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What Career in Industry for Engineers with a PhD ?

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Abstract

After a short historical detour about the origin of the PhD and a brief description of the situation in the world concerning the number of PhD graduations, particularly in engineering, I shall present the pros and cons of doctoral studies in science and engineering, through some opinions that have been recently expressed. Then, I shall describe the policy of industrial companies about PhD graduates and explain why the possibilities of career are actually limited. After that, I shall throw various lights on the problem arising from that contradiction between that limitation and the necessity of more innovation in Europe : do PhD students have the right motivation ? do they possess enough transferable skills ? are their curricula adapted to the needs of industrial companies ? is there enough R&D in Europe ? My conclusion will be that universities should actually reorient doctoral studies in engineering, have a more holistic and aggressive view on the question, and then make their own way, slowly but surely, in full knowledge of the facts.

0. Introduction

In this presentation I shall describe and discuss the perspectives of career that are offered by industry to engineers with a PhD, and this on behalf of the European Society for Engineers and Industrialists (**SEII**), which, as many of you already know, is a non-profit-making association, set up eight years ago with the aim of promoting the essential role of engineers in structuring our society.

I whish to address a warm " thank you " to Sergio POLESE, President of CLAIU-EU, and to their Past-President, Denis Mc GRATH, in charge of organizing this event, for having invited SEII to contribute a third time to their annual conference, since, two years ago in Brussels and one year ago in Rome, I presented the views of industry on the topics of their conferences. Thank you too to their nice and efficient secretary, Ann VAN EYCKEN.

1. Preliminaries

Before getting to the heart of the matter, I shall briefly recall what a doctorate is and what the different categories of doctorates are – to be sure that we are on the same wavelength – and present their situation in the world.

1.a. Back to the roots : a historical perspective

The word "doctorate" comes from the Latin "*doctum*", supine of the verb "*docere*", meaning "to teach". It referred to the Christian authorities, who taught and interpreted the Bible. There are presently two main types of doctorates :

- the Research Doctorates, awarded in recognition of academic research, and
- the Professional Doctorates, more closely aligned with the practice of a particular profession.

What the word "doctorate" refers to has changed over time and has also been subject to regional variations. If the first doctorates were Doctors of Divinity (or of Theology), two professional doctorates soon appeared in the Medieval Europe : Doctor of Laws and Doctor of Medicine.

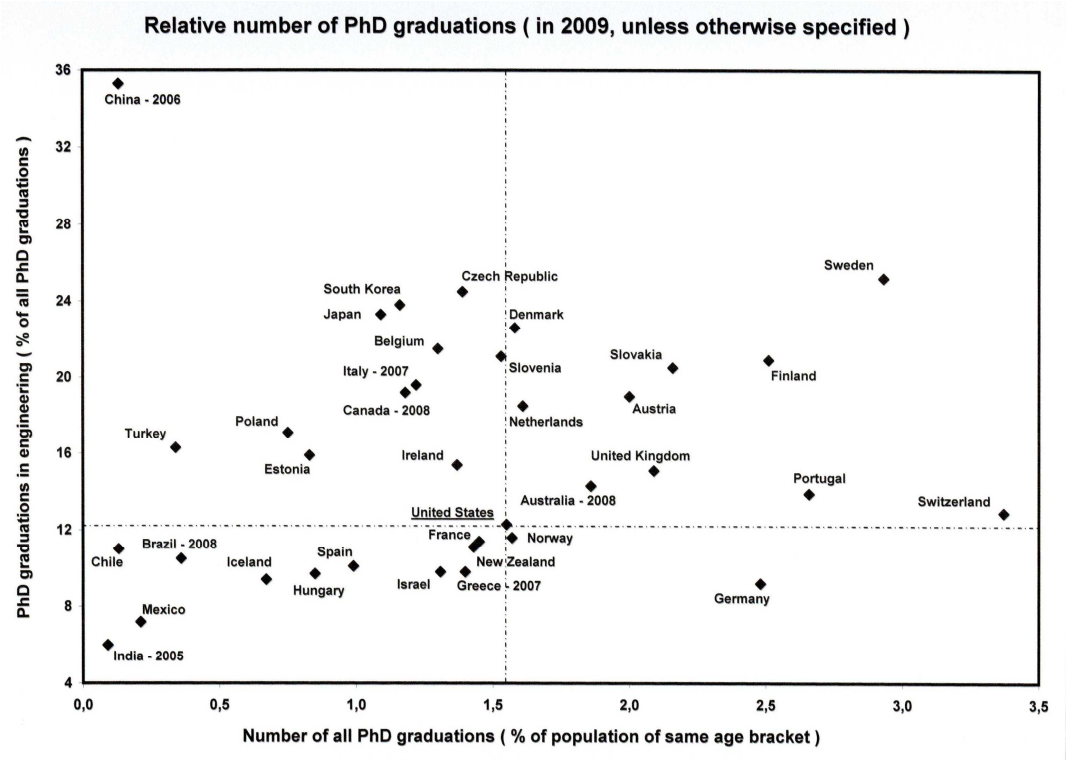
Aquatint of a Doctor of Divinity at the University of Oxford. From Rudolph Ackermann's *History of Oxford*, 1814

The situation changed in the early 19th century through the educational reforms in Germany, which started demanding contributions to research, attested by a dissertation, for the award of their final degree, which was labelled Doctor of Philosophy, in short Ph.D., because "philosophy" was the ancient name for "science". These reforms proved extremely successful and were imported to the United States, where the current triple structure of bachelor-master-doctor degrees in one discipline was created by fusing different European traditions. Later on, the degree spread to Canada and to England.

The result of this historical evolution is that most doctoral degrees in Science and Technology awarded in the world are research-based doctorates and that all opinions and testimonies I have gathered about the utility, for an engineer, to have a PhD, refer to that type of doctorate ; some professional doctorates addressing to engineers have begun to appear in North America, the United Kingdom and Australia, but they are still isolated cases.

1.b. The situation of PhD graduations in the world

The following diagram, which I have built from figures published in the last OECD Science, Technology and Industry Scoreboard **[1]**, compares the relative number of graduations delivered in 2009 at doctorate level in engineering, expressed as a percentage of all graduations at doctorate level, to the number of all graduations at doctorate level, expressed as a percentage of people in the same age bracket, in most developed and emerging countries.



If we take the values for the United States as a reference (as there is no absolute reference), they divide the diagram in four parts, and we can see that, globally, the scores of European countries are rather good. This is corroborated by a recent report of the European Commission [**2**], in which it was stated that : " *The European Union has a higher number of graduates from the first stage of tertiary education than the United States and Japan, as well as a higher share of graduates in Science and Engineering* ".

I am not going to study that aspect of the question any further, as this is not the aim of this presentation, but keep carefully the previous diagram in your mind as I shall later compare it with another one.

Let us now look at what some opinions about PhD studies are.

2. <u>The pros and cons of doctoral studies in science and engineering</u>

2.a. Opinions that are not in favour of them

From **Nature** – " ***Education : the PhD factory*** " **[3]** :

> *Scientists who got a PhD are rightly proud : they have gained entry to an élite, but not an élite as it once was. The number of new science doctorates in OECD countries grew by nearly 40 % between 1998 and 2008, and it shows no sign of slowing. Most countries are building up their higher-education systems because they see educated workers as a key to economic growth. But, in much of the world, science PhD graduates may never get a chance to take full advantage of their qualifications, with a dwindling number of academic jobs and an industrial sector unable to take up the slack. Supply has outstripped demand and, although few PhD holders end up unemployed, it is not clear that spending years securing this high-level qualification is worth it.*

Paula STEPHAN, Economist at Georgia State University in Atlanta **[3]** :

> *It is scandalous that US politicians continue to speak of a PhD shortage. The United States is second only to China awarding science doctorates and their number is growing. But no one should applaud this trend, unless Congress will put money into creating jobs for these people rather than just creating supply, because most doctorates are taking jobs that do not require a PhD. It is a waste of resources : we are spending a lot of money training these students, and then they go out and get jobs that they are not well matched for.*

Laudeline AURIOL, analyst for OECD **[4]** :

A non-negligible share of doctorate holders seem to be employed, either in non related or in lower qualified occupations. In 11 countries out of 20 for which data are available, one of these two indicators is at least equal to 10 % and in some instances much higher, as in Austria (29,5 %) and the Netherlands (20,5 %).

Andrzej KRAŚNIEWSKI, Secretary General of the Polish Rectors Conference **[3]** :

In Poland, more than half of students in engineering who begin a doctorate will not complete their PhD and, most of those who achieve it will end up taking jobs below their level of expertise.

But maybe the fiercest attack came from "**The Economist**" which, one year ago, published a long article entitled " ***The disposable academic : why doing a PhD is often a waste of time*** " **[5]** ; I cannot reproduce the whole article, but here are some selected sentences :

One thing many PhDs have in common is dissatisfaction … There seem to be genuine problems with our system, which produces an oversupply of PhDs … But universities have discovered that PhD students are cheap, highly motivated and disposable labour, as they do much of the university research these days … One OECD study shows that five years after receiving their degrees, more than 60 % of PhDs in Slovakia and more than 45 % in Belgium, the Czech Republic, Germany and Spain were still on temporary contracts ; the relative number of PhDs taking jobs that are unrelated to their is 30 % in Austria, 21 % in the Netherlands and 13 % in Germany … In engineering and technology, a PhD often earns less than a Master … The interests of academics and universities on the one hand and PhD students on the other hand are not well aligned … Many PhDs find it tough to transfer their skills into the job market … Some university departments and academics regard the number of PhD graduates as an indicator of success and compete to produce more … Many of those who embark on a PhD are the smartest of their class and would have been the best at everything they should do in their field anyway … !

2.b. Opinions that are in favour of them

Georg WINCKLER, Rector of the University of Vienna, gave a well argued opinion in favour of PhD graduation during the annual conference of the Centre for Doctoral Studies of his university, last June **[6]** ; here is the essence of what he said :

PhDs are strategic tools and a vital resource in a knowledge-based economy, and Europe needs 700,000 researchers more in order to enhance its competitiveness ! The many challenges that lie ahead of us require deeper knowledge and more flexibility. Universities must provide Europe with a new generation of highly adaptive experts in a globalized world. But, in order to achieve that, University-Industry cooperation is more than ever necessary, as a vehicle to enhance knowledge transfer.

In France, **Martine PRETCEILLE**, Professeur des Universités and General Manager of INTELLI'AGENCE, is categorical **[7]** :

The reference degree is PhD, not Master in Engineering, degree on which French enterprises usually leant. Now, we are in a knowledge economy and competitiveness is based on the capacity of enterprises to develop their research and innovations. PhDs are the ones who have the expertise to work in that field. The qualitative leap between a master and a doctorate is tremendous. But it is true that many PhDs are not well prepared for working in industry.

2.c. Could those opinions be reconciled ?

At first glance, the two sets of opinions I have just presented seem diametrically opposed and by no way reconcilable. But, if you look carefully at them, you will see that they actually do not conflict with each other, because they do not relate to the same thing :

- **Georg WINCKLER** and **Martine PRETCEILLE** are speaking of a desirable situation, of something they hope universities could do, through their PhDs in engineering, to foster the innovation capacity and, on the bounce, the competitiveness of European industry.
- While the other evidence is about the present situation of PhDs, namely their difficulty to integrate into professional life.

In other words, in the favourable opinions, it is the "on the bounce" that poses a problem and it seems, actually, that the "production" of PhDs in Science and Technology is badly aligned with their possibilities of career. So, we shall have to look closely into that.

Nevertheless, I am <u>not</u> going to consider their potential career in academia, as it is beyond the scope of this presentation and we know that, depending on the places and the circumstances, the number of positions of university professor with tenure that are opened every year is largely inferior to the number of PhDs applying for it. What about a career in industry ?

3. <u>The policy of industrial companies about PhDs</u>

The policy of industrial companies about the recruitment of PhDs tends to be more or less the same everywhere in Europe.

In large industrial groups, as SIEMENS and SOLVAY for instance **[8]**, PhDs' recruitment is linked to their volume of R&D ; this, nevertheless, requires further details :

- A PhD is generally not going to spend his whole professional life doing research work : he or she will have to move, at some time, towards more managerial tasks for which he or she has not always been sufficiently prepared.
- It is uncommon that new industrial processes and practices be created by individuals : enterprises are built and operated by groups, while PhD students are often alone in front of their thesis subject.
- How good the PhD candidate might have been marked by his university, the Human Resources Manager will always take into account his standard of "soft" skills ; as a more or less important part of the R&D work, depending on its technical level and complexity, can also be successfully tackled by engineers at Master level, the standard of soft skills of the candidate may be a more discriminatory criterion than the graduation level.
- And, last but not least, Human Resources Managers are very reluctant to take on a PhD graduate, however good he might be, to have him work in a position for which he is overqualified, because there is then a significant risk of him leaving the company within a few years for a better qualified position elsewhere or, otherwise, of him being unhappy – and probably not very much motivated – during his whole professional life.

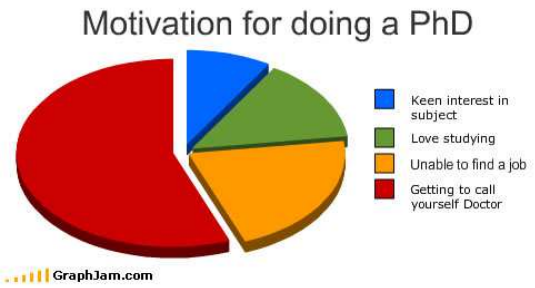
The policy is more or less the same in SMEs **[9]**, except that it is usually the activity of the company that determines if it is desirable or not to take on PhDs.

This leaves us with a **three-body problem** – academia on one side, industry on the other side, and engineers applying for or having gained a PhD in-between – to which I cannot hand a solution on a plate. Therefore, I am just going to present some food for thought by throwing successively various lights on the question and so, I hope, bring a small contribution to building up a solution.

4. Throwing various lights on the problem

4.a. The red light : motivation of PhD students

The figure on the right comes from a humour website and must therefore not be taken seriously. But it is true that many students who apply for a PhD do not know what their real motivation is. And even less do they know what is expecting them afterwards.



In a survey conducted at the University Pierre MENDÈS-FRANCE of Grenoble among some 400 of their past PhD graduates [**10**], it appeared that 37.5 % of them wanted to become an academic when they applied for the PhD, 31.4 % wanted to work in the private sector and 31.1 % did not know what they wanted.

As Peter BENTLEY said [**11**], a student needs to be very clear in his mind what the reasons are for becoming a PhD graduate. If it is because he is afraid to enter the arena of professional life or because his uncle Fergus imposed that as a condition for leaving him his old fully equipped Ford Mustang, he had better quit. If it is because he thinks he is going to earn more money, he had better quit also : other ways are generally more profitable and he is going to face a fierce competition to reach the best paid positions, particularly in industry, where Masters are already three years ahead.

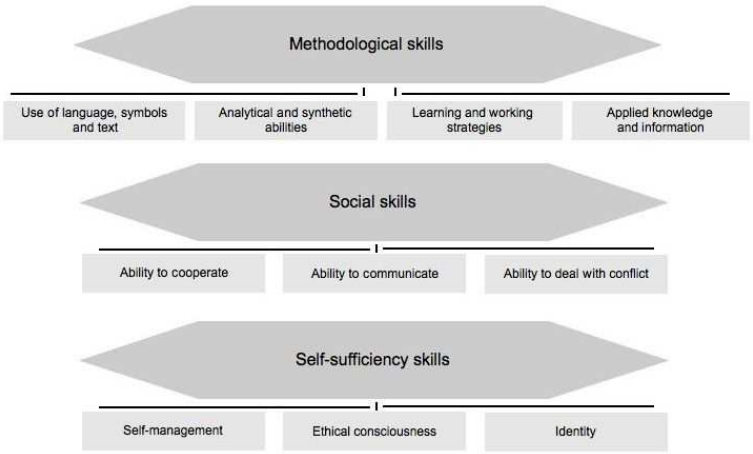
In order to make a career in industry that is worth their PhD, graduates have to know well enough what is waiting for them in that line of activity ; they have to be highly motivated for that sort of job, posses other valuable skills than research and be ready to learn much more during their career. Otherwise, the best thing they can dream of is a dead end job in R&D.

4.b. The green light : transferable skills

Two years ago, in Brussels, in my presentation about " *The Engineering Skills Needs of Industry* " at the CLAIU's annual conference, I explained how valuable the so-called "soft" skills are valuable in the eyes of Human Resources Managers when they have to take on engineers – was it at Bachelor, Master or PhD level – in industry.

Those soft skills are also called “transferable skills” and they are now claimed everywhere in the job market, with specialized consultants offering such long lists of them that, obviously, it is impossible not to possess a number of them ! Even the European University Association, in the framework of a broader study [**12**], has presented a list of 11 of such skills, which are highly rated at the time of recruitment of doctorate holders.

Since fall 2009, the University of Zürich is offering courses in transferable skills specially designed for academic work and doctoral studies. The figure on the right shows the model that is used to adapt the courses to the demands of the PhD candidates.



Actually this model represents all the skills that anybody should possess, at various levels, in order to be efficient in his (or her) work. Besides, the former Department for Education and Employment in UK defined transferable skills as *“ those skills that are central to occupational competence in all sectors and at all levels ”*.

I do not dispute the fact that having a good mix of such skills is desirable for the employability and career of engineers of any degree, but I share the point of view of Len HOLMES, presently Professor at the University of Luton [**13**], that the plethora of different lists and models makes them unusable, particularly as they presuppose :

1. that the ‘skills’ terms being used have the same, unequivocal meaning for all parties, which is totally unsustainable, and
2. that it is possible to differentiate between various levels achieved by the students in a given skill, which seems unrealistic.

The conclusion, concerning transferable skills, is that we are floundering in full subjectivity.

But the fact remains that they do exist, that employers are using them as a criterion and that candidates will have to prove, one way or another, that they do possess a good mix of transferable skills.

There is one transferable skill on which I would like to insist, it is **leadership**. A recent book by two experts from Yale University [**14**] describes the seven pillars of leadership ; they are :

1. **Integrity** : the fundamental leadership attribute, that keeps everything else secure.
2. **Empathy** : the fundamental ability to tune in to others and to motivate them.
3. **Emotional intelligence** : it improves the connection between what we feel and the way we act.
4. **Vision** : it starts with imagination and an inquisitive mind and provides direction.
5. **Judgment** : the ability to zero in on what is important, see the whole chessboard and take decisive action.
6. **Courage** : the ability of facing, mediating and shaping conflicts, sometimes at considerable risk to oneself.
7. **Passion** : it creates positive energy and attracts followers, but must stay balanced with the other six attributes.

It is important, because many other qualities of good leaders flow from them. For instance, **innovation skill** – something that is often pushed forward concerning PhDs in engineering – requires the imagination to conceive a new vision, the judgment to ensure this vision is practical and can be implemented, the empathy to anticipate how others will react to the new idea and to garner their support, and the courage to stick with a plan despite inevitable bumps in the road.

4.c. <u>The blue light : curricula for PhDs in engineering</u>

Earlier in this presentation, I have quoted **Martine PRETCEILLE** [**7**] about the importance of PhDs in engineering for the competitiveness of industry. She also said that : " *Those three years – or more – spent in order to gain a PhD graduation brings an invaluable <u>professional</u> experience to the student* ". Well, maybe her words have been misreported, but I completely disagree with that, at least concerning those students who intend to work in industry.

Actually, there is a difference between potential ability, even derived from the best university, and proven ability, as the one gained on the job, because the realities of the industrial workplace are quite different from research in university.

It is, of course, very interesting for universities to have as many PhD students as possible, first because they carry out a significant part or the research work of the university, and second because their number is a criterion for ranking and funding. As a result, the programmes have an incentive to attract students.

This is how an academic culture has developed, according to which doctoral studies in engineering provide students with top qualifications for research and development, which is probably true in most cases about their qualities, but certainly false in many cases about their perspectives of career, as I explained before.

A collateral and perverse effect of such an attitude is that PhD graduates, when postulating for a job in industry, try to sell their degree, not their skills and personality traits. A PhD degree has little value to non-academic employers, who want :

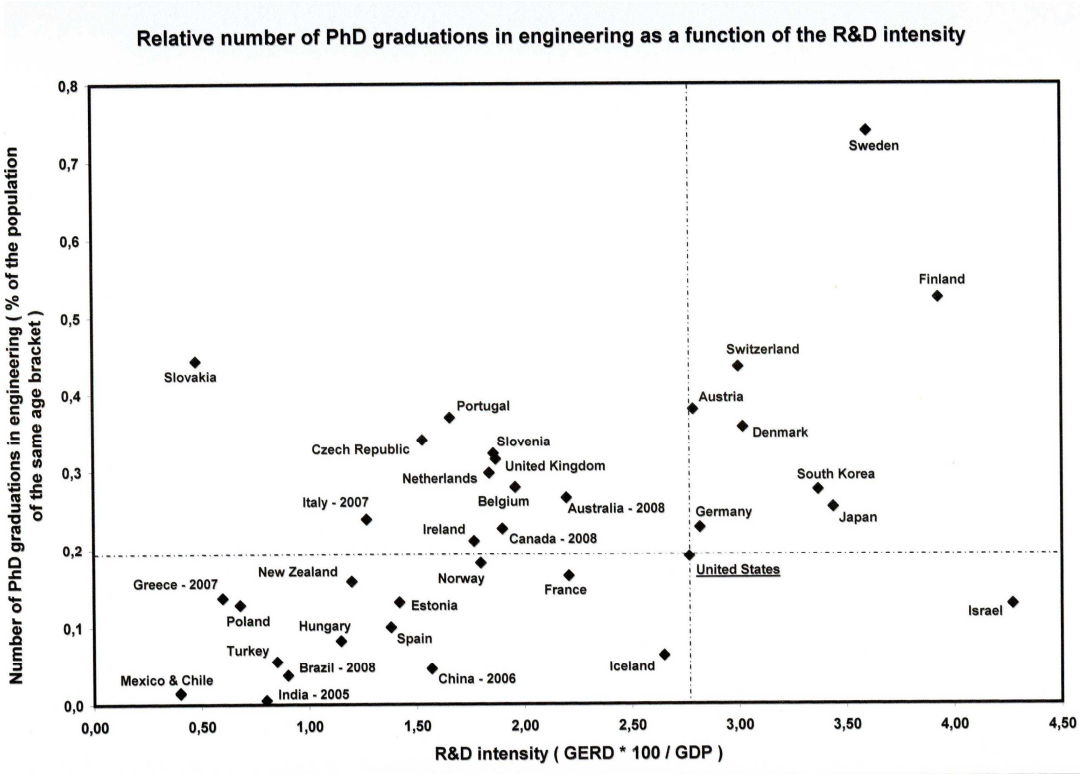
- **adaptive** people, who can rapidly fit into the workplace culture, work in teams, communicate well, take on responsibility, perform efficiently and effectively,
- **adaptable** people, who can use their abilities and skills to make the organization evolve through bright ideas and persuading colleagues to adopt new approaches,
- and **transformative** people, who can anticipate and lead change and who have higher level skills, such as analysis, critique, synthesis, …

Now, there are those new professional doctorates in engineering, which appeared mainly in Australia and in the United Kingdom, and above all those collaborative doctoral programmes studied by the European University Association, which I already mentioned [**12**]. It is too early to judge of their impact, but there is no doubt that doctoral studies lead in collaboration with an industrial company are much more profitable for the future graduates ; and they have a positive impact on University-Industry cooperation, not only in the field of research, but also in the framework of Continuing Engineering Education.

4.d. <u>The amber flashing light : R&D in Europe</u>

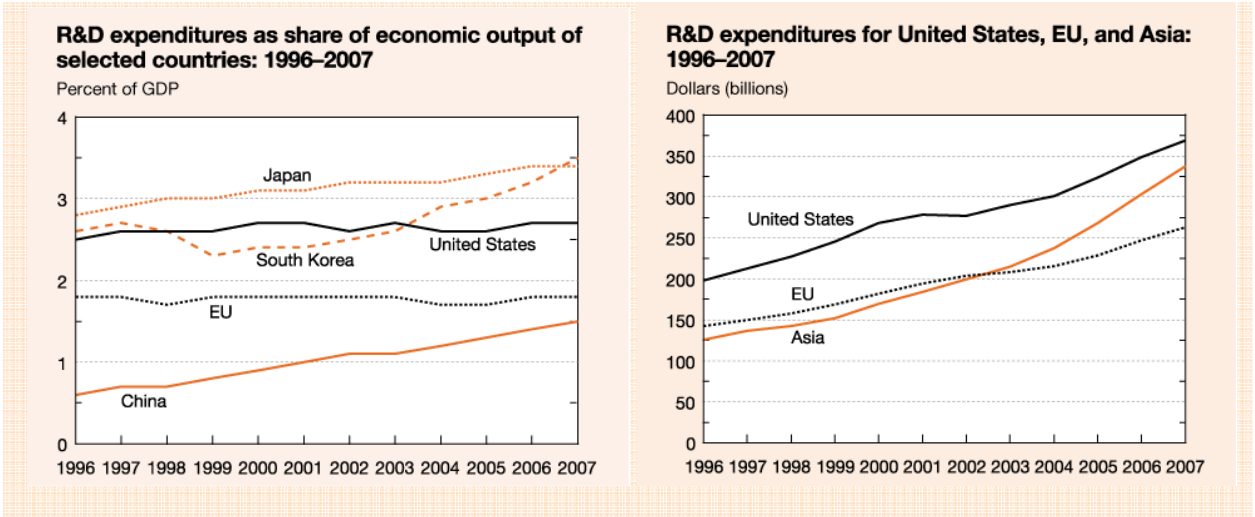
At the beginning of this presentation, I showed a diagram representing the position of different countries relatively to their relative number of PhD graduations, and it was apparent that the situation of European countries, compared with the United States, was rather good on that score.

Let us now have a look at the following diagram, where the relative number of PhD graduations in engineering is presented in function of the R&D intensity for the same countries and the same year.



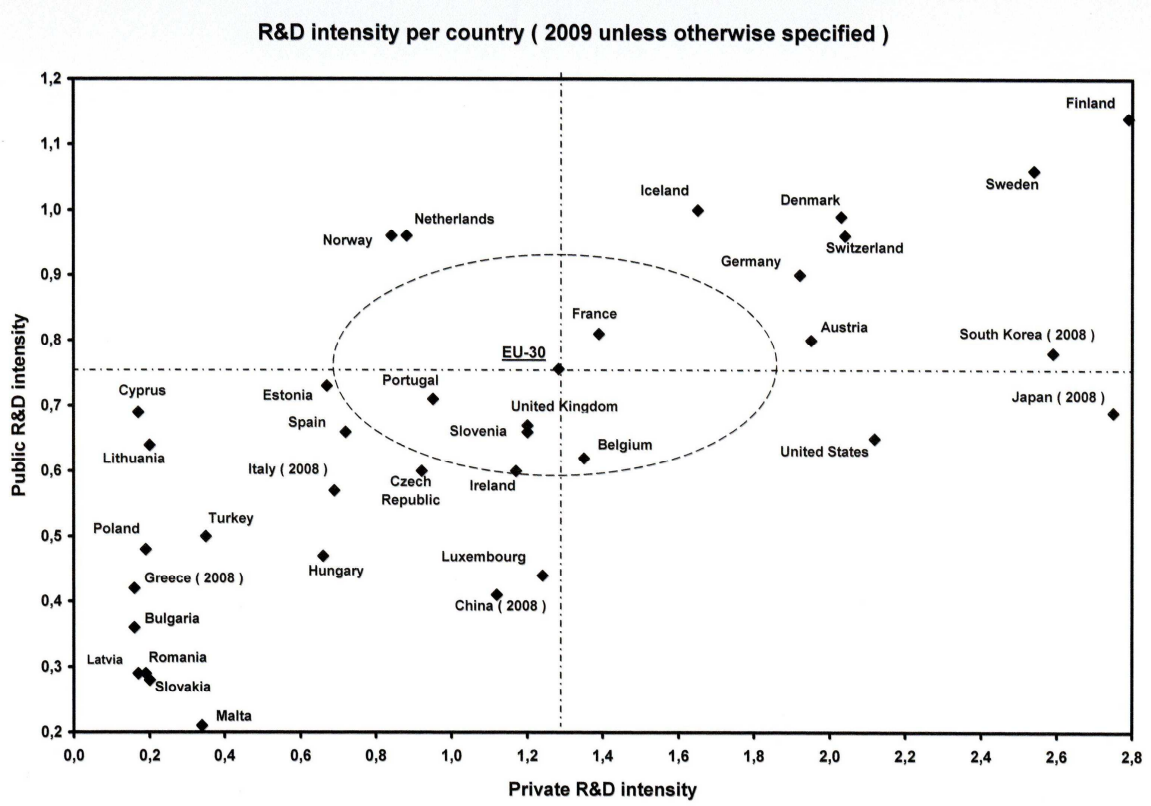
It immediately appears that, this time, the position of European countries, compared with the United States, is far to be good. Only Sweden, Finland, Denmark, Switzerland and, to a lesser extent, Austria and Germany are doing better. All other European countries lay far behind, particularly Spain, Estonia, Italy, Hungary, Poland, Slovakia and Greece.

In 2011, R&D intensity is expected to be of 1.8 % for Europe, compared with 2.7 % for the United States, 3.3 % for Japan and already 1.6 % for China ; it is even less than the average value for the whole world, which turns around 1.9 % ! Both following diagrams, coming from the already mentioned OECD report [**1**], are more explicit than a long speech:



These figures are incredibly low for a European Union, the governing bodies of which have set innovation as the main target for their competitiveness, with a knowledge triangle as a conceptual tool to foster knowledge transfer from universities to businesses.

But, we can still go further and compare R&D intensity in the public and in the private sectors, as derived from the already mentioned EC report [**2**] :



In this diagram, the two dotted lines correspond to the average values for Europe-30 (that is EU-27 + Iceland, Norway and Switzerland), while the ellipse delimits the area inside standard deviations for those same countries.

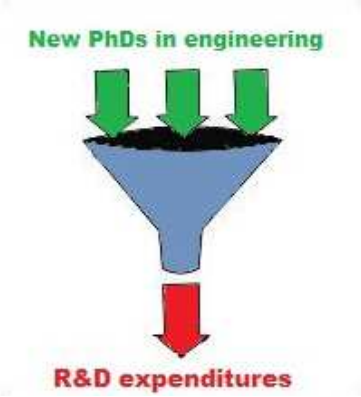
It is very interesting to notice that if, globally, Europe stands comparison with the United States, Japan and South Korea concerning the public R&D intensity, it is not the same relating to the private R&D intensity, for which Europe is laying well behind those competitors.

There are two other interesting figures in the same report :

- First, the number of researchers working in the private sector represents 80 % of all researchers in the United States, 75 % in Japan, but only 46 % in Europe !
- Second, if we look at the R&D intensity of industrial companies depending on whether they are “old” (created before 1975) or “young” (created since 1975), that intensity is

36 % higher in the United States than in Europe for the “old” companies, but 168 % higher for “young” companies ! This gives an idea of the difference of entrepreneurship between Europe and the USA.

This also means that the problem of Europe is not the number of PhD graduations, but the expenditures in R&D in industrial companies ! In other words, we are faced with a “ funnel effect ” : it is useless to pour plenty of new PhD graduates into the job market if their output is limited by a much too low volume of expenditures in R&D ! This explains the criticism I reported at the beginning, criticism which is therefore quite justified.



Where does that come from ? The question is not easy to answer, as there is certainly a combination of various causes.

People say that it derives from the fact that Europe does not have many natural resources in its ground ; but, is it not also the case of Japan and South Korea ? Or that our salaries – and particularly our social security systems – are too high ; but is it not in the European countries where they are the highest that the R&D intensity is also the highest ? Or also that the many successive wars that we have gone through have weakened our economy and that, precisely, those people who were fed up with that left Old Europe for the New World ; there is certainly some truth in that, but it cannot explain all the differences and apparently, if we look at what is happening now, many Europeans have not yet retained the lessons of history !

I want to pinpoint something that could also contribute to an explanation : it is the overwhelming power that financiers and economists have, directly or indirectly, on all the sectors of our society. They got into companies, where they hold managerial positions that were formerly held by engineers, and they generally insist on having short term returns on investments, which trims many potential R&D projects. On the other hand, shareholders, frightened by all that commotion, initiated by the rating agencies and reflected by the media, about the shakiness of the market, follow suit about their dividends.

This brief outline is slightly caricatured, but I do think there is much truth in it. Actually, it is precisely how financiers and lawyers have dismantled the industrial fabric in the United Kingdom not so long ago.

5. Conclusions

In this presentation, I have shown that the opinion according to which the supply of PhDs in engineering is overcoming the demand is true and that actually many of those PhDs cannot find a job corresponding to their qualifications.

Maybe is it also true, as Georg WINCKLER said, that Europe needs more researchers to enhance its competitiveness, but the comparison with the United States and Japan shows that it is essentially in industry that those researchers should be working, which is not presently the case because European industry does not invest enough in R&D.

One of the main reasons for such a situation is probably that many European industrial companies are managed by economists and financiers, who are looking essentially for a short term return on their investments, while R&D is a long term investment. Engineers, on the contrary, are characterized by a proactive vision of the future, but unfortunately, by lack of knowledge or interest, most of them do not reach top managerial positions.

It is therefore useless – and also a waste of resources – that universities should "produce" more PhD graduates, as most of them would have to accept positions for which they are overqualified. Instead of seeking quantity, universities had better improve the quality of their graduates, by developing their leadership and entrepreneurship skills.

One could think, for instance, of creating some sort of management-based doctorates, besides the present research-based doctorates, which would also include the management of R&D. Too many people are lacking in imagination and offering a strong resistance to change.

Engineers must take their future into their hands. Otherwise, no one will do it for them and mark out their way. As the Spanish poet Antonio MACHADO wrote :

Caminante, son tus huellas
el camino, y nada más.
Caminante, no hay camino,
se hace camino al andar.
Al andar se hace camino
y al volver la vista atrás
se ve la senda, que nunca
se ha de volver a pisar.
Caminante, no hay camino
sino estelas en la mar.

Wanderer, nothing but your tracks
are laying out your way.
Wanderer, there is no road,
the road is made by walking.
By walking, you make the road
and, when glancing back,
you see the track which
you will never tread again.
Wanderer, there is no road,
only wakes upon the sea.

This concludes my presentation. Thank you for your attention.

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