French engineering graduates in corporate R& D: Is it worthwhile?

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Labour markets for scientists and engineers

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I. **Introduction**

Traditionally, the French higher education system is segmented between *Grandes écoles* and universities. The first ones select their students through a competitive exam, after two years of prep schools. To enter the second ones, the French *"baccalauréat"*, the State final exam which ends secondary studies, is sufficient to enter. *Grandes écoles* specialise in two main disciplines: engineering and management. The reality is that most members of the French elite, either in public or private companies, received their training in some prestigious engineering schools. These include such schools as *Ecole Polytechnique*, *Ecole des Mines*, *Ecole des Ponts et Chaussées*, *Ecole Centrale*,...

Despite increased numbers of engineering schools, often linked to universities, at the beginning of the 1990s and consequently the increased number of graduates in engineering, such field of studies remains one of the more prestigious, mainly because its hard access to. Firms also consider that graduates from engineering schools received a general training in matters linked to company activities which allow these graduates to cope with a large spectrum of issues. Very often, graduates start their careers in tasks linked to production or to R&D activities before moving to less "industrial" tasks, such as business or management activities.

At the beginning of the 1990s, Beltramo, Bourdon and Paul presented a report for the French Commissariat au Plan on the prospect for the labour market for scientists, and other papers, which showed earnings differences between engineering graduates performing tasks in R&D or not (the first ones receiving 7% less than the others, other parameters taken into consideration). The objective of this paper is to assess to what extent, 15 years later, these results, which indicated lower earnings for researchers, is still valid.

The data used in this study is similar to that in our former work. The data is generated from the survey launched each year (each two years until 2002) by the CNISF (Conseil National des Ingénieurs et des Scientifiques de France) amongst the engineering graduates, whatever their age and experience. Usually, around 40,000 engineers answer the questionnaire. In this paper, we used the data from the survey conducted in 2006 and we consider only engineers working in companies. Those employed by public administrations, universities or public research are not taken into account. Weights have been used to correct for the representation of the different schools and the different ages in the sample.

In the first part of the study, earnings of engineers working in R&D will be compared with those of the other engineers. Using regression models, personal attributes will be considered (gender, degree, etc.). Specific attention will be devoted to differences in experience. The levels of responsibility which are implied by different types of activities will then be taken into consideration.

In the last part of the paper, the satisfaction of engineers involved in R&D and other activities will be scrutinised.

II. General earning models

According to the survey, amongst the 15,097 engineers covered by the survey, around 14% are working in R&D activities.

Engineering Graduates in R&D and in other activities

	Number	Proportion
R&D activities	2,095	13.9%
Other activities	13,002	86.1%
Total	15,097	100.0%

On average, as the simple regression model of the log of earnings on the R&D activities shows it, engineering graduates working in R&D activities earn 10.1% less than the ones working in other activities (taken the Kennedy's correction into consideration). Such a signal would not represent a stimulation to devote his/her career to such activities. Nevertheless, this first result has to be considered with caution, since other factors may interfere. Gender, location of work, prestige of engineering school, additional degrees to the engineering one represent parameters linked to the individuals that are crucial to be taken into consideration.

The basic model

Dependent Variable: log of annual earnings

	B	Std. Error	Sig.
(Constant)	10.996	.004	.000
R&D	-.106	.010	.000
	R Square	Adj.R Square	
	.007	.007	
Degrees of freedom	15,096		.000

Since, even at this level of degree, females earn less than males (for factors linked both to supply and demand of labour we will not discuss here) (15,084€), graduates from prestigious schools and working in the Paris region earn more (17,023€, 8,359€), these parameters need to be considered. As illustration, if females work more than males in R&D activities, the lower earnings for researchers could be partially explained by this fact. On the other hand, if R&D activities are more developed in the Paris region, the earnings difference between R&D and non R&D activities can be underestimated when this parameter is exogenous.

Females represent 11.7% of the considered population and 14.6% of them work in R&D activities against 13.8% of males. Engineers from the most prestigious schools represent % of the population, but they chose less frequently R&D activities (9.2% compared with 14.3% for the other engineers). Engineers who work in the Paris region count for 38% of the total engineers. A slightly lower proportion of them work in R&D activities (13.3% against 14.3%).

R&D activities by gender

Gender	R&D	Not R&D	Total	Count
Female	14.6%	85.4%	100.0%	1,766
Male	13.8%	86.2%	100.0%	13,330
Total	13.9%	86.1%	100.0%	15,096

R&D and prestige of engineering school

Type of engineering school	R&D	Not R&D	Total	Count
Most prestigious schools	9.2%	90.8%	100.0%	1,361
Other schools	14.3%	85.7%	100.0%	13,736
Total	13.9%	86.1%	100.0%	15,097

R&D activities by region

Region of work	R&D	Not R&D	Total	Count
Paris region	13.3%	86.7%	100.0%	5,751
Other region	14.2%	85.8%	100.0%	9,346
Total	13.9%	86.1%	100.0%	15,097

Engineering graduates may have an additional degree to the one in engineering. Some can prepare a degree in management or other related fields, other graduates can study for another scientific degree (such as a Master in Science); some others will continue their studies to get a Ph D. The distribution according to the R&D activities may vary according to these degrees.

R&D and Degree in Management

Degree in Management	R&D	Not R&D	Total	Count
Additional degree in Management	6.5%	93.5%	100.0%	2,055
No additional degree in Management	15.0%	85.0%	100.0%	13,042
Total	13.9%	86.1%	100.0%	15,097

On the one hand, a proportion of 13.6% of engineers hold a degree in management like MBA, which may allow running functions less technical than the traditional engineering ones. In fact, only 6.5% of these engineers holding a degree in management have R&D activities.

On the other hand, amongst the 13.4% of the engineers holding an additional degree in Science, 23.6% have chosen to practice in R&D. The same holds true for the engineers that became PhD graduates. They represent a small proportion of the total (4.5%), but a large proportion of them (38.8%) work in R&D activities.

R&D and degree in science

Degree in Science	R&D	Not R&D	Total	Count
Additional degree in Science	23.6%	76.4%	100.0%	2,030
No additional degree in Science	12.4%	87.6%	100.0%	13,067
Total	13.9%	86.1%	100.0%	15,097

R&D and Ph.D.

Ph D	R&D	Not R&D	Total	Count
With a Ph D	38.8%	61.2%	100.0%	678
No Ph D	12.7%	87.3%	100.0%	14,420
Total	13.9%	86.1%	100.0%	15,098

The same holds true regarding the characteristics of the company. If R&D activities are more developed in more remunerating sectors of activities or in larger companies, earnings differences between R&D and R&D will be underestimated when these factors are not considered. In fact, the proportion of engineers in the largest corporates (55.9% work in companies with more than 2,000 employees) who work in R&D activities is higher than for the ones working in the small companies (14.7% compared with 10.2%). A breakdown regarding the sectors of activity is given in the appendix.

R&D and size of the company

	Size of the company					
	1-20	21-499	500-1999	+ 2000	Total	Count
R&D	10.2%	13.1%	13.2%	14.7%	13.9%	2,094
Not R&D	89.8%	86.9%	86.8%	85.3%	86.1%	13,003
Total	3.9%	25.2%	15.1%	55.9%	100.0%	15,097

Once these different factors have been introduced into the model, the situation does not really change: R&D activities represent a negative difference in earnings of around 10.6%.

Earnings models with individual attributes, company characteristics and experience

Dependent variable: log of earnings									
	Unstandardized Coefficients		Sig.	Unstandardized Coefficients		Sig.	Unstandardized Coefficients		Sig.
	B	Std. Error		B	Std. Error		B	Std. Error	
(Constant)	10.659	.010	.000	10.573	.018	.000	10.211	.013	.000
R&D	-.088	.010	.000	-.110	.010	.000	-.064	.007	.000
Male	.261	.010	.000	.273	.010	.000	.099	.007	.000
Prestigious school	.213	.013	.000	.217	.013	.000	.154	.009	.000
Scientific degree	.008	.010	.435	.004	.010	.699	.010	.007	.151
PhD	.150	.017	.000	.128	.017	.000	.035	.011	.002
Degree in management	.265	.010	.000	.245	.010	.000	.124	.007	.000
Paris region	.106	.008	.000	.110	.007	.000	.076	.005	.000
Size of company (ref.” >=2,000")									
20-499				-.175	.017	.000	-.113	.012	.000
less than 20				-.054	.010	.000	-.054	.007	.000
Sector of activity (ref. Construction)									
Agriculture				.048	.031	.127	-.047	.022	.031
Chemistry				.226	.020	.000	.136	.014	.000
Equipment				.126	.017	.000	.068	.011	.000
Aerospatial				.093	.020	.000	.001	.014	.968
Food				.249	.023	.000	.141	.016	.000
Other industries				.257	.020	.000	.156	.014	.000
Energy				.193	.018	.000	.123	.013	.000
Distribution				.086	.029	.003	.068	.020	.001
Telecommunications				.140	.021	.000	.113	.015	.000
Social services				.001	.017	.971	.030	.012	.011
Assurance, banking				.244	.021	.000	.167	.015	.000
Other services				.125	.020	.000	.073	.014	.000
Experience							.063	.001	.000
Square of experience							-.001	.000	.000
	R Square	Adj.R Square		R Square	Adj.R Square		R Square	Adj.R Square	
	.142	.141		.198	.197		.616	.615	
Degrees of freedom	15,096			15,096			15,096		

Estimation through classical OLS

The role of the experience on the labour market

The experience is another major factor that has to be regarded with great attention. It is well-known that R&D activities often represent an entry point in the engineers' carreer for young graduates, which will move to other activities after some years of experience.

	Bracket (in years)											
	1-4	5-8	9-12	13-16	17-20	21-24	25-27	28-31	32-35	>= 36	Total	Count
R&D	19.2%	24.4%	17.3%	8.8%	10.1%	8.0%	5.5%	4.2%	2.1%	.3%	100.0%	2,095
Not R&D	17.6%	20.7%	17.1%	10.6%	10.2%	8.2%	6.5%	5.0%	3.7%	.6%	100.0%	13,002
Total	17.8%	21.2%	17.1%	10.3%	10.2%	8.1%	6.3%	4.9%	3.4%	.5%	100.0%	15,097

According to the table, engineers involved in R&D activities are over-represented in the brackets of low level of experience (until 8 years of experience). Despite the exception represented by the bracket 17-20 years, this result shows that the differences in experience can embodied part of the difference of earnings against researchers.

Actually, the introduction of the experience variable into the model changes radically the level of the R&D coefficient in the earning model, which becomes -6.4%, that counts for half of the estimation in the previous model. Half of the difference between the earnings of graduates working in R&D activities and the others are due to difference in the experience level. Nevertheless, it remains a difference of 6.4% against the researchers.

III. The role of the level of responsibility

Beltramo and Paul (1994) pointed out that part of the difference could be due to the change in the level of responsibilities between the two types of activities.

R&D and responsibility

Level of responsibility	General manager	Head of a service	Head of a small team	No responsibility	Total	Count
R&D	1.6%	20.1%	24.5%	53.8%	100.0%	2,094
Not R&D	8.5%	23.1%	23.0%	45.4%	100.0%	13,003
Total	7.6%	22.6%	23.2%	46.6%	100.0%	15,097

Three levels of responsibility have been considered in the survey: head of a small team, head of a service and general manager. These levels have been introduced in the general model (the same as already tested). Then, the population has been split into five categories of experience (1-4 years, 5-8 years, 9-12 years, 13-16 years and more than 16 years).

Once the level of responsibility has been introduced, the difference in earnings against researchers becomes smaller (3.5%) but it remains significant. That means that R&D is not as well remunerated as other activities within the companies.

The results concerning the level of responsibility are logical: the general managers earn more (around 52% more than the engineers without any responsibility), followed by heads of service (18.1% more) and the heads of small teams (6.5% more).

The evolution of the earnings difference between R&D and other activities is not linear. It is the lowest for the lower level of experience (as expected), then increases dramatically for the bracket '5-8 years', then it decreases regularly.

Earnings models with the level responsibility and experience

Dependent variable: log of earnings									
Level of experience	All			1-4 years			5-8 years		
	B	Std. Error	Sig.	B	Std. Error	Sig.	B	Std. Error	Si.
R&D	-.036	.006	.000	-.023	.010	.023	-.060	.011	.000
Small team	.065	.005	.000	.038	.009	.000	.083	.008	.000
Service	.181	.006	.000	.112	.015	.000	.145	.011	.000
General manager	.520	.009	.000	.266	.055	.000	.325	.043	.000
Other variables included in the model (the same than in the previous one)									
	R Square	Adjusted R Square		R Square	Adjusted R Square		R Square	Adjusted R Square	
	.695	.695		.221	.213		.229	.223	
Degrees of freedom	15,096			2,687			3,200		

Level of experience	9-12 years			13-16 years			>=17 years		
	B	Std. Error		B	Std. Error		B	Std. Error	
R&D	-.047	.015	.001	-.038	.023	.094	-.034	.013	.010
Small team	.069	.012	.000	.064	.019	.001	.086	.012	.000
Service	.168	.012	.000	.181	.018	.000	.228	.011	.000
General manager	.435	.023	.000	.455	.027	.000	.608	.013	.000
Other variables included in the model (the same than in the previous one)									
	R Square	Adjusted R Square		R Square	Adjusted R Square		R Square	Adjusted R Square	
	.284	.277		.310	.299		.413	.410	
Degrees of freedom	2,586			1,557			5,062		

Another method to study the joined effect of working in R&D and the level of responsibility according to the level of experience is to build a variable of interaction. In this new model, a distinction is made between four categories: 'no responsibility and working in R&D' (reference), 'responsibility and working in R&D', ''responsibility and not working in R&D, 'no responsibility and not working in R&D'. The model includes also all the variables already considered in the previous equations. Six equations are tested: one with all the engineers pooled together and five for each one of the bracket of experience.

Earnings models with interaction between R&D and responsibility

Dependent variable: log of earnings									
	Level of experience								
	All engineers			1-4 years			5-8 years		
	Unstand. Coef.			Unstand. Coef.			Unstand. Coef.		
	B	Std. Er.	Sig.	B	Std. Er.	Sig.	B	Std. Er.	Sig.
Responsibility and R&D (ref. not resp and R&D)									
Resp. and R&D	.277	.016	.000	.052	.021	.016	.086	.019	.000
Resp. and not R&D	.382	.012	.000	.082	.013	.000	.166	.014	.000
No resp. and not R&D	.074	.012	.000	.026	.012	.028	.057	.013	.000
Other variables included in the model (the same than in the previous one)									
	R Sq.	Adj. R Sq.		R Sq.	Adj. R Sq.		R Sq.	Adj. R Sq.	
	.642	.642		.209	.202		.217	.211	
Degrees of freedom	15,096			2,687			3,200		

	Level of experience								
	9-12 years			13-16 years			>+ 17 years		
	Unstand. Coef.			Unstand. Coef.			Unstand. Coef.		
	B	Std. Er.	Sig.	B	Std. Er.	Sig.	B	Std. Er.	Sig.
Responsibility and R&D (ref. not resp and R&D)									
Resp. and R&D	.117	.026	.000	.134	.046	.004	.198	.028	.000
Resp. and not R&D	.188	.020	.000	.195	.040	.000	.312	.023	.000
No resp. and not R&D	.045	.020	.027	.023	.041	.579	.042	.024	.078
Other variables included in the model (the same than in the previous one)									
	R Sq.	Adj. R Sq.		R Sq.	Adj. R Sq.		R Sq.	Adj. R Sq.	
	.217	.210		.220	.208		.250	.246	
Degrees of freedom	2,586			1,557			5,062		

On the average, the researchers with some responsibility earn 10% less than those not engaged in R&D activities. The difference is only 7.5 % against the researchers without any responsibility. Whereas the difference is around 2% for the two situations when the engineers count less than 5 years of experience, the maximum values are 11% against the most experienced researchers with responsibility (compared with engineers with responsibility not in R&D) and 6% for the researchers without any responsibility and 5-8 years of experience (compared with engineers without any responsibility and not in R&D). To get responsibilities and seniority does not allow researchers to earn incomes closer to the ones of other engineers. On the opposite, the earnings difference between managers in and out R&D activities increases with the level of experience.

IV. Do researchers pay for their taste?

The previous study results by Bourdon and Paul (1992) showed that engineers involved in R&D were more satisfied than others in their work. The study concluded that these engineers 'agreed to pay for their taste for research' by accepting lower wages. In the present study, several items regard the satisfaction of engineers with their occupation. Some results will be used here: major dissatisfaction in the work, satisfaction with creativity of work, with workload, with the value of work, with the exercise of responsibility, with the opportunities of development of career, with the earnings and benefits, with the way propositions are taken into account and with the recognition of merits by firms.

Some 15 years later, the situation has radically changed. Researchers are still dissatisfied with their earnings (40.6% declare to be dissatisfied with their earnings and compared to 34.0% for other engineers). They express more major dissatisfaction in their work (60.1% against 56.2%), in the value of their work (23.1% against 18.5%) and in the recognition of the merits that company pay back to them in formal or non formal dimensions (50.3% against 43.0%).

Could you say that you have no major dissatisfaction in the work?

	Yes	No	Total	Count
R&D	39.9%	60.1%	100.0%	2,095
Not R&D	43.8	56.2%	100.0%	13,003
Total	43.3%	56.7%	100.0%	15,098

Sign. Chi-2 : 0.001

	The part of creativity of your work				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	77.3%	11.7%	10.9%	100.0%	2,094
Not R&D	66.0%	15.7%	18.4%	100.0%	13,003
Total	67.5%	15.1%	17.3%	100.0%	15,097

Sign. Chi-2 : 0.000

	The workload				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	28.7%	46.5%	24.8%	100.0%	2,095
Not R&D	27.7%	44.1%	28.2%	100.0%	13,003
Total	27.9%	44.4%	27.7%	100.0%	15,098

Sign. Chi-2: 0.006

	The value of your work				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	61.9%	23.1%	15.0%	100.0%	2,095
Not R&D	67.3%	18.5%	14.2%	100.0%	13,003
Total	66.6%	19.2%	14.3%	100.0%	15,098

Sign. Chi-2 : 0.00

	The exercise of the responsibility				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	58.8%	21.8%	19.3%	100.0%	2,094
Not R&D	67.7%	17.8%	14.6%	100.0%	13,002
Total	66.4%	18.3%	15.2%	100.0%	15,096

Sign. Chi-2 : 0.00

	The opportunities in development of career				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	50.7%	34.4%	14.9%	100.0%	2,094
Not R&D	58.9%	27.6%	13.6%	100.0%	13,003
Total	57.7%	28.5%	13.8%	100.0%	15,097

Sign. Chi-2: 0.00

	Your earning and benefits				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	45.7%	40.6%	13.7%	100.0%	2,095
Not R&D	54.6%	34.0%	11.4%	100.0%	13,003
Total	53.4%	34.9%	11.7%	100.0%	15,098

Sign. Chi-2:0.000

	The way your propositions are taken into account				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	48.0%	34.0%	18.0%	100.0%	2,094
Not R&D	53.8%	27.9%	18.3%	100.0%	13,003
Total	53.0%	28.7%	18.3%	100.0%	15,097

Sign. Chi-2 : 0.000

	The recognition of the merits by your company				
	Satisfied	Dissatisfied	Indifferent	Total	Count
R&D	36.2%	50.3%	13.5%	100.0%	2,094
Not R&D	42.5%	43.0%	14.5%	100.0%	13,003
Total	41.7%	44.0%	14.4%	100.0%	15,097

Sign. Chi-2 : 0.000

They present a high level of dissatisfaction with other aspects of their work, such as the workload (46.5% against 44.1%), the exercise of responsibility (21.8% against 17.8%) and the way their propositions are taken into account (34.0% against 27.9%).

Nevertheless, other parameters can affect the level of satisfaction. The level of experience may influence answers to questions relating to career: less experienced people may be less satisfied with the level of responsibility or earnings, independently of their activity. The same

holds true with other factors such as the size of the company, questions regarding the way propositions are taken into account, and the recognition of the merits (the role of engineers may be considered more strategic in smaller companies). This is why logistic models of satisfaction have been run which consider these dimensions together with the R&D activities. By no means, the results have changed significantly. Engineers in this more recent survey engaged in R&D, are more dissatisfied than in the earlier study (detailed results are presented in the appendix).

The only item which documents a higher proportion of satisfaction within engineers in R&D concerns the part of creativity in the work: 77.3% of them are satisfied against 66.0% of engineers working in other activities. It is a moot point whether this dimension alone is sufficient to balance for all the negative aspects outlined above.

Conclusion

The general dissatisfaction of engineers working in R& D activities is highly significant. Earnings are not the only motive for such a negative feeling, but also value of their work, workload, recognition, including the way their propositions are taken into account.

The persistence of lower earnings for engineers working in R&D activities is noteworthy as observed in the following two factors. The first one regards solutions that have been envisaged by companies which were well aware of the negative consequences of the organization of R&D activities for the career and recognition of researchers. Numerous interviews conducted in French and British companies at the end of the eighties for analysing human resources policies for researchers (see Mason, Beltramo and Paul (2004) and Beltramo, Paul, Perret (2001)) noticed that companies were introducing specific instruments to counterbalance the negative aspects of R&D activities for careers.

The second and perhaps more pertinent factor concerns the growing importance of R&D activities for companies as a strategic factor for economic leadership, in a time of fierce competition and of fervent political will for expanding innovation within Europe.

Such a contradiction leaves ample scope for further investigation.

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Appendix

R&D and sector of activity

	Sector of activity								
	Agriculture	Energy	Chemistry	Equipment	Aerospace	Food	Other ind.	Construction	Distribution
R&D	14.7%	13.9%	16.3%	23.7%	21.3%	16.2%	15.8%	4.9%	0.4%
Not R&D	85.3%	86.1%	83.7%	76.3%	78.7%	83.8%	84.2%	95.1%	99.6%
Total	1.4%	9.1%	6.2%	25.2%	5.7%	3.7%	6.9%	4.9%	1.7%

	Sector of activity				Total	Count
	Telecommunications	Social services	Assurance, banking	Other services		
R&D	17.7%	5.0%	0.9%	6.4%	13.9%	2,095
Not R&D	82.3%	95.0%	99.1%	93.6%	86.1%	13,001
Total	4.8%	19.3%	4.9%	6.1%	100.0%	15,096

Logistic models of satisfaction

Dependent variable: satisfaction with	Exercise of responsibility			Opportunities of development of career			Earning and complements		
	B	Std. Error	Sig.	B	Std. Error	Sig.	B	Std. Error	Sig.
(Constant)	.851	.039	.000	.931	.034	.000	.235	.032	.000
R&D	-.298	.060	.000	-.392	.053	.000	-.337	.051	.000
Experience	.038	.003	.000	-.013	.002	.000	.018	.002	.000
-2 log likelihood	13,094.376			16,443.9			17,749.460		

Dependent variable	The way your propositions are taken into account			The recognition of the merits by your company		
	B	Std. Error	Sig.	B	Std. Error	Sig.
(Constant)	.815	.099	.000	.294	.094	.002
R&D	-.318	.053	.000	-.303	.051	.000
Experience	-.004	.002	.055	.007	.002	.001
Size of company (ref.”less than 20”.)						
20-499	-.022	.103	.833	-.209	.098	.033
500-1999	-.265	.107	.013	-.568	.103	.000
>=2000	-.106	.099	.287	-.460	.095	.000
-2 log likelihood	15,939.55			17,799.857		