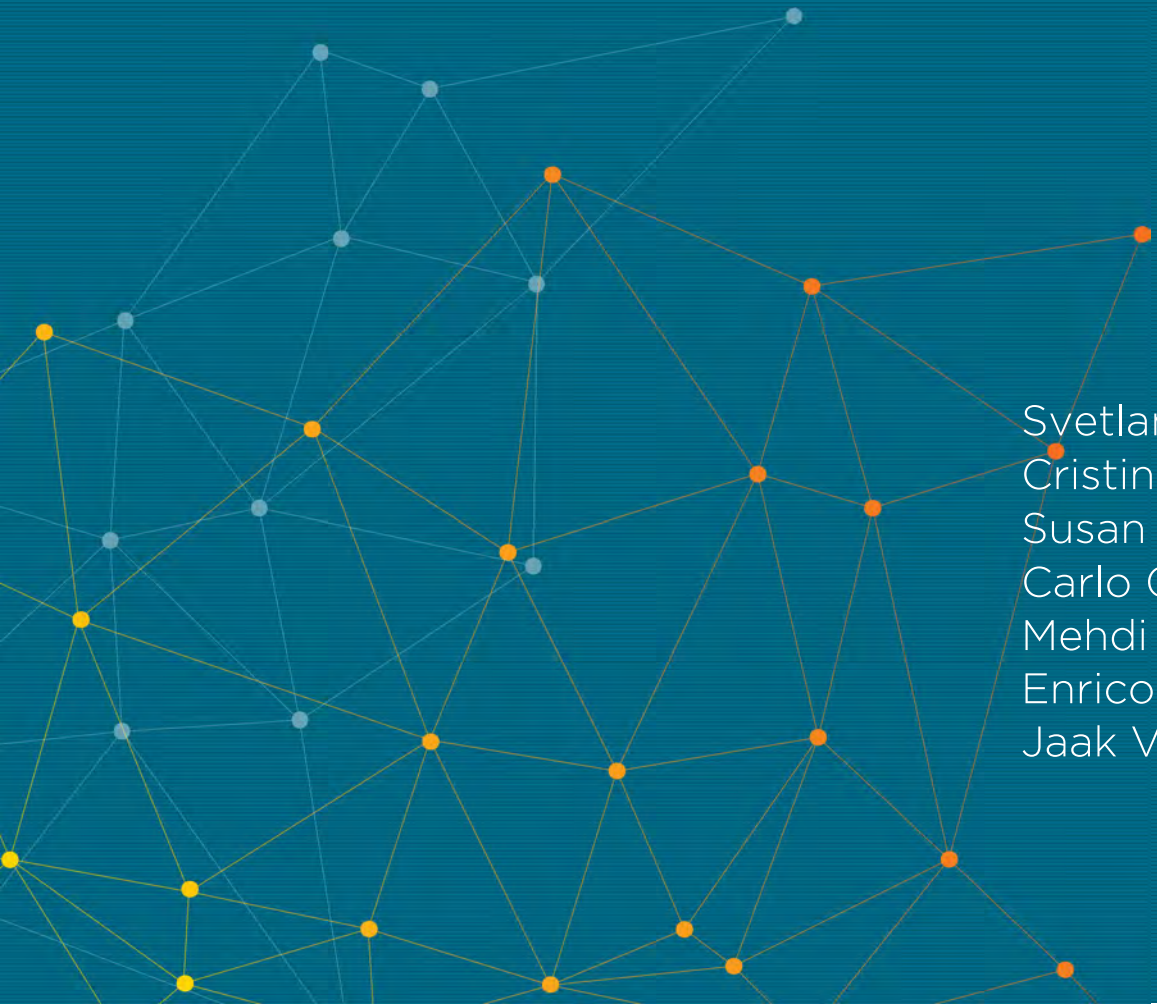
INFORMATICS EUROPE

INDUSTRY FUNDING FOR ACADEMIC RESEARCH IN INFORMATICS IN EUROPE

Pilot Study



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Industry Funding for Academic Research in Informatics in Europe

An Informatics Europe Pilot Study

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Executive Summary

The productive collaboration between university and industry in both basic and applied research is vital to the global knowledge economy in Europe. Closer, effective links between the private sector and academia can encourage the transfer and sharing of knowledge and human resources, create long-term partnerships and opportunities, drive innovation, entrepreneurship and ultimately economic development. Successful partnerships between academia and industry are of particular importance in the field of Informatics (Computer Science, Computing, etc) where the technology development in industry moves at a pace faster than the university education and research programs can adapt. Until now, no systematic study of the funding relation between industry and academia in Informatics has been reported in Europe and therefore no knowledge exists about which research areas receive more or less funding from industry.

This report presents the results of a pilot study exploring the landscape of industry-funded Informatics research in academic institutions in Europe. The main goal was to understand the current level of industry funding going to different areas of Informatics research in Europe, similarities or differences in the way this money is invested in different countries. Nine academic institutions in nine different universities from four European countries – Germany, the Netherlands, Switzerland and UK – have participated in the study, providing data about research projects and areas receiving funding from industry in 2017. The data was collected by Informatics Europe through direct contact with heads, faculty and administrative staff of the various institutions. Areas of Informatics research being funded have been pointed by the participants or inferred from the data collected, which included details of the projects and principal investigators. To comply with data protection regulation and assure confidentially to the participants all data has been reported in aggregated and anonymized form, such that in no way it is possible to link the university, academic unit and principal investigator names to the respective funding source and amount or research project details.

The results of our investigation have shown that:

- the nine academic institutions participating in the study shared a total of 42.6M EUR of industry funding during the period investigated, consisting in an average of 4.7M EUR per institution or 233K EUR per project. Close to 200 projects have been financed and the total funding varied significantly between academic units, from a minimum of 517K EUR to maximum of 21M EUR.
- the length of funding was also not uniform, ranging from 3 months to almost 15 years, with an average of 38 months per project and resulting in 70 EUR to almost 88K EUR of monthly funding per project and from 2K EUR to almost 16K EUR per academic unit.
- Human-Centered Computing, Data Science, Computing Methodologies, and Security and Privacy received together the highest amount of industry funding, around 65%, both in terms of total and monthly funding. These areas together received around 28M EUR for the whole period surveyed, or 710K EUR per month. At the bottom end were the areas of Mathematics of Computing, Networks, Hardware, and Theory of Computation, having received together only around 5% of industry funding, 2.3M EUR in total or 74K EUR per month.
- the highest number of funded projects were in the areas of Computing Methodologies (n=41), Security and Privacy (n=24), while the lowest number were in the area of Theory of Computation (n=5), Networks (n=5), Blockchain (n=5), Mathematics of Computing (n=1). The large number of projects in one area does not necessarily imply a higher amount of funding or vice versa. As an example, we found that 5 Blockchain projects received a total amount of 2.5M EUR, while 16 projects in Software and its Engineering received a total funding amount of 1.3M EUR.
- among the more specific areas cited, Visualization, Data Science, Artificial Intelligence, Ubiquitous Computing, Data Management Systems, Blockchain, Applied Computing for Life and Medical Sciences, Systems Security, Machine Learning and Architectures were the top ten fields receiving more than 70% of the total funding reported. Each of these research areas received above 1 Million EUR from industry during the whole period of funding reported.

1 Introduction

It is well known that the effective collaboration between university and industry is vital to the global knowledge economy in Europe. Closer links between business and academia can encourage the transfer and sharing of knowledge and human resources, create long-term partnerships and opportunities, drive innovation, entrepreneurship and ultimately economic development. Mutually beneficial for universities and companies, such cooperation is highly encouraged in all science areas, including Informatics[1].

Until now no systematic research has been done about industry funding going to academic research in Informatics in Europe. While there are some oft-quoted examples of large business investments from IBM, Intel, and Microsoft in academic research, little is known about the overall amount of industry funding spent in different areas of academic research in Europe. Which areas of Informatics are highly supported by industry and which lack business investment? What are the most common ways of industry-academia collaboration? How long do such cooperation projects usually last?

To address these questions and understand if the data of interest is actually readily available, Informatics Europe decided to run a pilot study including a few institutions – members of the association - in a few European countries.

The study had two main goals:

- understand the current level of industry funding going to different areas of Informatics research in different European countries, similarities or differences in the way this money is invested;
- evaluate the feasibility of a bigger scale study involving a higher number of institutions and countries, bringing forward a more pan-European view of the industry-academic research funding landscape.

Additionally, derived from the main goals we can also:

- estimate the overall amount of industry funding going to Informatics academic research and the average length of funding;
- identify which areas of Informatics research are currently receiving more industry funding and which lack business support;
- estimate the variations in amounts of industry funding within each specific area of Informatics research;
- find out the most efficient way of collecting the data of interest at the European level.

By reaching these goals, we can provide valuable insights for the academic Informatics community, as well as for governmental institutions and the private sector, allowing to:

- understand if industry support is proportionally distributed across different fields of Informatics research or there are some areas lacking Industry funding;
- estimate the share of industry funding in the total budget of academic institutions and compare it with funding coming from other sources such as university funds, national and international research foundations, government funds, etc.
- compare the trends in the industry-academia cooperation in Europe with other regions, e.g. Asia, North America, etc.

[1] The term Informatics represents what is also called, depending on the country, Computer Science, Computing, Computer Engineering, IT, ICT.

2 Methodology

2.1 Initial research on publicly available data

Our investigation began with a search for publicly available data on industry funding for academic research in Informatics in a few selected countries: Germany, the Netherlands, Switzerland and the UK.

The focus was on systematic reviews, annual reports, rankings and assessments published in these countries that report quantitative data on industry funding going exclusively to Informatics research. Articles, news releases and similar news publications that give single examples of research contracts concluded between a specific university and private company were not included. Table 1 shows a number of sources of the data available and briefly describes what kind of information can be used for the purpose of this study[2].

Table 1. Summary of the publicly available data about industry funding for Informatics research in Germany, the Netherlands, Switzerland and the UK.

Source of the data	Type of the data and information available	Website
	Germany	
1. CHE University Ranking (in cooperation with DIE ZEIT)	• Provides the ranking of German Universities by third-party funds/academic for 35 subjects of study (including Computer Science). • Reports third-party funds/academic from different external sources (e.g. German Research Foundation, German Federal Ministry of Education and Research, other foundations and industry).	https://ranking.zeit.de/che/en
2. TU Berlin, Faculty of Electrical Engineering and Computer Science, Research figures	• Provides amounts of third-party funding received by the faculty from national government, federal country, German Research Foundation, EC, other public funds and industry in 2001 - 2014.	https://www.eecs.tu-berlin.de/menue/research/research_figures/parameter/en
	The Netherlands	
3. Research Review Computer Science. 2009-2014 (published by De Onderzoekerij in 2016)	• Provides an assessment of publicly-funded Computer Science research at Dutch Universities including different parameters (e.g. research quality, external funding, relevance to society, etc.) • Shows the percentages of Universities' direct funding and funding obtained from research and contract grants.	http://www.siks.nl/20160212_report_CS_final.pdf
	UK	
4. The University of Edinburgh, Edinburgh Research Explorer	• Database of research projects which are not subject to non-disclosure agreements. It shows amounts, periods and sources of funding (e.g. EU government bodies, UK-based charities, industry, commerce and public corporations, etc.) separately for each research project within a specific academic unit.	https://www.research.ed.ac.uk/portal/en/projects/search.html

[2] This initial exploratory search was not exhaustive, therefore the list in Table 1 might omit other relevant data sources.

5. Review of enterprising activity 2016-17, Imperial College London	• Provides the total amount and distribution of 2016-2017 contract awards with corporate partners by sector.	https://www.imperial.ac.uk/enterprise/publications/enterprising-activity-2017
Worldwide		
6. The Times Higher Education World University Rankings (in partnership with Elsevier)	• Provides the ranking of the top 1000 universities in the world by "industry income" for different subjects of study (including Computer Science). • The category "Industry income" (scores from 0 to 100) accesses how much research income a university earns from industry (adjusted for PPP), scaled against the number of academic staff it employs. • Data is updated every year.	https://www.timeshighereducation.com/world-university-rankings/2018/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats

In this initial non-exhaustive exploratory search, we could identify only few public data sources that show the amount of industry funding for Informatics academic research. In most cases, funding is reported aggregated under overall third-party sources or aggregated with the data for Engineering and/or Technology. In cases where there is an option to select the field "Informatics", funding is given in scores or FTE units which allows ranking between Universities but complicates the estimation of the actual amount of industry funding per university. The only exception in our search is the University of Edinburgh that provides a public database listing all research projects run by a specific academic unit and indicating the funding source, amount and period. Although it does not include contracts under non-disclosure agreements, it gives a very good estimation of the industry funding going to the specific academic units.

Regarding the differentiation between areas of Informatics research, none of the public sources found provides such information, which makes impossible to understand which areas are highly supported by industry and which lack investment. This short investigation has confirmed our suspicion that the only possible way to get answers to these questions is by directly communicating with the various Informatics academic departments in Europe.

Informatics Europe represents the academic and research community in Informatics in Europe. Bringing together university departments and research laboratories, the organization is in a unique position to get access and analyze this sort of data.

2.2 Academic units selected for the study

As we have seen by our initial search, data on third-party funding, and specifically on industry funding, for academic research in Europe is not widely available. Given the complexity of the problem in hand we decided initially to set a pilot study involving only a small selected number of Informatics academic units[3] in a few countries. Three Informatics Europe member institutions in Germany, the Netherlands, Switzerland and the UK were initially contacted, consisting in a pilot study involving twelve academic units. The choice of countries and universities for the pilot study was basically determined by reliable personal contact with heads or faculty members of the respective academic units.

Two academic units, one from Germany, and one from Switzerland, declined to provide the data because of confidentiality concerns or for lack of perceived benefits compared to the efforts needed to collect and

[3] We use the generic term "academic unit" to replace different types of academic organizations: Department, Faculty, School, Institute, etc.

aggregate the requested data. A third academic unit from Germany was able to respond only partially the questions of the survey and did not share the list of industry-funded research projects, citing for a last-minute decision, a number of legal concerns, and therefore was not included in the study. In Table 2 are shown the nine academic units that provided the data. In spite of these drawbacks, the final response rate was high - 75% - reflecting trustful connections and an understanding of the importance of our pilot study. The data collected was organized and analyzed in this short report exploring some trends in industry funding for academic Informatics research in Europe. In the next sections we present the results and analysis of our pilot study.

Table 2. List of academic units participating in the pilot study.

	University	Department/Faculty/School/Institute	Website
Germany			
1.	University of Paderborn	Department of Computer Science	https://cs.uni-paderborn.de/en/department/welcome.html
The Netherlands			
2.	Delft University of Technology	Faculty of Electrical Engineering, Mathematics and Computer Science	https://www.tudelft.nl/en/ewi
3.	Vrije Universiteit Amsterdam	Department of Computer Sciences	https://www.cs.vu.nl/en/index.aspx
4.	Utrecht University	Department of Information and Computing Sciences	https://www.uu.nl/en/organisation/department-of-information-and-computing-sciences
Switzerland			
5.	École Polytechnique Fédérale de Lausanne EPFL	School of Computer and Communication Sciences	https://ic.epfl.ch
6.	University of Zurich	Department of Informatics	http://www.ifi.uzh.ch/en.html
UK			
7.	Imperial College London	Department of Computing	http://www.imperial.ac.uk/computing
8.	The University of Edinburgh	School of Informatics	http://www.ed.ac.uk/schools-departments/informatics
9.	University of Oxford	Department of Computer Science	http://www.cs.ox.ac.uk

2.3 Data Collection

To obtain the data of interest comparable across different countries, we elaborated an online survey (for details see Appendix A) that was distributed among our contacts in the various academic units. On average we received the data of interest within 2-3 months, with a few exceptions. In all cases several rounds of clarifications and explanations were necessary to get the data with the desired form and completeness.

Since our main interest was not only to understand the total amount of received industry funding but also its distribution across different areas of Informatics research, we asked respondents to indicate which Research Projects – active in 2017[4] - have received funding from industry and what was the amount and period of funding.

[4] Examples: funding started in 2017 will end in 2019, or 2022; started in 2010 and ended in 2017; started in 2012 and will end in 2018, or 2020.

To simplify the task, we included only projects with funding above 10K (in the national currency) and proposed different options for the data submission:

1. to list all industry-funded projects indicating their title, research area, head or principal investigator, period of funding and total amount received for the whole period of funding;
2. to share an existing complete list of industry-funded research projects in any convenient form (link to a website, database, document, etc), if such information was already available;
3. to indicate which Research Groups, Labs or Chairs of an academic unit have received funding from industry, if the information about research projects could not be retrieved.

In addition, we asked about the percentage of industry-funded projects, active in 2017, that received funding below 10K to understand the share of funding we were not considering in the main survey. Our final request was an estimation of the percentage of industry funding in the total of received third-party funding.

2.4 Survey Implementation

Following the first invitations to participate in the survey, we have received numerous requests and comments from participants regarding data confidentiality and complexity of the data collection. First, most academic units did not accept to disclose projects titles and principal investigators names. Some of the sponsored research projects were subject to non-disclosure agreements, some were in highly competitive fields and the participants did not want to disclose the funding details of such projects to third parties. Second, the collection and aggregation of the requested data was very time consuming and, in most cases, required involvement of Universities' central administration and accounting staff. In most cases, representatives of Informatics academic units had to ask central administration offices for permission to share such data with third parties and, if granted, to retrieve such information from central accounting systems. This interaction was time and effort consuming and made the data collection process longer than initially expected (up to 2-3 months in case of big institutions). In a few cases, some of the data of interest was not available, e.g. in cases where industry funding was granted as an unrestricted gift or fellowship that did not specify any area of research, or in cases where the ending date of funding could not be retrieved from the accounting system.

To not discontinue the survey and keep on collecting the data of interest, we had to comply with participants requests and made the following adjustments:

- we put an extra emphasis on data discretion and reassured participants that all data and results would be reported aggregated and in anonymized form so that in no way it would be possible to link the university/academic unit name with the respective funding amount, project or area of funding;
- if for confidentiality reasons academic units could not reveal the titles of the industry-funded research projects or names of the principal investigators, they could omit these data and indicate instead a top-level branch of Informatics research areas following the ACM 2012 Computing Classification System[5] or any other classification they found more appropriate;
- if the ending date of funding could not be specified, it was sufficient to indicate only the beginning date.

These adjustments allowed us to get the required data from 8 out of 12 participants. They all answered our survey and indicated at least a top-level branch of Informatics research being funded by industry, beginning of that funding and the total amount of money received. For one academic unit we retrieved all requested data (i.e. title of industry-funded project, period and amount of funding and name of principal investigator) directly

[5] The ACM 2012 Computing Classification System (https://dl.acm.org/ccs/ccs_flat.cfm) was published in 2012 and does not include some recently emerged areas of Informatics research. If this was the case, we proposed respondents to indicate the name of these areas.

by querying a public database and assigning ourselves the projects titles to the research areas of the ACM Classification.

It is important to notice that more than a half of the participants had difficulties to provide accurate answers to the questions about the share of industry funding in the total amount of third-party funding, and the percentage of the projects with funding below 10K. The complexity of calculation and the extra effort required to obtain such numbers were the main reasons for the lack of this information. We therefore did not include these data.

2.5 Data preparation

In total 9 academic units provided the data about 183 research projects, active in 2017, that received funding from industry for an amount above 10K (in the national currency). Each of the 183 projects included the following information:

- area of Informatics research,
- starting month of funding,
- total amount of funding received during the whole funding period.

Areas of Informatics research were taken from the ACM 2012 Computing Classification System[5]. Each project was assigned, either by the participants themselves or by the authors of the report, to one of following top-level branches of the ACM Classification:

- Applied Computing
- Computer Systems Organization
- Computing Methodologies
- Information Systems
- Hardware
- Human-centered Computing
- Mathematics of Computing
- Networks
- Security and Privacy
- Software and its Engineering
- Theory of Computation.

Since the ACM 2012 Classification does not include some recently emerged areas of Informatics research, we complemented the existing classification adding two additional areas:

- Blockchain
- Data Science (including Data Mining and Big Data).

Projects that received funding granted as an unrestricted gift or fellowship for an unspecified research area were grouped under the category “Undefined Area”.

In most cases, the study participants also provided 2nd-level areas of Informatics research taken from ACM 2012 Classification or other classification that they found more appropriate (e.g. Visualization, Artificial Intelligence, Machine Learning, Network Security, Software and Application Security, Software Creation and Management, etc.). When such information was not available, the project was associated only with the top-level branch and classified as e.g. “Theory of Computation: unspecified area”, “Human-Centered Computing: unspecified area”, etc.

Starting and ending period of funding were provided by all academic units, except one that could not indicate the ending date of all projects of the unit. To not exclude this data from our analysis, we assumed that funding

was granted either for one year, if the amount was below 100K, or for two years, if the amount was equal or above 100K (in national currency). Although this was an arbitrary assumption and might deviate from reality, the approximation goes in line with the data received from other academic units, i.e. in most cases, projects with funding above 100K last for at least 2 years.

Each academic unit provided the amount of funding in the national currency. Therefore, for the institutions in the UK and in Switzerland numbers were provided respectively in GBP and CHF. To facilitate comparisons, we converted GBP and CHF values in EUR using the following exchange rates: 1 GBP= 1.11 EUR and 1 CHF= 0.88 EUR.

3 Results and Analysis

3.1 Total amount of industry funding

The overall number of research projects funded by industry (active in 2017) in the 9 academic units included in this study was 183, the overall amount of funding received for the whole period surveyed was 42 609 771 EUR.

Table 3 provides descriptive statistics (average, standard deviation, minimum, maximum, median, first and third quartile) for the overall funding, analysing it per academic unit (n=9) and per project (n=183). Table 4 presents the same descriptive statistics for the number of projects, analysed per academic unit (n=9) and for their duration, analysed per project (n=183).

Table 3. Descriptive statistics: overall funding (in EUR) per academic unit (n=9) and per project (n=183).

	Average	Standard deviation	Minimum	Maximum	First quartile	Median	Third quartile
Funding per Academic Unit	4 734 419	6 626 453	517 328	21 312 999	1 623 438	2 157 240	2 512 000
Funding per Project	232 840	529 174	8 995[6]	5 277 050	42 376	89 500	199 566

Table 4. Descriptive statistics: number of projects per academic unit (n=9) and duration of funding (in months) per project (n=183).

	Average	Standard deviation	Minimum	Maximum	First quartile	Median	Third quartile
N° of projects per Academic Unit	20	16	7	53	9	13	29
Duration of Funding per Project	38	28	3	179	12	36	48

As seen in Table 3, there was an average of 4.7M EUR funding per academic unit (sd=6 626 453) or 233K EUR per project (sd=529 174). The funding varied significantly between academic units[7], from 517K EUR (minimum) to 21M EUR (maximum), as well as between research projects, from 9K[6] EUR to 5.3M EUR.

As shown in Table 4, both the number of projects and the duration of funding were also not uniform, ranging from 7 to 53 projects per academic unit (average = 20, sd = 16) and from a 3 months duration to almost 15 years per project, with an average of 38 months (3 years and 2 months) and sd=28 months.

To compare projects with different duration of funding, for each project we calculated the funding amount per month (monthly project funding) by dividing its total funding amount by the duration of funding in months. Table 5 provides the descriptive statistics of the monthly project funding per academic unit (n=9), by aggregating project funding of all projects in the same academic unit, and at the single project level (n=183).

[6] The minimum value below 10K EUR is from a project in Switzerland. Due to the currency conversion (1CHF = 0.88EUR), we had few projects whose funding is below 10K EUR (but not below 10K in CHF) among the results.

[7] The significant variation in industry funding between academic units can be explained by their different size (e.g. the smallest unit in our sample employed 14 (full) professors while the biggest employed 73). Since we did not include any question about the number of (academic and research) staff, the funding amounts reported were not normalized by the unit's size and should be therefore, compared with caution.

Table 5. Descriptive statistics: monthly funding (in EUR) per academic unit (n=9) and per project (n=184).

	Minimum	Maximum	First quartile	Median	Third quartile
Monthly Funding per Academic Unit	2 197	15 764	3 800	4 865	5 533
Monthly Funding per Project	70	87 951	1 499	3 774	7 403

As one can see, the range of monthly project funding was wide, varying from 70 EUR to almost 88K EUR across projects and from 2K EUR to almost 16K EUR across academic units.

For all examined quantitative elements, the medians and quartiles are more reliable measures of central tendency since all data analysed was positively skewed (i.e. most values fell toward the lowest side of the scale and there are very few high values). Drawing conclusions from median values, we found that on average an academic unit had 13 industry-funded research projects, active in 2017, and received around 2.2M EUR of funding during the period surveyed (interquartile range from 1.6M to 2.5M EUR – Table 3), or 5K EUR (interquartile range from 3.8K to 5.5K EUR – Table 5) in one month. The median funding amount of a project was 89.5K EUR (interquartile range from 42K to almost 200K EUR – Table 3) for the whole period of funding, or 3.7K EUR (interquartile range 1.5-7K EUR – Table 5) for one month.

3.2 Distribution of funding across areas of Informatics research

To identify which areas of Informatics research have been highly supported by industry and which lacked business support in the 9 institutions included in this study, we analyzed the distribution of funding across areas.

Tables 6a shows the total amount of funding and the average funding per project for the different top-level[5] research area branches. In Graph 1 one can see the distribution of the 183 research projects across these research areas. Table 6b shows the calculated sum of monthly funding and the average monthly funding per project in the different top-level[5] branches. Graph 2 shows the distribution of total and monthly funding across these areas. In addition, in Table 7 and Graph 3 we report the average length of funding for each top-level research area branch.

Table 6a. Areas of Informatics research receiving industry funding (in descending order, based on the total funding received).

N°	Areas of Informatics Research	N° of Projects	Total Funding		Average Funding/Project	
			in EUR	*%*	*in EUR*	*sd*
1	Human-Centered Computing	16	9 919 305	23.28%	619 957	1 330 917
2	Data Science (including Data Mining and Big Data)	14	7 369 190	17.29%	526 371	876 952
3	Computing Methodologies	41	5 333 704	12.52%	130 090	146 937
4	Security and Privacy	24	5 154 115	12.10%	214 755	252 419
5	Applied Computing	13	3 104 196	7.29%	238 784	280 874
6	Information Systems	6	2 741 858	6.43%	456 976	786 664
7	Blockchain	5	2 477 352	5.81%	495 470	602 003
8	Computer Systems Organization	16	2 097 318	4.92%	131 082	112 030
9	Software and its Engineering	16	1 328 658	3.12%	83 041	124 338
10	Hardware	9	970 108	2.28%	107 790	100 426
11	Undefined Area	12	753 892	1.77%	62 824	44 371
12	Networks	5	640 216	1.50%	128 043	160 515
13	Mathematics of Computing	1	413 495	0.97%	413 495	-
14	Theory of Computation	5	306 364	0.72%	61 273	57 691
	TOTAL	**183**	**42 609 771**	**100%**	**232 840**	**529 174**

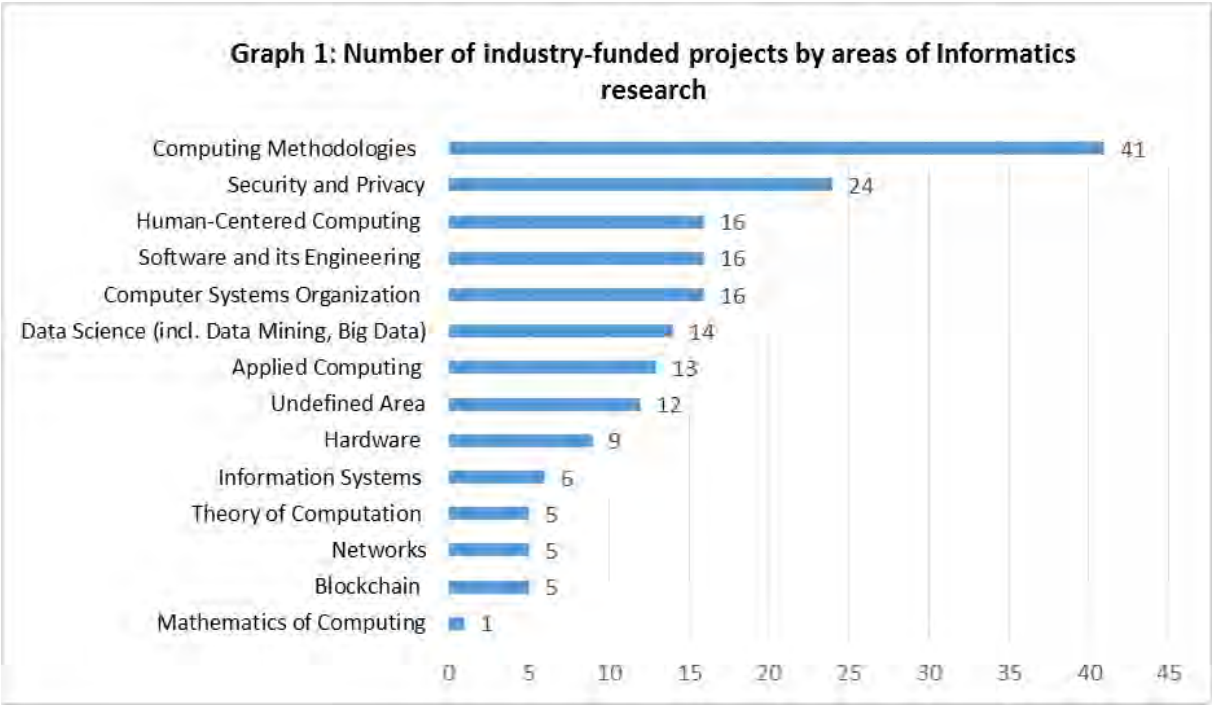
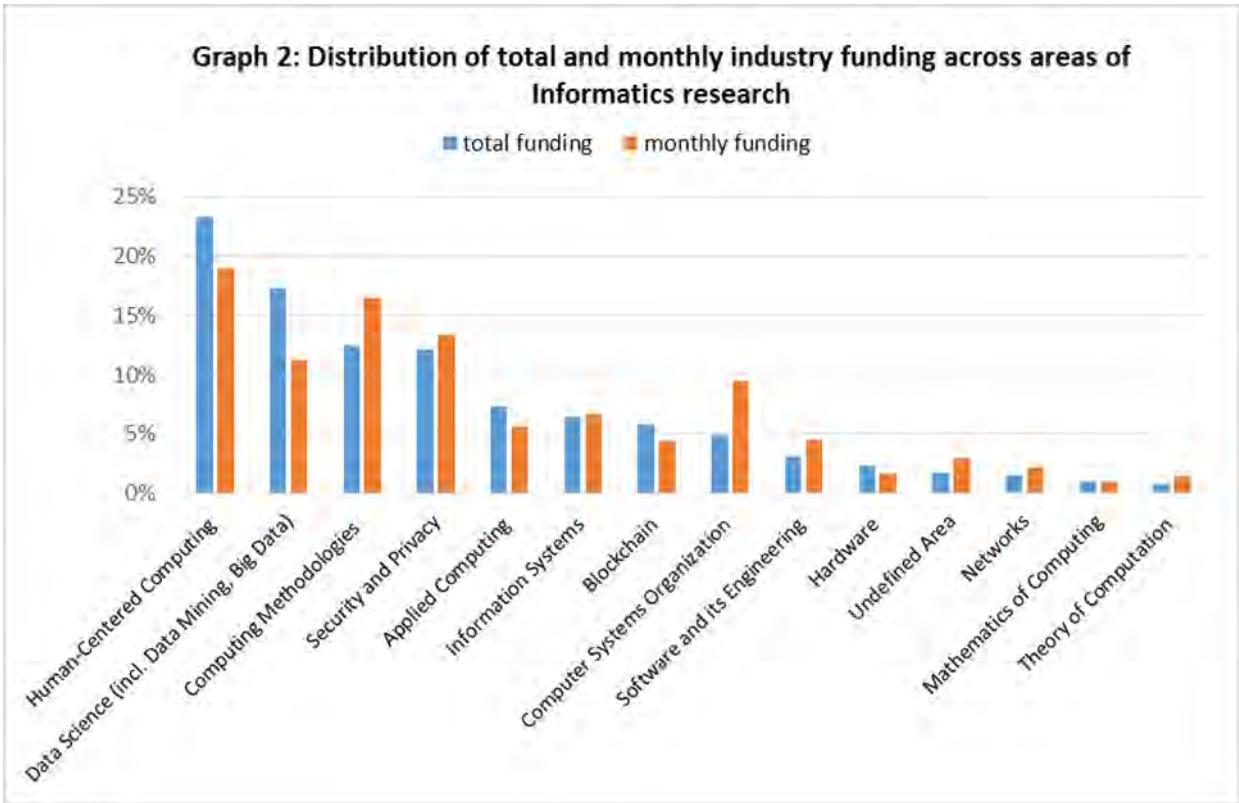


Table 6b. Areas of Informatics research receiving industry funding (in descending order, based on the monthly funding received).

N°	Areas of Informatics Research	N° of Projects	Sum of Monthly Funding		Average Monthly Funding/Project	
			in EUR	*%*	*in EUR*	*sd*
1	Human-Centered Computing	16	223 712	18.95%	13 982	21 362
2	Computing Methodologies	41	194 175	16.45%	4 736	3 799
3	Security and Privacy	24	158 488	13.42%	6 604	7 520
4	Data Science (including Data Mining and Big Data)	14	132 736	11.24%	9 481	14 487
5	Computer Systems Organization	16	112 226	9.50%	7 014	7 418
6	Information Systems	6	78 458	6.65%	13 076	21 885
7	Applied Computing	13	66 355	5.62%	5 104	4 470
8	Software and its Engineering	16	52 976	4.49%	3 311	3 103
9	Blockchain	5	52 753	4.47%	10 551	13 088
10	Undefined Area	12	34 656	2.94%	2 888	2 443
11	Networks	5	26 167	2.22%	5 233	4 803
12	Hardware	9	19 022	1.61%	2 114	1 957
13	Theory of Computation	5	17 310	1.47%	3 462	2 466
14	Mathematics of Computing	1	11 486	0.97%	11 486	-
	TOTAL	**183**	**1 180 520**	**100%**	**6 451**	**9 957**



The data shows that Human-Centered Computing, Data Science, Computing Methodologies, and Security and Privacy, were the areas receiving the most industry funding (around 65% altogether) in terms of both total (Table 6a) and monthly funding (Table 6b). Taken altogether projects from these areas received around 28M EUR for the whole period surveyed, or 710K EUR per month. At the bottom end were Mathematics of Computing, Networks, Hardware, and Theory of Computation, having received altogether around 5% of industry funding (2.3M EUR in total (Table 6a) or 74K EUR per month (Table 6b)).

The highest number of projects funded by industry were in the area of Computing Methodologies (n=41), Security and Privacy (n=24), while the lowest number were in the area of Theory of Computation (n=5), Networks (n=5), Blockchain (n=5), Mathematics of Computing (n=1) (Graph 1). It is important to notice that the large number of projects does not always imply the highest amount of funding and vice versa. For example, while relatively many projects were funded in the area of Software and Engineering (n=16), their total funding was relatively small (1.3M EUR in total, or 83K EUR on average per project). By contrast, five Blockchain projects (n=5) accumulated a total of 2.5M EUR of funding, giving on average 500K EUR per project.

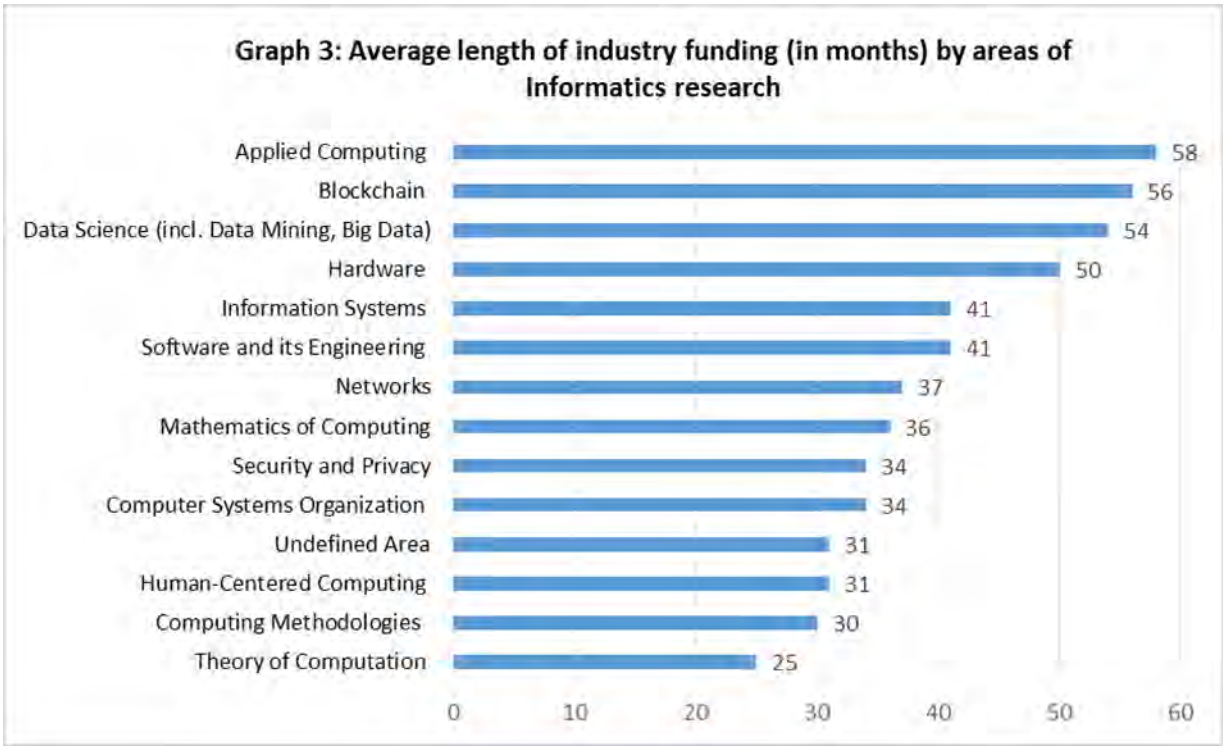
Other interesting insights might be obtained through the comparison of variances (Tables 6a, 6b) between areas of research. Thus, we found that areas as Human-Centered Computing, Data Science, Information Systems and Blockchain had very large standard deviations (almost twice higher than average values). This indicates that in these areas the variations in funding amounts between individual projects were very high (e.g. from 18K to 5M EUR of total funding per project in the area of Human-Centered Computing; from 30K to 3M EUR in the area of Data Science). In other areas, such variations were also observed but were not as significant.

With regard to the length of funding, projects with the longest period were in the area of Applied Computing, Blockchain, Data Science and Hardware (above 4 years); with the shortest in the areas of Theory of Computation, Computing Methodologies, Human-Centered Computing and Undefined Area (less than 32 months or 2.67 years) (Table 7).

Given that projects vary significantly in the length of funding, we compared which positions different areas of research have depending how the funding was calculated, either as total (Table 6a) or as monthly funding (Table 6b). While some areas had stable positions (e.g. Human-Centered Computing, Information Systems, Networks, etc.), others have notably changed their places (e.g. Computer Systems Organization: from 8th place in total funding to 5th place in monthly funding, Blockchain: from 7th to 9th place, Data Science: from 2nd to 4th place). Those areas whose position decreases in monthly funding compared to total funding have typically a longer funding period and vice versa (e.g. 56 and 54 months on average for Blockchain and Data Science vs 34 months on average for Computer Systems Organization).

Table 7. Average length of industry funding by areas of Informatics research (in descending order).

N°	Areas of Informatics Research	N° of Projects	Average Length of Funding	
			in months	*sd*
1	Applied Computing	13	58	39
2	Blockchain	5	56	38
3	Data Science (including Data Mining and Big Data)	14	54	16
4	Hardware	9	50	10
5-6	Information Systems	6	41	15
5-6	Software and its Engineering	16	41	43
7	Networks	5	37	26
8	Mathematics of Computing	1	36	-
9	Security and Privacy	24	34	17
10	Computer Systems Organization	16	34	42
11	Human-Centered Computing	16	31	31
12	Undefined Area	12	31	18
13	Computing Methodologies	41	30	18
14	Theory of Computation	5	25	18
	TOTAL	**183**	**38**	**28**



To further analyze which specific areas of Informatics research were included in the top-level branches described in this section, we report in Table 8 the distribution of total funding by 2nd-level research areas (or concepts) taken from the ACM 2012 Classification[8] and complemented with recently emerged areas. It is important to notice that we included in Table 8 only those 2nd-level areas that have been reported by respondents. The omitted areas either have not got any funding from industry or have been classified under "Unspecified Area"[9].

Table 8. Distribution of total industry funding by 2nd-level areas of Informatics research[8].

Areas of Informatics Research	N° of Projects	Total Funding		Average Length of Funding	
		in EUR	*%*	*in months*	*sd*
APPLIED COMPUTING	**13**	**3 104 196**	**100%**	**58**	**39**
• Art and Humanities	1	107 719	3%	48	-
• Computers in Other Domains	1	22 488	1%	119	-
• Education	1	43 177	1%	60	-
• Electronic Commerce	3	575 695	19%	60	23
• Life and Medical Sciences	7	2 355 117	76%	49	46
BLOCKCHAIN	**5**	**2 477 352**	**100%**	**56**	**38**
COMPUTER SYSTEMS ORGANIZATION	**16**	**2 097 318**	**100%**	**34**	**42**
• Architectures	7	1 026 663	49%	24	15
• Dependable and Fault Tolerant Systems	1	147 946	7%	12	-
• Embedded and Cyber-Physical Systems	8	922 709	44%	46	57
COMPUTING METHODOLOGIES	**41**	**5 333 704**	**100%**	**30**	**18**
• Artificial Intelligence	24	3 705 757	69%	34	20
• Computer Graphics	2	62 966	1%	12	0
• Distributed Computing Methodologies	1	134 029	3%	24	-
• Machine Learning	13	1 385 325	26%	28	14
• Symbolic and Algebraic Manipulation	1	45 627	1%	6	-
DATA SCIENCE (including Data Mining, Big Data)	**14**	**7 369 190**	**100%**	**54**	**16**
• Big Data	4	826 415	11%	53	18
• Data Mining	2	894 168	12%	47	19
• Data Science: unspecified area[9]	8	5 648 607	77%	57	16
HARDWARE	**9**	**970 108**	**100%**	**50**	**10**
• Hardware Architecture	1	81 803	8%	47	-
• Hardware Performance	1	40 494	4%	43	-
• Power and Energy	2	331 483	34%	55	6
• Hardware: unspecified area[9]	5	516 328	53%	50	13
HUMAN-CENTERED COMPUTING	**16**	**9 919 305**	**100%**	**31**	**31**
• Ubiquitous Computing	5	2 817 125	28%	32	25
• Visualization	7	6 929 292	70%	39	41

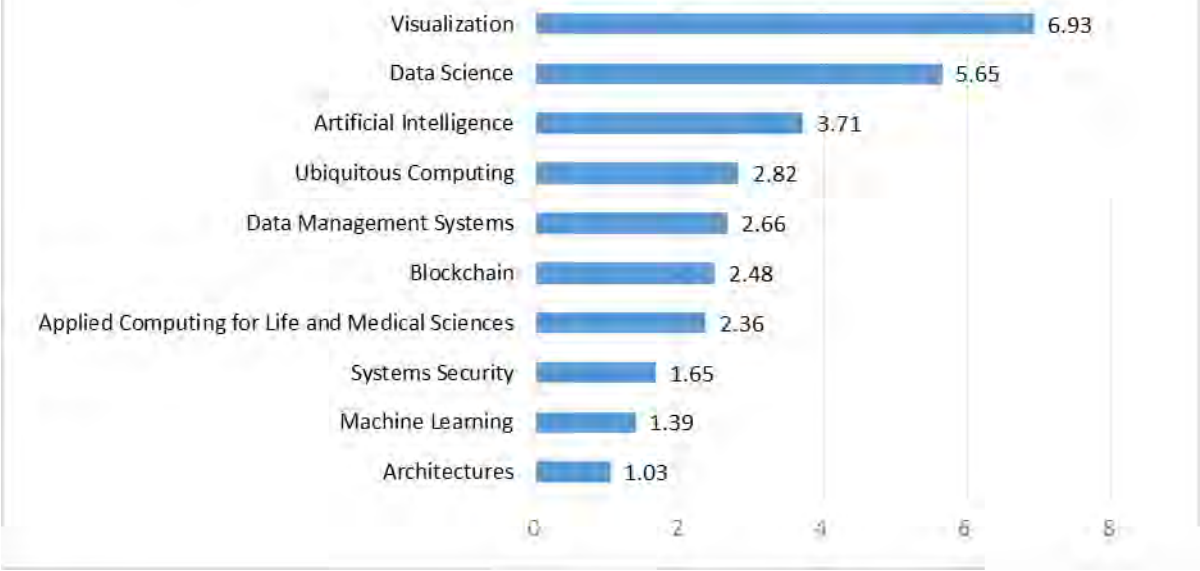
[8] 2nd-level areas - also called 2nd-level concepts - of Informatics research as defined in the ACM 2012 Computing Classification System and complemented with a few recently emerged areas.

[9] "Unspecified Area" groups the projects for which respondents were not able to specify the 2nd-level areas of Informatics research and might contain one of 2nd-level areas previously mentioned in Table 8.

• Human-Centered Computing: unspecified area[9]	4	172 888	2%	15	6
INFORMATION SYSTEMS	**7**	**2 741 858**	**100%**	**41**	**15**
• Data Management Systems	5	2 659 821	97%	35	7
• Information Retrieval	1	82 037	3%	69	-
MATHEMATICS OF COMPUTING	**1**	**413 495**	**100%**	**36**	-
• Discrete Mathematics	1	413 495	100%	36	-
NETWORKS	**5**	**640 216**	**100%**	**37**	**26**
• Network Types	2	96 102	15%	33	30
• Networks: unspecified area[9]	3	544 114	85%	40	30
SECURITY AND PRIVACY	**24**	**5 154 115**	**100%**	**34**	**17**
• Cryptography	1	71 962	1%	12	-
• Cyber-Security	2	957 457	19%	36	17
• Human and Societal Aspects of Security and Privacy	1	121 436	2%	50	-
• Intrusion and Anomaly Detection	2	700 204	14%	47	16
• Network Security	2	306 962	6%	24	17
• Security in Hardware	1	230 000	4%	48	-
• Security Services	4	658 038	13%	25	11
• Software and Application Security	2	204 141	4%	52	6
• Systems Security	3	1 654 955	32%	44	14
• Security and Privacy: unspecified area[9]	6	248 960	5%	25	20
SOFTWARE AND ITS ENGINEERING	**16**	**1 328 658**	**100%**	**41**	**43**
• Software Creation and Management	8	292 871	22%	19	20
• Software Notations and Tools	3	119 942	9%	47	5
• Software Organization and Properties	3	570 000	43%	84	86
• Software and its Engineering: unspecified area[9]	2	345 845	26%	54	8
THEORY OF COMPUTATION	**5**	**306 364**	**100%**	**25**	**18**
• Formal Languages	1	42 376	14%	48	-
• Models of Computation	1	14 115	5%	3	-
• Theory and Algorithms for Application Domains	1	45 583	15%	12	-
• Theory of Computation: unspecified area[9]	2	204 290	67%	30	8
UNDEFINED AREA	**12**	**753 892**	**100%**	**31**	**18**

As can be seen in Table 8, among the areas reported by respondents, Visualization, Data Science, Artificial Intelligence, Ubiquitous Computing, Data Management Systems, Blockchain, Applied Computing for Life and Medical Sciences, Systems Security, Machine Learning and Architectures were the top ten fields receiving more than 70% of the total funding reported (Graph 4). Each of these areas received above 1M EUR from industry for the whole period of funding reported.

Graph 4. Top ten 2nd-level areas of Informatics research receiving the most industry funding (in MEUR)



4 Conclusion and outlook

Our pilot study on Informatics academic research being funded by industry in Europe has shown that in the presence of trustful connections, the right approach, flexibility and sufficient time it is possible to get insightful results and make meaningful comparisons on the industry-academia funding landscape in Europe[10]. The excellent participation rate in the small-scale study is a promising result and makes us optimistic about implementing a large-scale study including a higher number of institutions in more European countries. However, it is clear that the time and effort necessary for the participant institutions to put together the data of interest is the biggest challenge for a larger study. The publication of the pilot study is a very important milestone and will certainly generate interest not only in the academic community but also in industry and funding organizations across Europe. The success of this pilot study is of vital importance for getting more Informatics Europe member institutions willing to participate and take the effort to collect and share their financial data.

[10] ***Disclaimer****: All facts and figures were obtained from the survey data. Although great care has been taken to ensure the data of interest was correctly collected, we give no warranty as to the accuracy or completeness of this information. The reader is solely responsible for any conclusions drawn from the information portrayed in this report as well as for the use of the data presented. Please report any incomplete or erroneous data to svetlana.tikhonenko@informatics-europe.org.*

5 Acknowledgements

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Appendix A: Survey Details

Dear Colleague,

Please answer the questions listed below on behalf of your academic unit - Faculty or School, Department or Institute.

The survey can be saved and resumed later. If you cannot answer some questions, you might skip them. Whatever you can share with us is of great value for the community!

Q1. Please indicate the full name of your University, academic unit, your name, phone and email address.

University

Academic unit (Department/School/Institute/Faculty)

Name

Phone number

Email

i Your name, phone and email are needed to contact you for any further clarification and will not be disclosed.

Q2. We are interested to know which Research Projects in your academic unit have received funding from industry for an amount above 10K (in national currency).

Could you list all industry-funded research projects - active in 2017 - in your academic unit, by indicating their:

- **Project Title or Research Area**
- **Head or Principal Investigator (optional)**
- **Period of Funding (starting and ending date)**
- **Total Amount of Money Received in the Whole Period of Funding?**

☐ Yes, I could fill in all necessary information about industry-funded research projects **(go to Q3a)**

☐ Yes, I have already a list of industry-funded research projects with all necessary information and could share it with you **(go to Q3b)**

☐ No, I do not have such information but could indicate which Research Groups, Labs or Chairs of my academic unit have received funding from industry (**go to Q3c**)

☐ No answer **(go to Q3d)**

Q3a. Please download the Excel form and include all industry-funded research projects active in 2017 in your academic unit. Include only projects with funding higher than 10K and indicate the following:

- **Project Title.** If this information is confidential, please indicate instead the specific **Research Area** using e.g. the ACM 2012 Computing Classification System (https://dl.acm.org/ccs/ccs.cfm)
- **Head of the Project or Principal Investigator (PI) (optional)**
- **Period of Funding (starting and ending date)**
- **Total Amount of Money Received in the Whole Period of Funding.**

After completing the Excel form provided, please upload it using the link "Upload files" below.

Upload Files

Q3b. If you have already a complete list of industry-funded research projects with all necessary information (i.e. title, PI, period and amount of funding) please:

- give us the link to the web-site where we could find it OR,
- indicate the name and email of a person who could provide us with such list OR,
- upload, using the link below, the file(s) with the compiled list of industry-funded research projects.

URL of website

Name of the contact person

Email of the contact person

Please upload your files

Upload Files

Q3c. Please download the Excel form and include all Research Groups of your academic unit that had industry-funded research projects active in 2017.

Consider all research projects, grants, contracts with funding higher than 10K and indicate the following:

- **Full Name of the Research Group**
- **Research Area (optional),** using e.g. ACM 2012 Computing Classification System (**https://dl.acm.org/ccs/ccs.cfm)**
- **Head of the Research Group or Principal Investigator (optional)**
- **Period of Funding (starting and ending date)**
- **Total Amount of Money received by each Research Group in the Whole Period of Funding.**

After completing the Excel form provided, please upload it using the link "Upload files" below.

Upload Files

Q3d. You have left the previous question unanswered. Could you please indicate the reasons why you could not provide us with the data of interest?

Q4. If there were any projects in your academic unit <u>active in 2017</u> funded by industry <u>for an amount equal or below 10K</u> (in national currency), what is their <u>share (in %)</u> in the total amount of industry funding?

- ☐ We had projects active in 2017 with industry funding equal or below 10 K and their share is: [ ]
- ☐ We didn't have any projects active in 2017 with industry funding equal or below 10K.

Q5. This question regards the overall <u>third-party funding</u> which your academic unit has received in 2017.

Third-party funding *refers to money earned from external sources additional to the regular fixed University budget. Typical sources of such funds are research grants of a National Research Council, various foundations grants, project funding from the federal and national ministries or the EU, as well as funding from industry.*

Please estimate the percentage (%) or actual amount (in national currency) of your academic unit's third-party funding for 2017 coming:

	%	***amount***
only from industry		

<u>(Optional)</u> Please give additional estimates (in percentages or in actual amounts) of your academic unit's third-party funding for 2017 coming from the following sources:

	%	***amount***
Government (e.g. federal, national and regional ministries)		
National Research Council or Foundation (e.g. DFG, SNSF, NWO, etc.)		
European Commission		
Other third-party funding_____		

Q6. Do you have any comments or suggestions for our survey?

Thank you very much for participating in our survey! Your feedback is of great value for the European Informatics research community! The results of our pilot study will be shared with you as soon as possible. We will keep you updated!

www.informatics-europe.org