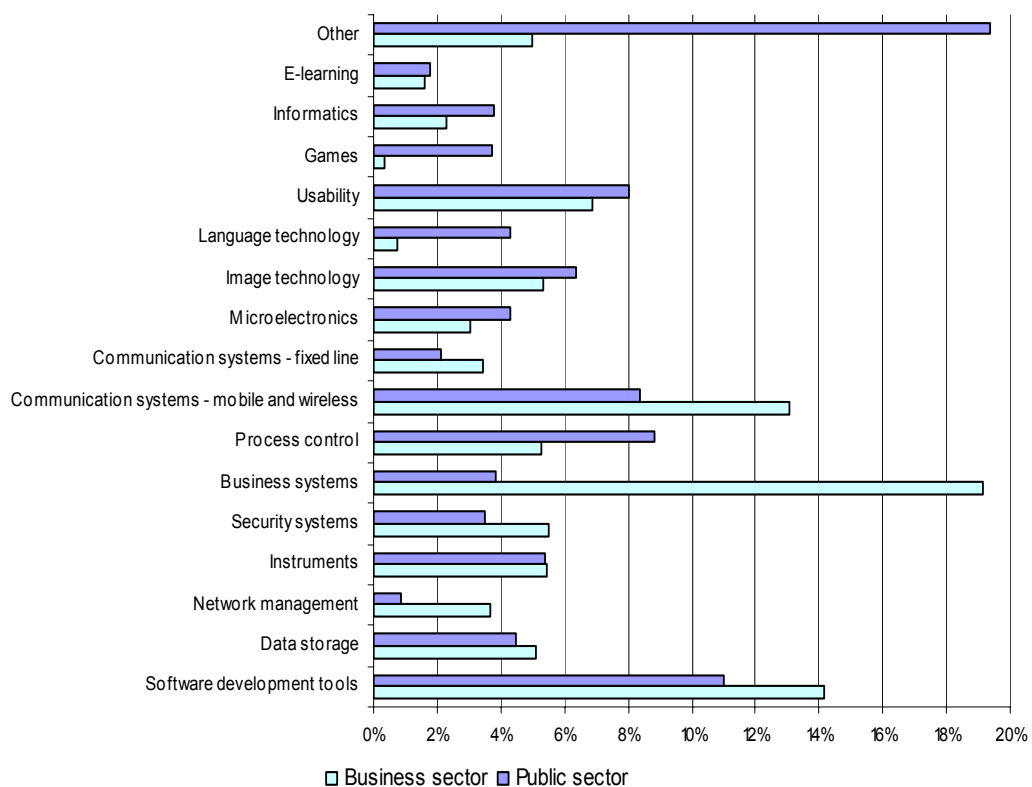
Note: Figure numbers sum to 100% for the 6 application groups within for each type of R&D.  
Source: Table 14 and 15.

Figure 12 shows which ICT research areas the business sector and public sector has placed their ICT R&D within. Almost half of all business sector ICT R&D is

concentrated in three research areas: business systems, wireless communication systems and software development tools.

Public sector ICT R&D is more evenly distributed across research areas. The four largest areas for the public sector are software development tools, process control, wireless communication systems and usability.

**Figure 12. Business and public sector ICT R&D by ICT research area, 2005. Percent.**



Source: Table 16 and 17.

In general, the distributions of business and public sector ICT R&D are fairly similar across research areas. One exception to this, however, is business systems, which accounts for close to 20 percent of ICT R&D in the business sector but only around 4 percent in the public sector. Finally, note that a relatively large share of public sector ICT R&D, close to 20 percent, could not be placed in any of the research areas. This reflects in part basic research that cannot be attributed to a specific area, and humanistic research that is not directly related to any of these product oriented areas.

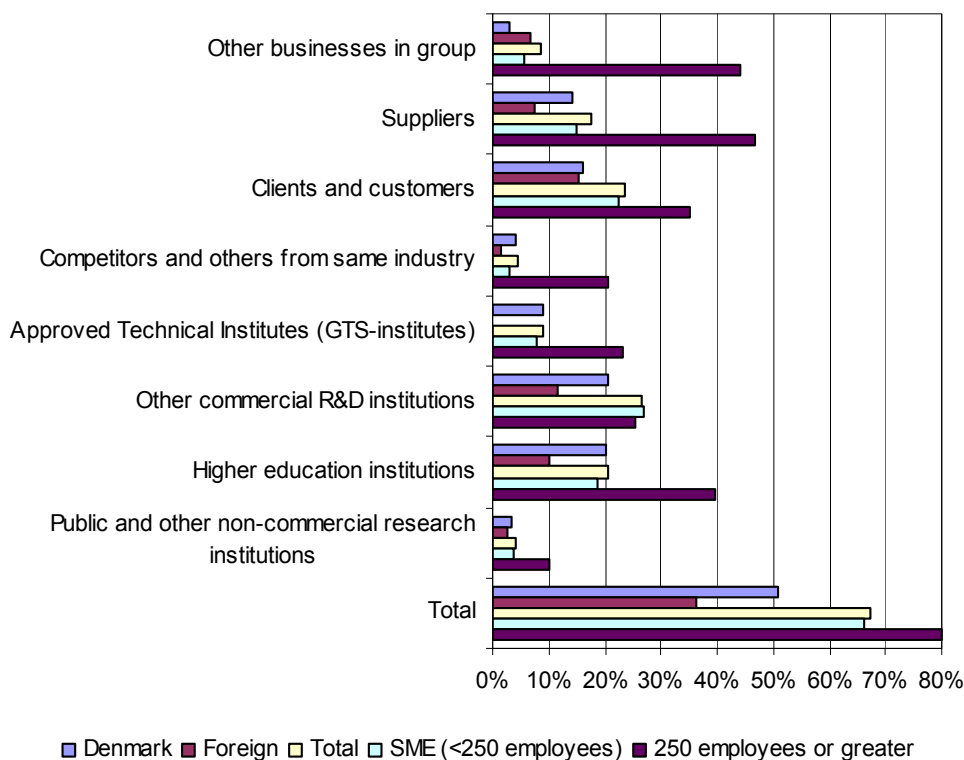


## 6. R&D cooperation within ICT

Danish businesses with ICT R&D are often engaged in cooperation concerning their ICT R&D activities. Around two thirds of all businesses with ICT R&D are engaged in cooperation with others. This share is though somewhat less than that for the business sector as a whole, where 75 percent of R&D active businesses were engaged in R&D cooperation in 2005. Of those businesses with cooperation, 88 percent cooperate with other businesses while 34 percent cooperate with universities. Large businesses cooperate more often than small and medium sized firms, particularly with other businesses. On the other hand, there is little difference in cooperation between ICT manufacturing and ICT services.

As can be seen from figure 13, 21 percent of businesses with ICT R&D have cooperation with a university. Difference in cooperation with universities compared to businesses may be due in part to differences in 'research profiles' in terms of research and development activities. Businesses that do not engage in any basic or applied research themselves may generally have less demand for cooperation with universities. Note, on the other hand, that a much higher share of larger businesses have cooperation with universities.

**Figure 13. Business sector R&D cooperation within ICT, 2005. Percent.**

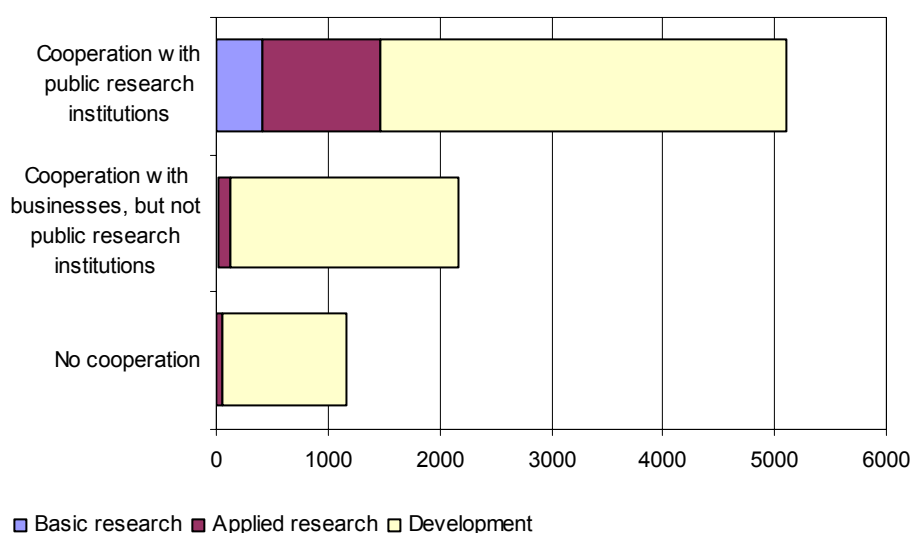


Note: Shares are of those businesses that have ICT R&D.  
Source: Table 21 and 23 and additional tabulations.

Figure 13 also shows shares with ICT R&D cooperation with partners in Denmark and international partners. Typically, businesses cooperate less with international partners, due in part to both geographic and cultural differences. This is in general also the case here. Around half as many businesses have cooperation with foreign universities or commercial R&D labs compared to domestic partners. The difference is smaller for cooperation with other businesses, and an almost equal share cooperate for foreign customers compared to domestic customers.

Figure 14 shows businesses ICT R&D expenditures for three groups of businesses characterised by ICT R&D cooperation. As can be seen, businesses without cooperation have a negligible share of total expenditures within basic and applied research. Total ICT R&D for this group is around 1 billion kr. (€134 MN).

**Figure 14. Business sector ICT R&D by type of cooperation, 2005. MN kr.**



Source: Additional data tabulations.

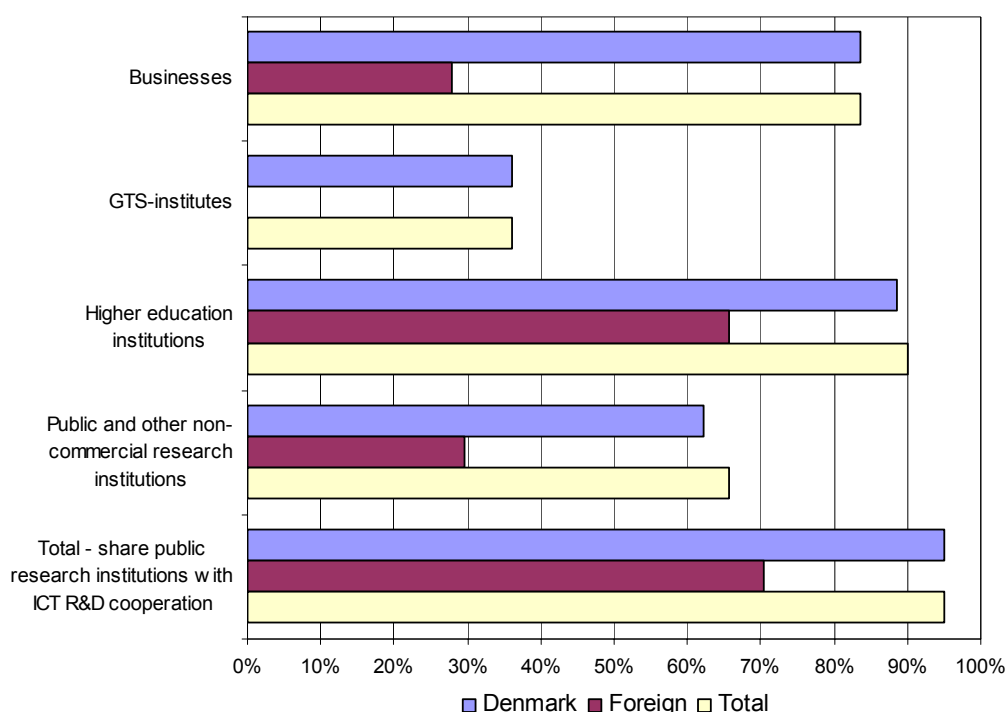
Businesses with cooperation with universities have the largest share of ICT R&D, around 5 billion kr. (€ 670 MN). These businesses also have the largest share of basic and applied research, which may in many cases help facilitate cooperation with public research.

Businesses with ICT R&D cooperation, but not with public research account for over 2 billion kr. of total ICT R&D in the business sector. In contrast to those businesses that cooperate with public research institutions, these businesses have a very small share of expenditures within basic and applied research, with around 95 percent devoted to development work.

Turning to cooperation in the public sector, almost all public research institutions, around 95 percent, engage in cooperation with others for their ICT R&D. The far majority of these institutions cooperate both with other public research institutions and businesses. Shares of cooperation with these two groups are around 85-90 percent.

Cooperation shares are somewhat more diverse when looking at international cooperation. The share of public research institutions that cooperate with international businesses is much lower, under 30 percent, while a high share cooperates with international universities, around two thirds.

**Figure 15. Public sector ICT R&D cooperation, 2005. Percent.**



Note: Shares are of those institutions that have ICT R&D.

Source: Table 22 and additional tabulations.

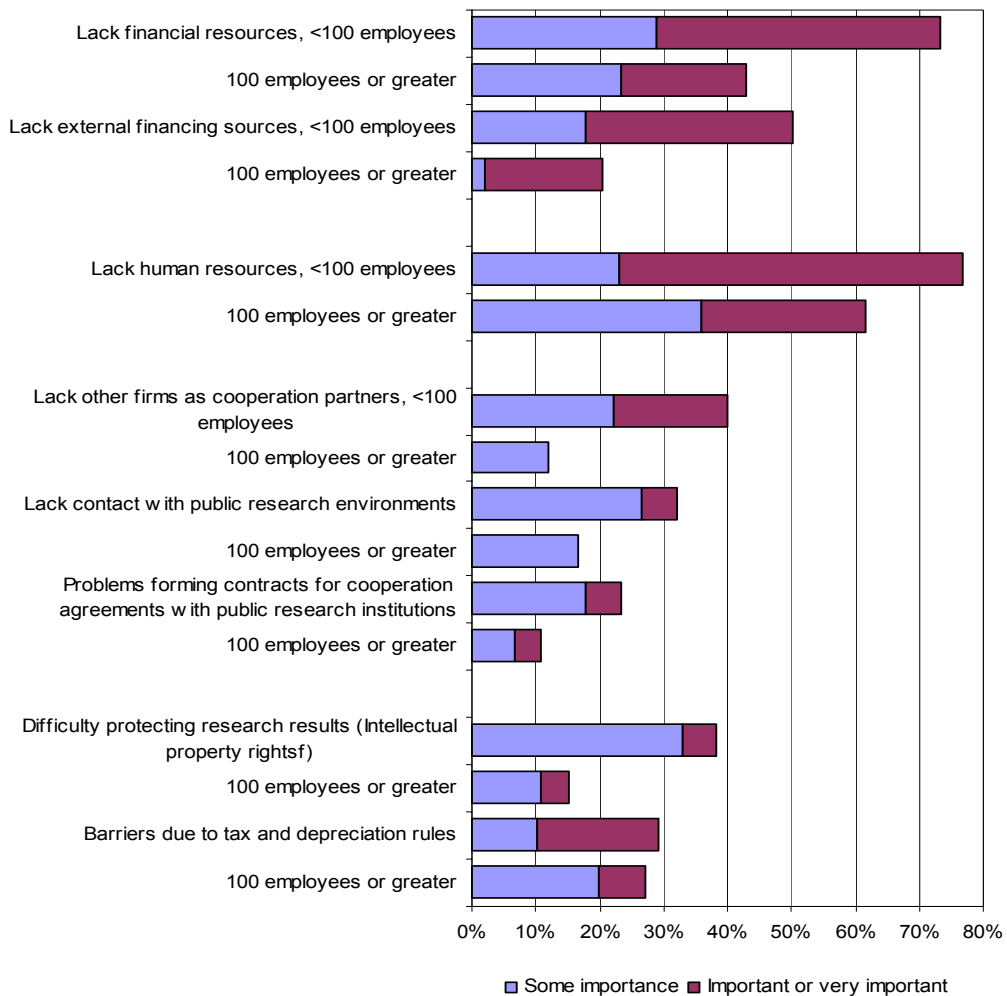
## 7. Barriers to ICT R&D

Both businesses and public research institutions were asked to assess the importance of a number of potential barriers for ICT R&D, concerning resources, personnel, cooperation and regulations.

Figure 16 shows shares of ICT R&D businesses that give each barrier either some importance or important/very important. The most widely cited barrier is lack of human resources followed by lack of financial resources, and financial

sources. Property rights, contractual problems and lack of cooperation partners are given less importance as barriers to ICT R&D.

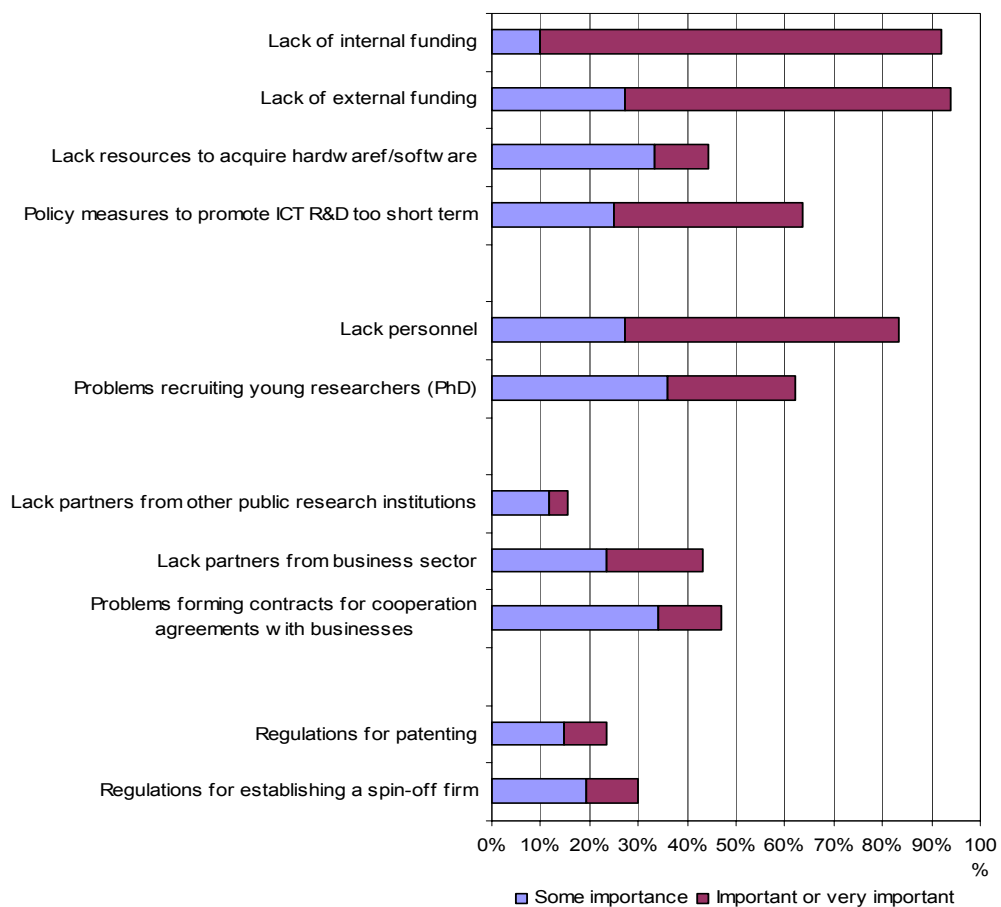
**Figure 16. Barriers to ICT R&D in the business sector, 2005. Percent.**



Source: Table 31.

Public sector institutions were asked to consider the same four types of barriers. As can be seen from figure 17, lack of financial resources and personnel are also the largest barriers for public research institutions, though in opposite order. In particular, both internal and external funding are cited as the largest barriers to ICT R&D in the public sector. A commonly held view by many of the public research institutions is that existing research programs directed at ICT R&D have a too short time horizon. A much smaller share cited property rights as a hindrance to ICT R&D and, as for businesses, lack of cooperation partners and contractual problems were given less importance than financial and human resources. However, these latter two were given greater importance in the public sector than for businesses.

**Figure 17. Barriers to ICT R&D in the public sector, 2005. Percent.**



Source: Table 32.

## **Danish Research and Development within Information and Communication Technology, ICT**

- **R&D Statistics 2005** is a survey of ICT R&D in both the public and business sector in Denmark.

### **Main results of the survey:**

- Total R&D expenditures within ICT in Denmark amounted to 9.7 billion kr. (€ 1.3 BN) in 2005 (0.6 % of GDP), which is an increase of 13 percent in relation to 2003.
- 8.8 billion kr. was spent on intramural ICT R&D in the business sector in 2005.
  - Of this amount, 7.2 billion kr. of expenditures were by businesses in the ICT sector.
  - Growth in ICT R&D in the business sector is primarily due to increases in expenditures for businesses with 1000 employees or greater, and mainly for businesses within ICT services.
  - In all 34 percent of total R&D in the business sector was within ICT.
  - 21 percent of business sector ICT R&D in 2005 was externally financed.
- 0.8 billion kr. was spent on intramural ICT R&D in the public sector in 2005.
  - In all, 7 percent of total R&D in the public sector was within ICT in 2005.
  - 29 percent of the public sector's ICT R&D was externally financed.
- In 2005 17,603 persons were engaged in ICT R&D, accounting for 12,216 full-time equivalents.

Read more in this publication and on the website for the Danish R&D Statistics:

[www.forskningsanalyse.dk](http://www.forskningsanalyse.dk)

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