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European Research Projects on Quantum Technologies and High Performing Computing: Analysis of The Communication Strategies

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Abstract

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Part I

Introduction

Chapter 1

The role of science communication

This chapters presents a concise overview of the importance of science communication in modern society. Section 1.1 outlines the characteristics of the knowledge era. Section 1.2 focuses on the related economical and societal challenges. Section 1.3 highlights the need for scientific citizenship in the knowledge era. Section 1.3 presents science communication as a requirement for scientific citizenship.

1.1 The knowledge era

Three economical eras have been identified in the history of human civilisation. The first one was the agricultural era. This is believed to have started between 10000 and 8000 B.C. in different regions in the world [1, 2]. The second one is the industrial era. It began in England in the 18th century as a result of the industrial revolution [3, 4]. The third one is the knowledge era, and it is the age into which human civilization is currently entering [5].

The three eras are based on different primary production resources. The agricultural age was founded on the work of people and animals. The ultimate source of richness and development in the industrial era was the work of people and machines. Finally, the current era is not based on the capacity to produce and accumulate tangible goods, but rather on the ability to store, generate and apply new knowledge [6].

The information on which the current era is based is mainly scientific. In the past centuries, the impact of science on humanity has been growing without interruption [7]. Nowadays, the outcomes of scientific activities permeate our society and heavily shape our life style. Examples range from telecommunications to medicine, or from artificial intelligence to the development of new materials.

The reason for the increasing impact of science is the peculiar nature of scientific knowledge as a resource [8]. Just like any other resource, it is important for its capacity to provide solutions to problems. However, contrarily to resources such as water, food or oil, scientific knowledge is potentially unlimited, as it is capable of generating itself (knowledge leads to new knowledge). Moreover, the same knowledge can be used simultaneously by multiple entities. Hence, scientific knowledge is intrinsically a non-exclusive good.

For its characteristics as a resource, scientific knowledge has revolutionised the world economy. The current science-driven change of the global market has introduced countless positive innovations. However, it has also led to dramatic societal changes.

1.2 Challenges in the knowledge era

The relationship between scientific research and society has changed significantly after the second world war. From the second half of the 20th century, several countries have started using science and its generation of new knowledge and technology as a source of economical growth. This process has progressively become more intense over the last decades. Nowadays, nations invest significant fractions of their gross domestic product in research and development.

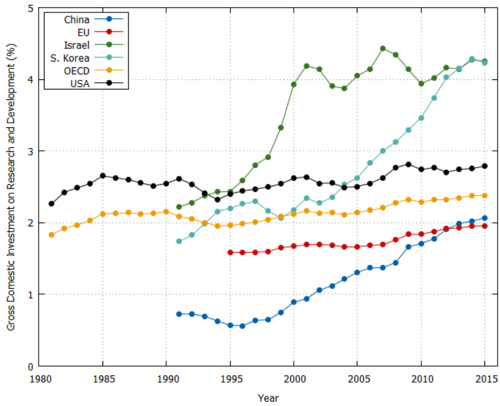

Figure 1.1: Gross domestic percentage invested in science and development over the past years by some of the world's leading economies. The image is based on data of the Organisation for Economic Co-operation and Development (OECD) [9].

Examples are the European Union, the United States, and Asiatic countries such as China and South Korea, see figure 1.1.

The capacity of scientific knowledge to generate richness has attracted a growing number of private investors. As a result, in many countries private investment on scientific research is larger than public funds [10]. One example are the United States, where the former is currently twice as large as the latter [11].

The leading role of private investors is based on a reinterpretation of knowledge as a resource. To pursue personal profit, investors are typically non interested in sharing the knowledge they develop or they way they use it to create goods. This approach limits the possibility to generate new knowledge from the results of others. Moreover, people with limited buying power cannot afford specific classes of products and benefit from the knowledge behind them. One example are patented expensive medicines [13]. In such

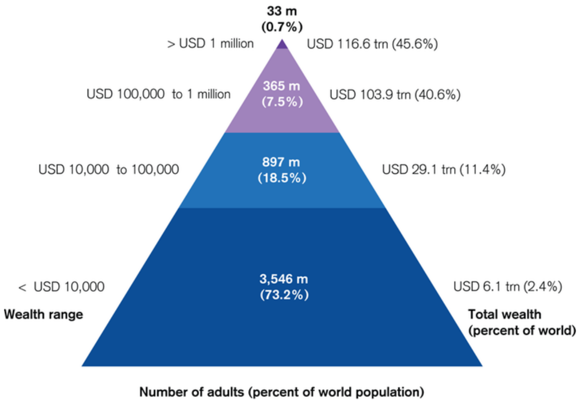

Figure 1.2: Distribution of the global wealth among the world's population. Original image in [12].

a scenario, knowledge as a resource partially looses the intrinsic characteristics mentioned in Section 1.1 of being unlimited and non exclusive.

The current knowledge-driven development of the global economy has two important consequences. Firstly, humanity is richer than ever before [14]. Secondly, the progressive concentration of the generated richness in the hands of few individuals is causing societal inequality, see figures 1.2 and 1.3.

The increasing inequality is an obstacle for the creation of a democratic society [15]. The scenario humanity is facing can change if knowledge will not be used as a mere instrument of power, but rather as a common good everyone should benefit from. This paradigm shift can be achieved through the acquisition of the scientific citizenship.

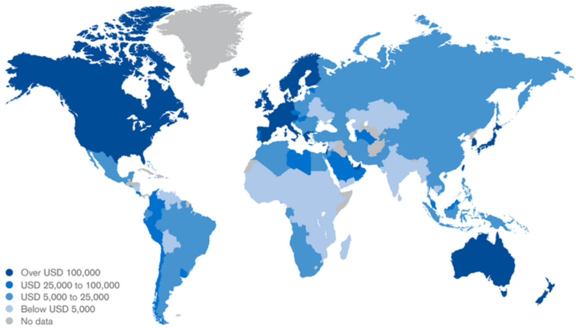

Figure 1.3: Comparison among nations of the current annual wealth per adult. Original image in [12].

1.3 The scientific citizenship

The potential of scientific knowledge to be a pillar of democratic societies was first recognised by English philosopher Francis Bacon in the 17th century. He proposed that science and technology should not bring advantages to a limited number of societal groups or nations, but rather to the whole humankind [16]. This vision is efficaciously outlined in his utopian novel *The New Atlantis*.

Bacon's ideas are extremely topical. As mentioned in section 1.2, the equal access to goods generated by scientific research is fundamental to prevent societal divisions and exclusions.

A second ingredient for the creation of a democratic society is the people's awareness of the scientific process, as well as of its goals, outcomes and limits [17]. In fact, democratic societies are founded on the engagement of citizens when decisions impacting the community must be taken. Because of science permeating role in today's society, science-related issues are no exception [18]. Examples are topics such as mandatory vaccination, euthanasia, abortion, animal experimentation, alternative medicine, nuclear energy, recycling and, in general, the public investments on research assigned by policy makers. Hence, a better understanding of science is a key factor to ensure effective participatory processes [19].

The population's engagement in decision-making processes is only fruitful if scientific innovations are neither passively accepted nor irrationally feared. To this aim, people must be given the ability to intervene in an informed, rational and critical way. This scenario is only possible if individuals are formed and trained in an adequate cultural context. In other words, if people acquire the so-called scientific citizenship [20].

How to best prepare individuals to become scientific citizens is still debated [21]. Nevertheless, a key ingredient has been identified in the need to bring scientists and citizens closer to each other. It is widely accepted that the construction of a democratic knowledge era depends crucially on the continuous dialogue and information and knowledge exchange between these two communities. A paradigm which motivates the growing importance of science communication.

1.4 Science communication and modern society

Science relies heavily on communication. To be useful, research results must be communicated to the rest of the scientific community. This has become even more crucial in the era of Big Science [22]. Modern physics offers illustrative examples in this direction. Large-scale experiments such as the LHC particle accelerator at CERN in Switzerland or the LIGO-Virgo gravitational-wave observatories in the USA and Italy are built and maintained by international collaborations of thousands of scientists from tens of different countries [23–25]. These titanic efforts can only be successful if supported by effective internal communication.

The relationship between science and communication has evolved with the transition to the knowledge era [26]. Nowadays, science communication can no longer happen exclusively within the scientific community. As outlined in Section 1.3, the construction of a democratic society requires the engagement of disparate societal groups in the decision-making processes related to scientific questions [27]. Examples are scientists, policy makers, private investors, non-governmental organizations, citizens etc. Hence, when discussing with each other, these groups make use of science communication.

The aforementioned societal groups have different cultural background and objectives. Thus, they adopt different languages when talking about scientific issues. Moreover, to be effective, each group must tune its science communication on the targeted audience, with the optimal choice depending on both the content and considered communication channel. As a consequence, numerous different kinds of science communication can be identified.

The present thesis focuses on science communication aiming to inform citizens on a non-technical level of current investigation lines. This is the oldest type of science communication not confined within the scientific community. The first example in this direction was the *De Rerum Natura* by Roman poet Lucretius in the first century BC. Another historically very important book was Galileo Galiei's *Sidereus Nuncius* in the XVII century. His work rapidly spread all over the world short after publication and revolutionised humanity's self-perception by propagating the author's innovative astronomical discoveries [28].

More specifically, this thesis focuses on a specific class of EU-funded research project and on their use of the web 2.0 social media to communicate results and objectives. As outlined in the next chapters, the ultimate goal is to investigate whether European scientists are properly exploiting today's most effective communication channels to inform citizens of two of the future's most important scientific challenges: the development of quantum technologies and high-performing computers.

1.5 Chapter summary

In this chapter, the following items have been discussed:

1. Human society is currently entering the so-called knowledge era. This age is characterised by the fact that scientific knowledge has become one of the most important sources of wealth.

2. The knowledge era offers unprecedented opportunities to improve people's life quality. However, it also presents new challenges. In particular, the unequal access to scientific knowledge and technology may prevent the realisation of democratic systems.

3. The construction of a democratic society in the knowledge era depends on the engagement of citizens and stakeholders in the debate on the impact of scientific issues on their lives. This can be achieved by training people to discuss scientific questions in a constructive and critic way, i.e., if individuals acquire the so-called scientific citizenship.

4. One key factor to help people acquire the scientific citizenship is science communication. There exist disparate kinds of science communication, depending on the interacting societal groups. The present thesis focuses on science communication adopted to inform citizens via social media of recent developments in European research projects.

Chapter 2

FET in Horizon 2020

This chapter focuses on the FET funding programme. Section 2.1 illustrates the Horizon 2020 initiative. Section 2.2 is a description of FET in the framework of Horizon 2020. Sections 2.3 and 2.4 summarise the FET effort towards the development of quantum technologies and high-performing computers, i.e., the two most important research lines for the scope of this thesis.

2.1 The Horizon 2020 programme

Horizon 2020 is the biggest Research and Innovation programme funded by the European Union to date. It targets a smart and sustainable societal and economic growth via the development and application of scientific research. The available budget totals nearly €80 billion over a seven-year period (from 2014 to 2020) [29].

Horizon 2020 is Europe's eighth Research and Innovation programme in chronological order [30–33]. The first was launched in 1984. Duration and allocated budget of each Research and Innovation programme are shown in figure 2.1.

Any natural or legal persons (e.g. universities, research organisation and companies) can apply for Horizon 2020 funding. The main

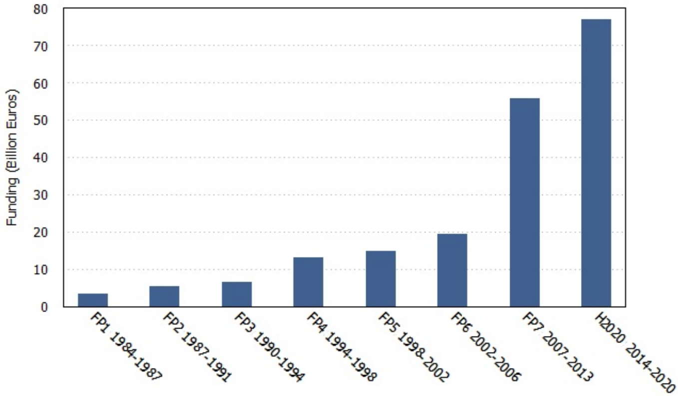

Figure 2.1: Duration and allocated budget of Europe's Research and Innovation programmes (also known as Framework Programmes, FP). Budgets are expressed in billion Euros. Data from [34].

categories into which applications must fit into one of the following categories:

- **Excellent Science:** this initiative supports the excellence of European scientific research on a global level and in a variety of fields [35].
- **Industrial Leadership:** this class of projects targets the development of technological innovations for the future market and the growth of European small and medium enterprises [36].
- **Societal Challenges:** this category focuses on priorities of the European society such as health, education, energy supply and food by combining knowledge and methods from disparate scientific fields [37].

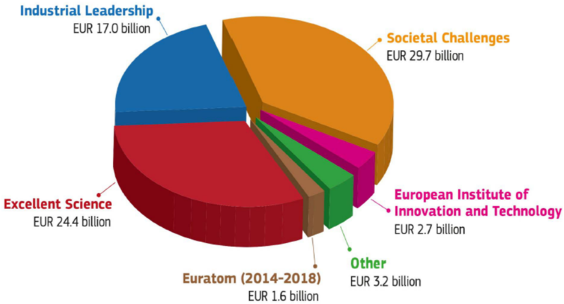

Figure 2.2: Budget breakdown of the Horizon 2020 programme. Original image in [40].

- **European Institute for Innovation and Technology:** this institute is an independent European body supporting growth via the promotion of synergies in the fields of education, research and business [38].
- **Euratom:** this pillar funds nuclear research in the framework of the decarbonisation of the energy supply [39].

The Horizon 2020's budget breakdown into the aforementioned lines of action is shown in figure 2.2.

2.2 The FET programme

As mentioned in section 2.1, one of the actions of Horizon 2020 is the Excellent Science programme. This initiative supports researchers and institutions developing new science and cutting-edge technology. The goal is to keep European research at the forefront of scientific innovation and discover applications to improve the citizens' life and ensure economical growth.

Excellent Science is based on the following pillars:

Line of action	Estimated final budget
ERC	13.1
FET	2.7
MSCA	6.2
RI	2.5

Table 2.1: Estimated final budget breakdown of the Excellent Science initiative. ERC stands for European Research Council; FET for Future and Emerging Technologies; MSCA for Marie Skłodowska-Curie Actions; RI for Research infrastructure. Budgets are in billion Euros. Data from [40].

- **European Research Council:** it distributes funding in every research field to single scientists and with the requirement of scientific excellence [41].
- **Future and Emerging Technologies (FET):** it finances collaborative research exploring visionary and radically new investigation lines [42].
- **Marie Skłodowska-Curie Actions:** this initiative assigns grants to researchers at any stage of their career and encourages mobility between countries and fields of expertise [43].
- **Research infrastructure:** it promotes the creation of transnational networks of research infrastructures as well as the training of qualified staff [44].

The estimated final budget breakdown of Excellent Science is reported in table 2.1.

This thesis focuses on the communication activity of the 151 FET projects funded to date within Horizon 2020. The list of these projects is available in appendix A. The distribution of projects participants per country as of June 2016 is shown in figure 2.3.

The FET funding scheme comprises three calls for applications: FET Open, FET Proactive and FET Flagship [46–48].

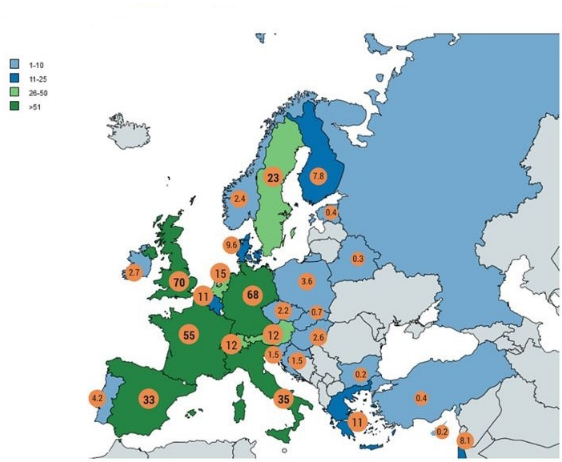

Figure 2.3: Participants in the Horizon 2020 FET programme on a country basis as of June 2016. Numbers correspond to FET funding in million Euros. Colours indicate the number of participants. Adapted from image in [45].

FET Open

The FET Open call is not bound to one specific investigation theme. However, submitted research proposals must satisfy the following "gatekeepers": scientific and technological breakthrough; foundational; novelty; high-risk; long-term vision; interdisciplinary.

FET Open promotes the Coordination and Support Actions (CSA) as well. These aim at identifying and fulfilling the optimal conditions for FET-related collaborative investigation. One CSA type of action is FET Innovation Launchpad, which investigates and explores possible economical and societal applications of FET results [49]. The list of Horizon 2020 projects funded within the FET Innovation Launchpad action is reported in appendix B.

FET Proactive

The FET Proactive call nurtures the birth of synergies on specific research lines by bringing together scientists from interdisciplinary fields. Considered research lines are not ready for the market yet.

Currently, FET Proactive comprises three calls related to "Boosting emerging technologies" and three under "High Performance Computing". Given its relevance for this thesis, the "High Performance Computing" FET Proactive call is illustrated in section 2.3.

FET Proactive invests resources also on identifying investigation roadmaps, design and distribute material for educational purposes and disseminate FET results among interested stakeholders.

FET Flagship

FET Flagships are Europe's main research effort. They are large-scale, decade-long projects with budgets totalling one billion Euros each. The ultimate goals are to shed light on key scientific themes and apply the results to European society. To date, three FET Flagships have been approved in the Horizon 2020 programme:

- **Human Brain Project:** it targets groundbreaking steps forward in neuroscience [50].
- **Graphene:** it explores graphene's properties and possible applications [51].
- **Quantum Technologies:** it aims at developing innovative technologies based on the laws of quantum physics.

The Human Brain Project and Graphene Flagships started in April 2016. The Quantum Technologies Flagship will start in 2018. Given its relevance for this thesis, the Quantum Technologies Flagship is described in section 2.4.

2.3 FET and high-performing computing

Current and future scientific and engineering challenges require increasing levels of computational performances. The demand can be satisfied via the construction of large computer clusters and the development of suitable programming languages. The former provide higher computational power for parallel calculations, the latter an optimal exploitation of the clusters' resources. The use of such practices is known as high-performing computing (HPC) [52].

In terms of increasing computational power, one major HPC goal is the transition from the peta- to the exascale. This corresponds to the increase from 10^{15} floating point operations per second, i.e. the limit of present-day most powerful supercomputers, to 10^{18}. The upgrade to the exascale is motivated by its major impact on all scientific fields, as it would push forward research and the development of new technology over the next decades [53].

As mentioned in section 2.2, the European HPC effort is funded within the "High Performance Computing" FET Proactive call [54]. This call comprises three initiatives: *i*) co-design of HPC systems and applications; *ii*) transition to exascale computing; and *iii*) exascale HPC ecosystem development. The main goals of the three initiatives are to develop the next-generation high-performing computers towards exascale and to provide access to the resources offered by supercomputers. The list of Horizon 2020 FET projects active in HPC is available in Appendix B.

2.4 FET and quantum technologies

Quantum technologies arise from applications of quantum physics. They are an important research topic on a global level for their potential to revolutionise human societies.

The so-called first quantum revolution started at the beginning of the past century with the development of quantum theory. The growing understanding of the atomic world led to the birth of new disciplines, such as informatics and microelectronics, and to the construction of countless fundamental tools and electronic devices. Examples range from computers and cameras to lasers and photocopy machines. The first quantum revolution played a key role in starting the knowledge era of human society.

It is believed that the second quantum revolution will be driven by the ability acquired by humankind to actively engineer the quantum world to its own purposes [55]. This is expected to lead to a complete new class of technologies which would reshape our society. One example is the development of quantum computers. If successfully developed, such machines will be far more powerful than any present and future computer based on classical architectures [56]. The urge for Europe to stay at the forefront of the second quantum revolution is outlined in the so-called Quantum Manifesto [57].

The development of quantum technologies is a central objective of the FET programme. The list of Horizon 2020 FET projects in this field is reported in Appendix B. Their activity is supported by the ERANET Cofund in Quantum Technologies, a FET Proactive initiative fostering synergies and partnerships among researchers and other stakeholders [58]. Finally, as mentioned in section 2.2, one dedicated flagship initiative will be launched in 2018.

2.5 Chapter summary

In this chapter, the following items have been discussed:

1. Horizon 2020 is the largest research funding programme of the European Union. It is planned to run from 2014 to 2020 and has a total budget of nearly €80 billion.

2. One funding scheme of Horizon 2020 is Future and Emerging Technologies (FET). The FET call finances visionary research projects targeting scientific breakthroughs and the development and application of radically new technologies. The estimated FET final budget will total nearly €3 billion.

3. The development of quantum technologies is part of the FET effort. In particular, a FET Flagship on quantum technologies has been approved in 2016 by the European Commission and will start in 2018. Allocated funds sum up to €1 billion.

4. Another major goal of the FET initiative is the development of high-performing computers. This investigation line targets a power increase in modern supercomputers of three orders of magnitude (from 10^{15} to 10^{18} floating point operations per second). The upgrade from the peta- to the exascale will provide unprecedented computational resources in practically all scientific fields.

Part II

Analysis and results

Chapter 3

FET projects and social media

This chapter presents an overview of the presence of FET projects on social media. Ut enim ad minim veniam, quis nostrum exercitationem ullam corporis suscipit laboriosam, nisi ut aliquid ex ea commodi consequatur. Quis aute iure reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint obcaecat cupiditat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

3.1 Data set

This thesis focuses on the online communication activity of FET projects funded within Horizon 2020. The list of projects was downloaded on 15th July 2017 from CORDIS, the main portal of the European Commission on results of EU-funded research projects [59]. FET projects approved after 15th July 2017 are not considered in this thesis.

The list consists of 151 projects and it is reported in Appendix

A. For each project, Appendix A reports budget and start and end date, as well as the activated online communication channels (see section 3.2 for the channels considered for this thesis).

Some projects in the list were not considered for the present analysis. Excluded groups were the Flagship and Launchpad projects (see section 2.2 for a brief description of the two classes), as well as projects started after 1st February 2017. Disregarded projects are listed in Appendix B. This procedure reduced the data set from 151 to 130 samples.

Flagship projects were disregarded due to their budget. The funding at their disposal is far superior compared to the other FET projects, see Appendix A. Thus, the Human Brain and Graphene Projects can invest larger resources and were not considered representative of FET initiatives in terms of communication effort.

Launchpad projects were not considered as their ultimate goal is to find applications of results achieved by other FET initiatives. This class of projects is characterised by limited interest in communication activities. Moreover, the available budget is relatively small, of the order of hundred thousand Euro.

Projects started after 1st February 2017 were not considered as the time span between this date and the list download was judged insufficient to fully develop and launch an adequate communication activity. The only exception is the DEEP-EST project. By the time of writing, DEEP-EST has already started a solid online communication activity.

For some of the analyses in this thesis, the data set of 130 projects was divided into three sub-groups. The first group consists of the 22 projects active in HPC and the transition to the exascale (see section 2.3). The second subgroup includes the 10 projects in the field of quantum technologies (QT, see section 2.4). The third group comprises the other 98 projects. The lists of HPC and QT projects are reported in Appendix B.

It must be borne in mind that the analyses presented in this thesis have been performed on small data sets. The low number of projects indicates that results show limited robustness under even small changes in the data. Hence, the results reported in this work should serve as a guideline rather than as definitive statements.

3.2 Considered communication channels

The communication channels offering the widest potential audience are based on the internet. Examples are websites and social media. For this reason, online channels are pillars of the FET communication strategy.

Different approaches can be considered to assess the use of online communication channels made by FET projects. One quantitative estimate is the fraction of projects active on specific platforms. For this thesis, the following communication channels were considered:

Website Websites are the online channels offering the highest degree of freedom. They allow the owner to personalise the content, its presentation strategy and graphic visualisation.

Facebook Facebook is the most used social media worldwide. It offers direct interaction among users and it is mainly designed for free time.

Twitter Twitter is very effective for concise science-related communication. It requires high posting rates and offers less personal interaction compared to Facebook.

LinkedIn LinkedIn is designed for professional content and enables the creation of closed groups. Nevertheless, interaction among users and outreach within the groups are limited.

YouTube YouTube is the world's main platform for video sharing. It offers a very direct communication channel, but it is not very effective at engaging users.

Instagram Instagram has a very active and rapidly growing community. It requires content with high visual impact and offers limited interaction among users.

ResearchGate ResearchGate offers the possibility to share technical documentation and engage in scientific discussions with researchers. As members are mainly scientists, the reachable community is significantly smaller and more homogeneous compared to other social networks.

3.3 Search for channels

The analyses presented in this thesis are based on the number of FET projects considering the online communication tools mentioned in section 3.2. To determine these values, a search was performed for all projects in Appendix A.

The search was conducted as follows. First, projects were contacted directly and asked on which channels they are active. However, in many cases it was not possible to find the contact details or no answer was received. This happened for 42 projects out of the 130 of interest for the present analysis (more specifically, for 4 out of 22 HPC projects, 1 out of 10 QT projects and 37 out of 98 other projects). A desk search was then performed to gather the required information for the 42 projects.

It cannot be excluded that the desk search failed to find all websites or accounts activated on the social channels considered for this thesis. Thus, it is highly probable that the list of accounts in Appendix A is incomplete. The results presented in this thesis must therefore be considered as inferior limits when describing the actual scenario.

3.4 Overall use of channels

Out of the 130 projects in the data set, 124 have created a website, 66 have opened accounts on Twitter, 26 on Facebook, 20 on LinkedIn, 13 on YouTube, 10 on ResearchGate and ... on Instagram. The results, expressed as percentage values, are reported in Figure 3.1.

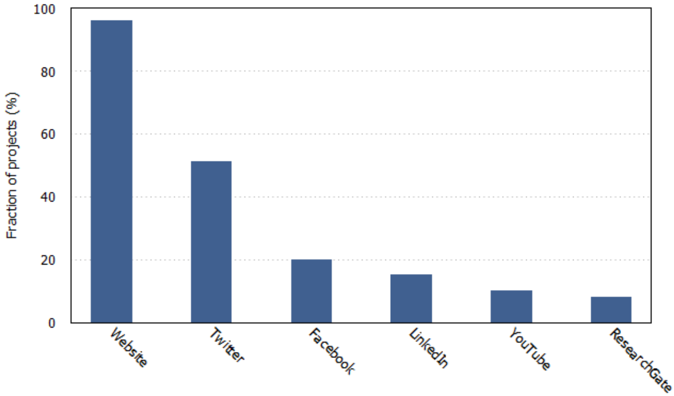

Figure 3.1: Fractions of FET projects making use of the communication channels considered for this thesis.

The results show that almost all FET projects have created a website. Facebook and Twitter are the two most popular social media within the FET community, hence reflecting the scenario experienced in society. Nevertheless, the fraction of projects active on Twitter is significantly larger than that on Facebook. This is opposite to what occurs in society, where Facebook is the most used social media. This indicate that Twitter is considered a more suitable tool for scientific communication.

YouTube and Instagram are not common communication channels among FET projects. This is probably due to the difficulty of collecting content with high visual impact and suitable for drawing attention of disparate audiences not familiar with the research field. The difficulty arises from the fact that the objectives and results of FET projects are often very technical and not appropriate for image-based communication. In the case of YouTube, there is the additional complication of the high resources needed for the production of high-quality videos.

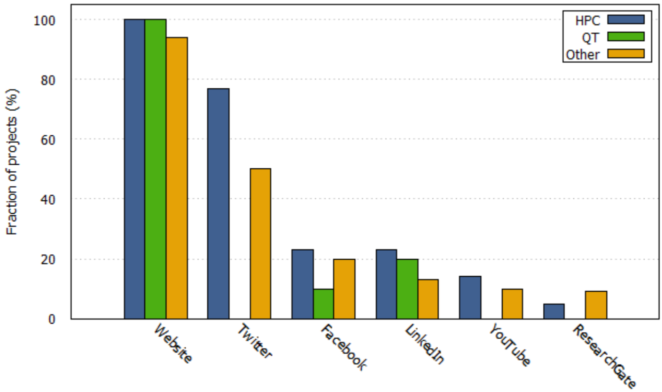

Figure 3.2: Fractions of FET projects making use of the communication channels considered for this thesis. Results are given as a function of the three project classes considered for this thesis. No QT project is active on Twitter, YouTube or ResearchGate.

The number of projects active on ResearchGate is low. This is probably due to the fact that ResearchGate is not a suitable channel for large-scale communication activity. In fact, the reachable audience is typically limited to researchers active in similar investigation fields

3.5 Online presence breakdown

The analysis in section 3.4 was repeated on the projects sub-groups outlined in section 3.1: HPC, QT and Others. This enabled a comparison of how disparate classes of FET projects make use of online communication channels. The results are shown in figure 3.2.

The figure shows that basically all FET projects have created a website, regardless of the considered sub-group. As for the most used social platforms within the FET community, i.e. Twitter, Facebook and Linkedin, the HPC class has opened the most accounts compared to QT and other projects. The result indicates that HPC projects are among the most active FET initiatives in terms of online communication.

The QT sub-group seems to follow the opposite strategy. The fraction of projects making use of social media is significantly smaller compared to HPC and other FET projects. In particular, none of them has opened an account on Twitter, the most used social platform within the FET community.

The limited use of social media made by QT projects highlights two facts. First, the QT Flagship will design its future online communication activity without guidelines based on previous experiences from the same investigation field. Second, classes of projects facing similar challenges in terms of result communication and engagement of non-expert audiences may opt for very different strategies. This is the case of HPC and QT projects, which pursue very technical objectives and, in particular, share the common goal of improving current computers[1].

3.6 Budget impact

The number of channels considered by projects depends mainly on the pursued communication strategy and the available budget. The two factors are interconnected, as the former is heavily impacted by the latter. Thus, it is worth assessing how deeply the online communication activity launched by FET projects is influenced by the allocated funding. One approach in this direction consists of searching for the dependence of the number of activated channels on the available funds. The results are shown in figure 3.3.

[1] Although both HPC and QT projects focus on the development of present-day computers, the strategies followed by the two sub-groups are very different: the former aims at improving current classical architectures, the latter at exploiting a completely new approach, see sections 2.3 and 2.4.

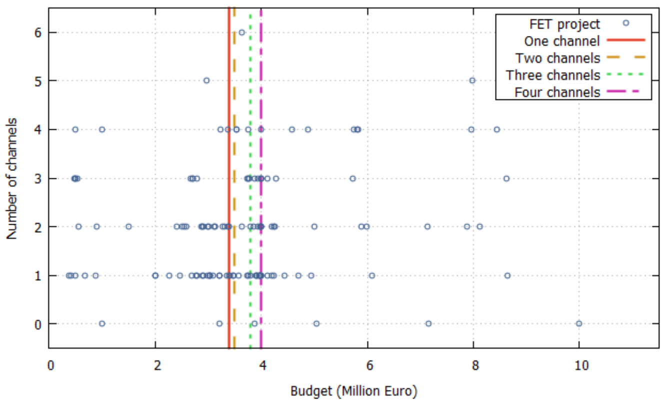

Figure 3.3: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the group of projects with activated channels ranging between one and four. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The following projects were used for the median calculation but lie outside the plotted budget range: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

The plot shows that the majority of the projects has activated a number of channels between one and four. For each of these amount of channels,the median of the corresponding projects' budgets were calculated. The median was preferred to the arithmetic mean as it is a more robust indicator in the presence of outliers. The values are reported in table 3.1 and drawn as vertical lines in figure 3.3.

The analysis suggests a weak correlation between the number of activated channels and the available budget. On one hand, the larger the median, the higher the number of channels, On the other hand, the variation between the median values are of the order of

Number of channels	Budget median
One	3.4
Two	3.5
Three	3.8
Four	4.0

Table 3.1: Medians of the projects' budgets calculated over the groups identified with the number of activated channels. Median are in million Euros and approximated.

percent. Moreover, it must be borne in mind the the budget data corresponds to the total available funding, and not to the fraction allocated for communication purposes. Hence, in absolute terms of funds and remembering that budgets are distributed over the project's duration (some years), the differences are not significantly large. The result indicates that the decision on the number of channels to open for a given project is not strongly influenced by the available budget, but rather on the pursued communication strategy.

3.7 Budget impact

The results in the previous section were further analyse to have a further comparison of the QT and HPC projects. Figure 3.4 shows the QT and HPC projects as a function of the number of activated channels and available budget. The plot shows that QT projects have budgets between €2 and €4 Million and in general have activated one channel. HPC projects in the same budget window have activated more channels. This result shows that HPC projects make larger use of online communication channels regardless of the available budget. Hence, it is a different strategy.

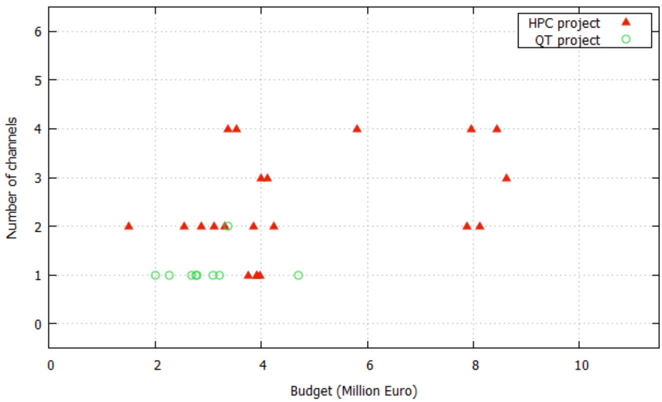

Figure 3.4: Percentage of FET projects making use of the communication channels considered for this thesis.QuantERA (€40.5 Million, 3 channels)

Appendix A

List of FET projects

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Project	Start date	End date	Total fund	EU fund	Website	Twitter	Facebook
ABIOMATER	01/11/2015	31/10/2018	2 978 882	2 978 882	blogs.exeter.ac.uk/abiomater	@abiomater	
A-LEAF	01/01/2017	31/12/2020	7 980 861	7 980 861	a-leaf.eu	@aleaf_h2020	aleaf.h2020
ALLScale	01/10/2015	30/09/2018	3 366 196	3 366 196	allscale.eu/home	@AllScaleEurope	AllScaleProject
AMECRYS	01/10/2016	30/09/2020	3 533 813	3 533 813	amecrys-project.eu	@amecrysproject	amecrysproject
aPad	01/05/2017	31/10/2018	99 750	99 750			
AQuS	01/01/2015	31/12/2017	2 000 500	2 000 500	kip.uni-heidelberg.de/aqus		
Bio4Comp	01/01/2017	31/12/2021	6 084 949	6 084 949	bio4comp.org		
BREAKBEN	01/01/2016	31/12/2018	3 998 793	3 998 793	breakben.eu	@BREAKBENeu	
CASEK	01/04/2017	30/09/2018	100 000	100 000	casek.eu		
CF-Web	01/06/2017	30/11/2018	99 125	99 125			
ChipScope	01/01/2017	31/12/2020	3 759 790	3 759 790	chipscope.eu	@ChipScope_EU	chipscope
CHROMAVISION	01/06/2015	31/05/2019	3 567 025	3 567 025	chromavision.eu		
ComPat	01/10/2015	30/09/2018	4 122 864	3 942 885	compat-project.eu	@compatproject	
CResPace	01/01/2017	31/12/2021	4 944 347	4 944 347	crespace.eu		
DEEP-EST	01/07/2017	30/06/2020	15 873 341	14 998 342	deep-projects.eu	@DEEPprojects	
DIACAT	01/07/2015	30/06/2019	3 872 981	3 872 981	diacat.eu	@DIACAT_EU	
DISCOVERER	01/01/2017	31/03/2021	5 726 750	5 726 750	discoverer.space	@DISCOVERER_EU	
DMS	01/04/2017	30/09/2018	100 000	100 000			
D-Noise	01/05/2017	31/10/2018	130 937	100 000	d-noise-fet.eu		
DOLFINS	01/03/2015	28/02/2018	4 250 000	3 270 646	simpolproject.eu	@SimPolProject	
DREAM	01/01/2015	31/12/2018	2 784 240	2 730 241	robotsthatdream.eu	@robotsthatdream	
ECOSCALE	01/10/2015	30/09/2018	4 237 397	4 237 397	ecoscale.eu	@ECOSCALE_H2020	
ENTIMENT	01/07/2017	31/12/2018	100 000	100 000			
EuroEXA	01/09/2017	28/02/2021	19 949 022	19 949 022			
ESCAPE	01/10/2015	30/09/2018	3 977 952	3 977 952	hpc-escape.eu		
EuroLab-4-HPC	01/09/2015	31/08/2017	1 489 981	1 489 981	eurolab4hpc.eu	@eurolab4hpc	
ExaFLOW	01/10/2015	30/09/2018	3 312 235	3 312 235	exaflow-project.eu	@exaflowproject	
ExaNeSt	01/12/2015	30/11/2018	8 442 547	8 442 547	exanest.eu	@exanest_h2020	Exanest_h2020-282450078883797
ExaNoDe	01/10/2015	30/09/2018	8 629 247	8 629 247	exanode.eu	@ExanodeProject	Exanode-1669383456699997
ExCAPE	01/09/2015	31/08/2018	3 910 140	3 910 140	excape-h2020.eu		
EXDCI	01/09/2015	28/02/2018	2 551 875	2 551 875	exdci.eu	@exdci_eu	
FEMTOTERABYTE	01/03/2017	29/02/2020	3 712 832	3 712 832	physics.gu.se/english/research/femtoterabyte		
FET2RIN	01/12/2015	30/11/2018	472 468	472 468	fet2rin.com	@Fet2Rin	fet2rin
FLAG-ERA II	01/12/2016	30/11/2021	18 341 250	6 052 612	flagera.eu		flagera
flora robotica	01/04/2015	31/3/2019	3 641 781	3 641 781	florarobotica.eu	@florarobotica	florarobotica
GOAL-Robots	01/11/2016	31/10/2020	3 481 875	3 481 875	goal-robots.eu		
GRACeFUL	01/02/2015	31/01/2018	2 404 943	2 404 943	graceful-project.eu	@gracefulproject	
GrapheneCore1	01/04/2016	31/03/2018	89 000 000	89 000 000	graphene-flagship.eu	@GrapheneCA	GrapheneFlagship
greenFLASH	01/10/2015	30/09/2018	3 760 793	3 760 793	greenflash-h2020.eu		
HELENIC-REF	01/06/2015	31/05/2018	2 578 386	2 578 386	helenic-ref.eu		
INTERLACE	01/05/2017	31/10/2018	99 978	99 978			

Project	Start date	End date	Total fund	EU fund	Website	Twitter	Facebook
NTERTWINE	01/10/2015	30/09/2018	3 861 400	3 861 400	intertwine-project.eu	@intertwine_eu	
I2C8	01/05/2017	30/04/2018	99 937	99 937	lrn2cre8.eu		
LiRichFCC	01/10/2016	30/09/2019	4 114 753	4 114 753	lirichfcc.eu		
LLR	01/01/2017	31/12/2020	3 962 500	3 956 500	llr-fet.eu		
LMCat	01/01/2017	31/12/2020	3 726 942	3 726 942	lmcat.eu		
Lumiblast	01/10/2016	31/03/2021	3 031 375	3 031 375	lumiblast.eu		
MAGENTA	01/01/2017	31/12/2020	4 999 778	4 999 777	magenta-h2020.eu		
MAGicSky	01/09/2015	31/08/2018	3 396 439	3 396 439	magicsky-fet.eu	@magicskyf	
AGNEURON	01/01/2016	31/12/2019	3 473 026	3 473 026	magneuron.eu		
MANGO	01/10/2015	30/09/2018	5 801 820	5 801 820	mango-project.eu	@mangoeu	
M-CUBE	01/01/2017	31/12/2020	4 582 346	3 945 346	mcube-project.eu	@MCUBE19	h2020fetopen
Microflusa	01/09/2015	31/08/2019	3 027 637	3 027 637	microflusa-project.eu		
MIR-BOSE	01/01/2017	31/12/2020	3 786 160	3 786 160	mir-bose.eu		
RG-GRammar	01/08/2015	31/07/2018	3 999 661	3 999 661	mrg-grammar.eu	@MrgGrammar_proj	mrggrammar
NanOQTech	01/10/2016	30/09/2019	3 378 428	3 378 428	nanoqtech.eu		
NanoSmell	01/09/2015	31/08/2019	3 979 069	3 979 069	nanosmell.org		
Neurofibres	01/01/2017	31/12/2020	5 888 491	5 094 120	neurofibres.eu	@neurofibres	
NEXTGenIO	01/10/2015	30/09/2018	8 114 504	8 114 504	nextgenio.eu	@nextgenio	
nuClock	01/06/2015	31/05/2019	3 970 327	3 970 327	nuclock.eu		nuclock.eu
OPRECOMP	01/01/2017	31/12/2020	5 990 510	5 990 510	oprecomp.eu	@oprecompproject	
PHENOMEN	01/09/2016	31/08/2019	2 915 886	2 915 886	phenomen-project.eu		
PhySense	01/06/2017	31/05/2018	99 991	99 991	physense.eu		
QCUMbER	01/09/2015	31/08/2018	3 219 721	3 219 721	qcumber.eu		
Qdet	01/05/2017	31/10/2018	100 000	100 000			
QuantERA	01/11/2016	31/10/2021	40 464 570	11 510 008	quantera.eu		QuanteraCoFund
QUCHIP	01/03/2015	28/02/2018	2 681 713	2 681 713	quchip.eu		
QUIC	01/03/2015	28/02/2019	2 774 375	2 386 875	quic-project.eu		
QuProCS	01/04/2015	31/3/2018	2 268 746	2 268 746	quprocs.eu		
QUSMI	01/05/2017	31/10/2018	96 462	96 462	nvision-imaging.com		
READEX	01/09/2015	31/08/2018	3 534 198	3 534 198	readex.eu	@readex_eu	
RECORD-IT	01/09/2015	31/08/2018	4 193 147	4 193 147	chalmers.se/en/projects/Pages/RECORD-IT.aspx		
ROMA	01/06/2017	30/11/2018	99 675	99 675			
RYSQ	01/03/2015	28/02/2018	4 695 000	4 383 000	qurope.eu/projects/rysq		
SC-square	01/07/2016	31/8/2018	499 603	499 603	sc-square.org		
SENSE	01/09/2016	31/08/2019	886 500	886 500	sense-pro.org	@senselowlight	
SensAgain	01/09/2017	28/02/2019	99 912	99 912			
SiLAS	01/01/2017	31/12/2020	3 985 417	3 985 417	silasproject.eu		
SmartNurse	01/05/2017	31/10/2018	100 000	100 000			
socSMCs	01/01/2015	31/12/2018	3 778 125	3 778 125	socsmcs.eu	@socSMCs	
ubCULTron	01/04/2015	31/03/2019	3 987 650	3 987 650	subcultron.eu	@subCULTron	
2D-INK	01/01/2016	31/12/2018	2 962 661	2 962 661	2d-ink.eu	@2D_INK	2D-INK-1419976004971237
TRACHIRAL	01/01/2017	31/12/2020	3 999 250	3 999 250	ultrachiral.iesl.forth.gr	@ultrachiral	
VISORSURF	01/01/2017	30/6/2020	5 748 000	5 748 000	visorsurf.eu	@VisorSurf	VisorSurf/?ref=br_rs
WASPSNEST	01/06/2017	31/05/2018	99 775	99 775	fp7wasps.org/en/		
WhiteRabbit	01/04/2017	31/07/2018	99 750	99 750			

Appendix B

Specific lists of FET projects

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