Earnings of young doctorates in private jobs after participation to post-doctoral programs

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Résumé.

Dans cet article, nous nous intéressons au devenir professionnel des jeunes diplômés de doctorat, ayant obtenu leur diplôme dans des disciplines relevant des sciences exactes en 1996. La création des programmes post-doctoraux visait à son origine les jeunes docteurs souhaitant poursuivre une carrière académique. Cependant, une part non négligeable de jeunes passés par un post-doctorat sont recrutés dans le secteur privé, et en particulier sur des positions professionnelles hors du domaine de la recherche. La question qui se pose dès lors est celle de la valeur sur le marché du travail de cette expérience post-doctorale. Nous proposons ici d'estimer une fonction de gains pour les jeunes docteurs en emploi dans le secteur privé en contrôlant de leur participation à un post-doctorat. Afin de contrôler le biais de sélection qui survient dans le cas où des dimensions individuelles inobservées sont corrélées entre la participation au post-doctorat et le niveau de salaire perçu, nous estimons un modèle à effet de traitement. Le principal résultat est que lorsque le biais de sélection n'est pas contrôlé, la participation à un post-doctorat a un effet positif sur les gains, cependant, lorsque l'effet de sélection est contrôlé, ce rendement positif disparaît. Ce résultat nous conduit à supposer que le stage post-doctoral joue davantage le rôle d'un signal dans le début de carrière des docteurs. Ce résultat est par ailleurs renforcé lorsque nous contrôlons en plus du possible effet de sélection produit par le fait que notre échantillon de travail ne prend en compte que les docteurs en emploi dans le secteur privé.

Abstract.

In this paper, we address the question of destination of post-doctorates for young French PhD graduated in exact sciences in 1996. The creation of post-doctoral program was firstly designated to PhD willing to embark on a public career. However, an important part of post-doctorates rather get to the private sector, particularly outside research positions. The question that occurs is that of the value of post-doctoral experience. We propose here to estimate earnings of young doctorates in private jobs had they participated to a post-doctoral program. To control for selection bias arising in the case where unobservable elements are correlated between participation and earnings, we estimate a treatment effect model. The main finding is that when selection bias is not control for, post-doctoral participation increases earnings, however, when controlling for selection bias, there is no more a positive effect of the participation. As regards to this finding we point out that post-doctoral program play much more the role of a signal in the first-stage career. This finding is also strengthened when using a bivariate selection rule. In that case, we also control for the endogenous nature of having been recruited in the private sector.

JEL classification: J31, C35

Key-words: PhD career, treatment effect model, bivariate selection rule.

The French academic system yields around 10 000 PhD per year in all fields of education, so that France is among the countries which have a huge number of young PhD. Comparatively, Europe has 68 000 new PhD each year and USA more than 40 000 (Nsf, 2002). The number of PhD in science and engineering has doubled over the last twenty years or so in countries like Japan, France, Germany and the United Kingdom, under the stimulus of higher education and research policies based on the premise that the production of high-level scientific diplomas was a key to future economic growth. The stakes are high, especially in the medical, engineering and biological sciences. Yet the number of doctoral students fields is tending to decline or to remain at the same level. In the French higher education system, 6 000 PhD are graduated in exact sciences each year, whereas the number of thesis in human and social sciences is growing slowly (40% on all PhDs in 1998).

At the same time, we observe a decrease in the number of job offered in the public sector for research since the beginning of the 90s. The public research system in France is rather specific, offering, at least theoretically, rapid access to tenured positions in universities or in public institutions (CNRS, INSERM, INRA…) and being rather different from other research systems such as the US, German or British systems. In the United States, university teachers may be recruited on a permanent or non-permanent basis, assistant professors may acquire tenure after many years or be hired on a temporary basis. Access to tenured positions is not immediate in Germany either, and a substantial proportion of recent doctorate recipients take up jobs in private sector research (Verdier *et al.*, 2001), especially as the links between science and industry are traditionally strong.
Coming back to the French case, a point which is crucial is that recruitments on tenured positions are yearly organised and recent doctorates may apply several times before obtaining a job in the public sector for research. The new orientations of public policy are tending to reduce the number of tenured job offers and to increase the number of jobs on temporary contracts, that is fixed-term contracts or post-doctoral programmes. At present, we can notice that there is an overproduction of PhDs compared to the number of jobs offered in the public research system. This key figure is not limited to the French case and the same pattern can be found in the US (Lowell, 2001).

Also, since the mid-nineties, the papers dealing with the analysis of job opportunities for young PhD show an increasing proportion of them employed in the private sector (for France, see Béret *et al.*, 2003). Young scientists, mainly those with degrees in mechanics, engineering sciences or computer science are more and more attracted to the private sector and less and less to academic careers. This partially results from the existence of a queue entry-level academic positions and at the same time from a major transformation of doctoral training occurring during the last decade which is tending to improve and develop links between science and industry (Beltramo *et al.*, 2001; Mangematin, 2000).

Confronted to a stressed labour market, policy makers created waiting time positions, namely post-doctoral programmes. The labour market for young PhD is also very specific and characterised by a huge number of post-doctoral positions, fixed-term contracts financed by research contracts and mainly obtained immediately after graduation. In that way, post-doctoral positions are supposed to be selective waiting time positions at the entry of academic sector and to improve the probability to obtain an academic job for those who did not obtain it immediately after graduation.

As far as we know, this field of study was discussed little, undoubtedly because of scarcity of data on that topic (Recotillet, 2003). Furthermore, assessment are mainly related to the estimation of the probability to obtain an academic job (see for the French labour market, Cahuzac and Robin, 2003; Hanchane and Recotillet, 2003). Cahuzac and Robin (2003) distinguish between post-doctoral positions and fixed-term contracts and show that for PhD graduates in life sciences the participation to a post-doctoral program induces a shrinkage of the instantaneous rate of transition to an academic job or to an industrial research job. Using longitudinal data on early careers of PhD graduated in all fields of education, Hanchane and Recotillet (2003) rather illustrate a positive effect, but weak, of post-doctoral positions on the probability to be recruited as researcher in the public system.

The objective of the present paper is to enlarge the assessment of the post-doc effect to the career of those who did not attend the public sector for research, using French longitudinal data on PhDs' early careers. Given the lack of academic jobs, a part of post-doctorates turn to private sector and choose a career of industrial researcher, expert or consultant.
This lead to consider a model of circulation on the labour market for doctorates that we propose to test, at least partially, using individual data on labour market mobility. Beside the traditionally segment composed of research and development in the public and private sector in which differentiations occur between occupations (between assistant professors and full time researchers) and firms (between multinational firms and others), a new segment is appearing, leading doctorates to jobs outside research and development in the public or private sector.

Our basic assumption is that this way of structuring labour market for recent doctorates produces a double differentiation of doctorates which itself will lead to a segmentation in the job opportunities. The construction of a European knowledge society also paves the way for reading in doctorates diplomas the core of new elites[1] (D1), and, depending on their place in the depicted labour market (briefly in or out R&D[2]) will belong or not to the definition of scientific elites. In short, expansion of doctorates diplomas in higher education systems would lead to internal differentiations between doctorates themselves. Production of elites would concern only a part of this model of labour market circulation. The status of post-doctoral positions is also questioned, as they are fairly intended to support entry in higher education or research. As such, they could be considered as a way to distinguish between our two types of doctorates. From an econometric point of view, we also anticipate that a selection effect is strongly expected and, as a matter of fact, must be treated and controlled.

In the case that we are dealing with, the question that unsurprisingly arises is the value of a post-doctoral experience for PhD who are finally employed in the private sector. Stating that post-doctoral programs are devoted to public research carriers, we face nevertheless to a not unimportant part of post-doctorates which are employed in the private sector afterwards. The question that we propose to answer is that of facing a positive wage premium or not on jobs in the private sector from a post-doctoral experience. The change observed in the career of those who attended a post-doctoral program and then got a job in the private sector could be interpreted as an anti-screening device or/and as a period of human capital accumulation – specific or general following the definition given by Becker (1964).

Whereas the identification of screening and human capital remains a well known difficulty in labour economics, the treatment effect model framework might be a well suited modelling to go further in that way. From the econometrical point of view, the empirical assessment proposed here consists of identification of post-doctorate's effect which allows us to isolate the endogenous bias. Generally speaking, the endogenous bias comes from the existence of unobservable individual characteristics which are correlated both in the earnings observed in private sector and the probability to go through a post-doctorate, given that participation to a post-doc is assumed to be selective. As we are able to observe the wages earned by doctorates had they participated to a post-doctorate or not, we depart from standard Heckman two-step estimator and opt for a treatment effect model (Barnow *et al.*, (1981); Woolridge, 2002).

Following the estimation of a treatment effect model, we go further in estimating a bivariate selection rule, trying to control for selection bias from post-doctoral participation and private orientation. Actually, according to the model of doctorates circulation we have in mind, we suspect that turning to the private sector after the thesis is negatively correlated to post-doctoral participation, as post-doctoral positions might be more suited to embarkment in a public career.

[1] Exception should be made for France, where *Grandes Ecoles* is still considered as the main way of producing elites.

[2] More detailed segmentation undoubtedly take place according to reputation effects of labs, universities etc.

Data are presented in section 2, a treatment effect model is addressed in section 3, whereas section 4 consists of the estimation of a wage equation with bivariate probit selection rule in order to control for public / private choice on the job market. The final section concludes.

2. Data

The outcome of participation to a post-doctoral program on earnings in private jobs is examined by estimating the previous treatment model for young PhD awarded during the year 1996 and surveyed in 1999 in France[3]. The sample -1744 young people- is nationally representative of French PhD awarded in 1996 in exact sciences, human and social sciences. Among the 1744 young PhD, 844 obtained a job in the private sector, nearly 50% of the sample, whom 685 graduated in exact sciences. The main advantage of this database is to provide information on participation to post-doctoral program, which is in itself a very scarce information. More than a quarter of young PhD had attended a post-doctoral program (about an half for natural and life sciences PhD, see table 1) and 20% of them had a job in the private sector afterwards. As post-doctoral positions seems to be radically different whether field of graduation (exact sciences or human and social sciences), our empirical test is restricted to PhD in exact sciences. Furthermore, the latter are more often recruited in the private sector than graduated in human and social sciences who, for the most part, still enter the public sector.

Table 1 – Proportion of post-doctorate, by fields of education

N=1744	% fields	% post-doctorate at least one time on 3 years	% post-doctorate at least one time on 3 years, except those still in post-doctoral position at the time of the survey
Mathematics, physics	16%	18%	20%
Mechanic, engineering sciences, computing	19%	11%	13%
Chemical	13%	18%	22%
Natural sciences	25%	45%	34%
Law, economics, management	13%	4%	6%
Human sciences	14%	4%	5%
Total	100%	27%	19%

[3] This longitudinal survey has been carried out by the Centre for Research on Qualifications (French Ministry of Education).

The database is longitudinal so that we have at our disposal the monthly position on the labour market of PhD graduates during three years after graduation. In addition, a detailed description of the first and last job is collected in the survey (wage, status, size of the company, occupation…). Information on participation to post-doctoral position consists of a question asked to graduates (yes/no) but no more precise details are available. We are also forced to treat post-doc positions as homogeneous even if we suspect heterogeneity in their forms (post-doc abroad or not, granting support, reputation of the lab…). Most of the PhDs who participated to a post-doc did it at the very beginning of the career (Table 1). Nevertheless, nearly 7% of the entire sample is still in post-doc at time of the survey, so that the assessment conducted here is restricted to those who come to an end of the post-doc.

Another part of the information collected concerns doctoral training in itself and is supposed to strongly influenced the early careers of PhD: time to degree, type of financial support (private, public…), training in a company, PhD completed after graduation in a *Grandes Ecoles* (engineers diplomas). Some papers in the literature on French doctorates have shown that doctorates already graduated from *Grandes Ecoles* have very similar professional destinations as engineers without doctorate diploma (Beltramo *et al.*, 2001).

3. A treatment effect model to assess post-doctoral participation

The econometrical measure of participation to a program has been widely studied in a literature confronted by selection effect (Maddala, 1985; Heckman and Robb, 1985; Woolridge, 2002). The main difficulty is that only individuals who have been enrolled in a program are observed. Thus, we ignore what would happen to these individuals had they not participated to this program. Furthermore, the decision to participate to a post-doctoral program is certainly not random and we can easily assume that there are selection effects related to unobserved characteristics.

The model used in that paper, first presented by Barnow, Cain and Goldberger (1981) is useful to estimate the effect of an endogenous variable, z_j, on a continuous variable, y_j, precisely the earnings three years after PhD award, conditionally to independent variables, x_j :

$$y_j = x_j\beta + \delta z_j + \varepsilon_j \qquad [1]$$

where z_j is a binary endogenous variable indicative of post-doctoral program.

Assuming that participation to a post-doctoral program is a fully random process, an estimation of [1] could be done with standard methods (Ols). However, stating that participation to a post-doctoral program is a non random process and that the selection effect produces a bias when estimating parameters by Ols, we need to estimate a selection model in which we could obtain the

structural effect of post-doctoral program. By that way, the estimation strategy proposed by Barnow, Cain and Goldberger is fully convenient.
The binary variable z_j is modelled as the outcome of an unobservable latent variable z^*_j, so that:

$$z_j^* = w_j\gamma + u_j \qquad [2]$$

where w_j is a vector of exogenous variables and u_j is an error term.

The participation to a post-doctoral program is the outcome of the following variable :

$$z_j = \begin{cases} 1, \text{ if } & z_j^* > 0 \\ 0, \text{ if } & z_j^* \leq 0 \end{cases} \qquad [3]$$

A selection bias arises since $E\left(z_j\ \varepsilon_j \middle| w_j\right) \neq 0$ or $E\left(\varepsilon_j\ u_j\right) \neq 0$, that means the error terms of the principal equation and that of the selection equation are correlated (Moffit, 1995). So that we assume that the error terms of the equations [1] and [2] have a bivariate Normal distribution with mean 0 and covariance matrix $\begin{bmatrix} s & r \\ r & 1 \end{bmatrix}$.

Given this assumption and with the aid of [1] and [3] we derive the wage expectation conditional to the participation to the post-doctoral program :

$$E\left[\, y_j \middle| z_j = 1\right] = x_j\beta + \delta z_j + E\left[\varepsilon_j \middle| z_j = 1\right] \qquad [4]$$

From a generally point of view :

$$E\left[\, y_j \middle| z_j\right] = x_j\beta + \delta z_j + \lambda h_j \qquad [5]$$

with the hazard h_j constructed as follows :

$$h_j = \begin{cases} \phi\left(w_j\hat{\gamma}\right) / \Phi\left(w_j\hat{\gamma}\right) & z_j = 1 \\ -\phi\left(w_j\hat{\gamma}\right) / \left(1 - \Phi\left(w_j\hat{\gamma}\right)\right) & z_j = 0 \end{cases} \qquad [6]$$

Finally, it is very useful to derive the estimation of wage expectations differences conditional to participation or not to a post-doctoral program (Greene, 2000):

$$E\left[y_j \middle| z_j = 1\right] - E\left[y_j \middle| z_j = 0\right] = \delta + \lambda \left[\frac{\phi(w_j\hat{\gamma})}{\Phi(w_j\hat{\gamma})\ \left\{1 - \Phi(w_j\hat{\gamma})\right\}}\right] \qquad [7]$$

The λ parameter measures the selection effect, obtained from a two-step estimation of [5]. Another interpretation is that the model is augmented by a regressor h_j which is the conditional expectation to the participation to a post-doctoral program.

Given equation [5] we can see that since $\lambda = 0$, the estimation of δ is corrected from the selection bias and is no more affected by the correlation of the unobserved terms. In presence of $\lambda > 0$, and if we do not control for the endogenous character of the post-doctoral variable, the δ parameter is underestimated. Conversely, in the case of $\lambda < 0$, the endogenous variable is overestimated, so that the unobserved in the both equations go in the same way. If the unobserved have a positive effect on participation to a post-doctoral program and if the same unobserved have a positive effect on getting highly paid jobs, we can intuitively conclude that the outcome of participation to a post-doctoral program is overestimated.

The treatment effect model could also be expressed in terms of human capital and signalling theory. In this econometric framework, the δ parameter captures the human capital accumulation effect and the λ parameter is the outcome of non random selectivity, coming up from correlation of unobserved terms. It is commonly agreed that participation to post-doctoral program is related to particular characteristics, nevertheless, in the human capital theory these characteristics are fully unobserved, whereas in the signalling framework the participation to a program is partially founded on existing signals. In the modelling, the selectivity is broken up between human capital accumulation (specific or general) and productivity signalling. In the case of no selection effect and insignificant δ, the human capital accumulated during the post-doctoral experience is not transferable to the firm.

Most of the doctorates received a financial support for their doctoral training (4% received no support, see table 4 in Appendix). This pattern is very specific to graduated in exact sciences as far as in human and social sciences one PhD on two benefits from a funding. Actually, in exact sciences, private supports are more developed, based on cooperation between the French Ministry of Research and companies (*Cifre* financial support); in our sample, nearly one PhD on three received a grant from private funding, without real strong differences between fields of education, although fields like natural sciences, mechanics, engineering sciences or computer sciences find more easily applications in industrial research.

Coming to the estimation of the treatment effect model, the variables displayed in table 2 have been computed and introduced in the econometric modelling. Some of them are used in the wage equation and in the Probit estimation. In the concern of identification, some are used only for the wage equation and some are strictly used for the Probit equation.

Below, table 2 reports estimates firstly of the wage equation without controlling for selection bias and secondly the treatment effect model (including the Probit estimation of going through a post-doctoral position).

Selectivity in the participation to a post-doctoral program

Estimates coming from Probit estimation of post-doc equation reveals the existence of selectivity in gaining a post-doc after a Phd. It would be necessary before to come back on the different dimensions that are supposed to influence the probability to participate to a post-doc. As stated in the introduction, post-doctoral positions are theoretically considered as academic waiting time jobs for young doctor who are planning an academic career. This way, and as we do not know the professional plan of the PhDs, the financial support could be a good indicator of it. In the same manner, remember that academic recruitments are organised yearly and that we should expect a seasonal effect on the probability to participate to a post-doc program: the more the time of defence is far from recruitment period, the more they have chance to plan to go through a post-doc. We also introduce a quarter dummy (SEASON) in the model to test this seasonal effect.
After estimation, it appears that five categories of exogenous variables affect the probability of participation to a post-doc. They are related to field of education, financial support, age at time of graduation, place of doctoral training and seasonal dummies.

Traditionally, doctorates in life science or in chemistry often take post-doc positions at the very beginning of their career, more than PhD in mathematics, mechanics, engineering sciences or computer sciences. The labour market of PhD gives the impression of being quite different depending on the field of education. Whereas doctorates in mechanics, engineering sciences or computer sciences are more attracted to the private sector than the public sector of research, they are also less attracted to post-doctoral positions after the PhD thesis. In chemistry or in natural and life sciences, post-doc are more heterogeneous, being post-doc supported jobs, fixed-term contracts in firms or in national labs (Verdier *et al.*, 2001) so that this status has a weakened meaning in terms of selectivity.

Table 2 – Ols estimates and treatment effect model

685 obs.	**Ols Estimates**	**Treatment model**

			Estimates	
Ln Wage equation	**Coefficient**	**Std-error**	**Coefficient**	**Std-error**
CONSTANT	7.612***	.0689	7.613***	.0729
FIELD				
Mathematics	-0.069**	0.033	-0.073**	0.036
Chemistry	-0.038	0.033	-0.019	0.039
Natural sciences	-0.079**	0.038	-0.067*	0.035
Mechanics	-	-	-	-
ENGINEER	0.054	0.035	0.048	0.032
FINANCIAL SUPPORT				
private	-0.022	0.036	-0.027	-0.077
TRAINING	0.656*	0.038	0.055	0.035
POSTDOC	0.068**	0.035	-0.074	0.134
TIME	-0.0009	0.001	-0.001	0.001
SENIORITY	0.004*	0.002	0.004**	0.002
SENIORITY2	-0.00002	0.00002	-0.00002	0.00002
RESEARCHER	0.025	0.029	0.025	0.027
SIZE				
<50	-	-	-	-
[50;200[	0.037	0.040	0.039	0.037
[200;500[	0.076*	0.046	0.080**	0.039
≥500	0.085***	0.032	0.089***	0.032
UNEMPLOYMENT	-0.034*	0.017	-0.031*	0.017
Postdoc equation			**Treatment estimates (Probit estimates)**	
CONSTANT	-	-	0.833	0.999
FIELD				
Mathematics	-	-	-0.209	0.199
Chemistry	-	-	0.506***	0.177
Natural sciences	-	-	0.352**	0.173
Mechanics	-	-	-	-
ENGINEER	-	-	-0.172	0.178
FINANCIAL SUPPORT				
private	-	-	-0.075	0.173
public	-	-	0.321**	0.143
no support	-	-	-0.130	0.369
TIME	-	-	-0.0002	0.0064
AGE	-	-	-0.073**	0.037
MALE	-	-	-0.179	0.126
PLACE				
University	-	-	-	-
Company	-	-	-0.497**	0.219
laboratory	-	-	0.320**	0.133
SEASON				
1st quarter	-	-	0.166	0.170
2nd quarter	-	-	0.147	0.160
3rd quarter	-	-	0.389**	0.168
4th quarter	-	-	-	-
SELECTION PARAMETER	-	-	0.085	0.77
Implementation of equation [7]	-	-	[7.641]-[7.635]=0.006	-

Note : *** 1%, ** 5%, * 10% levels of significance. F(15,669)=8.81 for Ols estimates. Wald-X^2(21 df)=95.6 for treatment effect model.
The treatment effect model is estimated in full information.

On the opposite, financial support and place of doctoral training are both signals of high selectivity on access to post-doctoral positions. Doctorates benefiting from public grants (financial support from Ministry of Research) take part more probably in a post-doc experience than those having a private funding. This strengthens our assumption that post-doctoral positions are waiting time positions for academic jobs, so that PhDs who have not been recruited in the research public sector could certainly take less advantage of their post-doctoral experience. On another hand, the probability to go through a post-doc when doctoral training took place in a company is lower, whereas the is no significant effect of the private funding on the probability to go through.

Place and time are both exogenous dimensions that change the probability of participation. Depending on the time of graduation, enrolment in post-doc position is slightly higher. We can notice that distribution of defences is strongly seasonal: defences are more frequent at the end of the year civil (third and forth quarter) due to the organisation of academic recruitments. Estimates produce a significant seasonal effect which displays a diary effect. Those who defend their PhD thesis early (3rd quarter) comparatively to the usual period of defence (4th quarter) are more likely designed for waiting time positions, in this case post-doctoral positions.

Male and female have the same probability to participate to a post-doc program, whereas age is a decreasing factor for the participation. We can easily assume that as post-doc often take place abroad, mobility is discouraged for a period of time quite long (usually one year long or more); this result was already put in evidence by Cahuzac and Robin (2003).

Unexpectedly, time to graduation seems to have no effect on the probability to take a post-doc job. Nevertheless, time to graduation could be seen as a potential signal of quality (shorter thesis are assumed to be better) or a human capital effect when doctorates apply for a post-doc supposed to be selective. Following the knowledge theories, during their PhD, doctorates produce knowledge and circulates it (Mangematin and Robin, 2003). Doctorates produce knowledge in the form of scientific papers, industrial cooperation, contribution to patents and circulate it mainly after they have been awarded their doctorate. Also, the more the time to graduation is long, the more the time of production is extended too and the effect of TIME variable should be significant. This is simply due to the fact that AGE partially capture this quality effect. The younger, that is those whom time to graduation is shorter, are more probably selected for post-doc participation.

As we seen in this section, several elements invite us to conclude that participation to post-doctoral programs are highly selective. We then expect that the outcome of participation to a post-doc would be overestimated if selection effect is not controlled for. This is the main finding of the next section.

A spurious positive effect of post-doctoral program on wages

The coefficient of the participation to post-doctoral program is no more significant on earnings in private jobs as soon as we control for the endogenous status of post-doc variable. However, without controlling for selection bias of post-doc variable, OLS estimates yield a positive wage return gained from this experience.

We could conclude that there is no wage premium gained from this experience. Moreover, the estimate of selection parameter is positively signed, although not significant. An implementation of [7] yields the net wage premium potentially gained for young people having participated to post-doctoral program and reveals that the wage differential expectation is close to zero (0.006). This main result suggests that, conditionally to regressors included, there is no direct effect of participation to post-doctorate program. In that way, it does not produce transferable human capital but creates either positive signal, differentiating doctorates.

Two of the variables that could explain the internal differentiation lie on time to degree (TIME) and financial support (FINANCIAL SUPPORT), as time to degree could represent a factor of human capital and financial support acts for a signal. Neither of these two key variables are statistically significant, almost certainly already included by POSTDOC effect (that means indirectly by the selection equation).

Signals yielded by unemployment are also noticeably actives: each unemployment period induces a relative wage loss from approximately 3%. Although few PhDs are frequently unemployed, these young people highly qualified undergo the negative effect of unemployment, since at the same time they have difficulties to get value from their post-doctoral experience, in the sense that the POSTDOC coefficient is insignificant.

At last, young PhDs who have been recruited as researcher in the private sector do not take advantage from wages higher when they went through post-doctoral program, whereas, at the same time, return from seniority is slightly significant. Whereas the knowledge theory paves the way for a valuable doctorate in the R&D sector, being able to solve complex problems, to define problem, to play the role of a gatekeeper, allowing for knowledge translation and absorption, force is to note that this model of knowledge do not fit with wage returns.
This is corroborated by the insignificant ENGINEER coefficient, while co-construction of competencies would be expected to be valued on the private part of the labour market[4]. This is finally also not surprising that wages expectation are lower in small productive units, as a part of R&D activity is externalised more and more frequently.

[4] This result have been also noticed on a recent study using another longitudinal database on early-stage career of doctorates.
Giret J.F., Perret C., Recotillet I. (2003) "Les jeunes scientifiques dans le secteur privé: quel rendement de la formation doctorale" in "Mondialisation et régulation sociale", Tome 2, L'Harmattan eds., pp.841-854.

As post-doctoral program and jobs as researchers in the R&D activity sector do not provide significant premium wage, we could presume that these scientists "pay" to be scientists, as Stern underlined in a recent paper (Stern, 1999), in an increased way for doctorates graduated in mathematics or natural sciences, compared to those graduates in mechanics or engineering sciences.

4. A sample selection model based on a Bivariate selection rule

From the beginning of the paper, we sustained that post-doctoral programs are mainly designated to academic research careers. As data on doctorates destination indicate, a unimportant part of them turns to private job after their post-doctorate job. In the model estimated in the previous section, we did not take into account the possible selection bias that occurs when including only doctorates in private job at time of the survey. We may nevertheless suspect that some unobserved terms are common in the determination of post-doctoral participation and job destination (public or private). The model proposed in this section attempts to control for this selection bias using a bivariate selection rule.

Equation [1] becomes :

$$y_j = x_j \beta + \varepsilon_j \qquad [8]$$

to which we add the bivariate latent processus:

$$\begin{aligned} z^*_{priv} &= b'_{priv} x_{priv} + u_{priv} \\ z^*_{post} &= b'_{post} x_{post} + u_{post} \end{aligned} \qquad [9]$$

with $z_j = 1 \quad if \quad z > 0, 0 \text{ otherwise for } j = priv, post$

To account for selection bias, we assume that e, u_{priv}, u_{post} are correlated. This implies that the errors terms of [8] and [9] are distributed following a trivariate normal distribution whom one only knows the variance (σ^2, 1, 1). Inverse mills ratio from bivariate probit estimation are hold from a first step estimation and are then included in the wage equation. The corrected sample selection model is by the way:

$$E\left[y \middle| z_{priv} = 1, z_{post} = 1\right] = xb + a_1 l_1 + a_2 l_2 \qquad [10]$$

The corrective terms; namely λ_1 and λ_2 are determined as follows:

$$l_1 = \frac{f(-b'_{priv}\, x_{priv})\Phi\left[(-b'_{post}\, x_{post} - r\, x_{post}) / \sqrt{(1-r^2)}\right]}{\Phi_2}$$

$$l_2 = \frac{f(-b'_{post}\, x_{post})\Phi\left[(-b'_{priv}\, x_{priv} - r\, x_{priv}) / \sqrt{(1-r^2)}\right]}{\Phi_1}$$

with ϕ the density and Φ the cumulative of a normal distribution and ρ the estimated correlation parameter from [9]

The model is implemented on the full sample of doctorates employed in a private firm or in the public sector at time of the survey. Estimations are reported in table 3 (below) and descriptive statistics of the variables can be found in table 5 (Appendix). The sample size is then 1,264 individuals for which we give details in the table 3 (685 are in the private sector in march 1999 and 284 participated to a post-doctoral program). The same regressors as in the previous section are included in the post-doc equation. In the second equation, that explaining the fact that doctorates have been recruited in the private sector information on thesis has been introduced: field of education, type of financial support, training in a firm and time to graduation. The underlying assumption is that the more links are established within firms during the thesis, the more doctorates are attracted to the private sector (Beltramo *et al.*, 2001).We also include a regional information on density of researchers in the private sphere, expecting that in labour markets with a high density of researchers in firms, attraction to the private sector is greater.

A selection effect based on public / private job type

What we observe first from the bivariate selection rule is a negative correlation between the two equations 'being in the private sector" and "going through a post-doctoral job", meaning that unobservable terms from the private job equation are negatively link to those of the post-doctoral job equation. As far as unobservable that have a positive effect on recruitment in the private sector have a negative impact on participation to a post-doctoral program, we might infer that selection criteria are based on different element on one hand in the private sector and on the other hand in the participation to a program. This finding strengthen the hypothesis that post-doctoral program is more related to public career whom selection rules are rather different, as academic rules (publications for instance) are often opposed to private criteria.

Table 3 – Ols Estimates and bivariate selection rule

1264 obs.	**Ols Estimates**		**Selection model**	
Ln Wage equation	**Coefficient**	**Std-error**	**Coefficient**	**Std-error**
CONSTANT	7.4251***	0.0328	7.6259***	0.4199
MALE	0.1245***	0.0187	0.1535**	0.0670
FIELD				
Mathematics	-0.0127	0.0242	-0.1820	0.1326
Chemistry	-0.0175	0.0251	0.0096	0.1393
Natural sciences	-0.0422*	0.0233	-0.0779	0.1327
Mechanics	-	-	-	-
ENGINEER	0.0606***	0.0235	-0.0279	0.1087
FINANCIAL SUPPORT				
Private	0.0021	0.0233	0.0393	0.2019
Public	-0.0624***	0.0204	-0.2078**	0.0917
No support	-	-	-	-
POSTDOC	-0.0006	0.0207	-	-
TIME GE 4	-0.0136	0.0209	0.1358*	0.0811
SENIORITY	0.0025***	0.0005	0.0008	0.0041
RESEARCHER	0.0007	0.0253	-0.0416	0.1588
SIZE				
<50	-	-	-	-
[50;200[	0.0122	0.0278	0.01630	0.1066
[200;500[	0.0453*	0.0248	0.0178	0.1156
≥500	0.0966***	0.0203	0.0467	0.0835
PRIVATE SECTOR	0.1286***	0.0255	-	-
Selection parameters				
λ1	-	-	0.3064	0.3902
λ2	-	-	-0.1727	0.1841
Bivariate selection rule				
Postdoc equation				
FIELD				
Mathematics	-	-	0.2756**	0.1314
Chemistry	-	-	0.6722***	0.1372
Natural sciences	-	-	0.4980***	0.1204
Mechanics	-	-	-	-
ENGINEER	-	-	-0.0386	0.1226
FINANCIAL SUPPORT				
private	-	-	-0.2007	0.1403
public	-	-	0.2628***	0.0965
no support	-	-	-0.5362*	0.2954
other	-	-	-	-
TIME	-	-	-0.0033	0.0046
AGE	-	-	-0.0693***	0.0252
MALE	-	-	0.0940	0.0899
PLACE				
University	-	-	-	-
Company	-	-	-0.3873**	0.1814
laboratory	-	-	0.1465	0.0928
SEASON				
1st quarter	-	-	0.2252*	0.1169
2nd quarter	-	-	0.2597**	0.1104
3rd quarter	-	-	0.3398***	0.1181
4th quarter	-	-	-	-
Private equation				
MALE	-	-	-0.0464	0.0796
FIELD				
Mathematics	-	-	-0.1700	0.1098
Chemistry	-	-	0.2794**	0.1177
Natural sciences	-	-	-0.2142**	0.1038
Mechanics	-	-	-	-
ENGINEER	-	-	-0.1314	0.1020
FINANCIAL SUPPORT				

Private	-	-	0.6696***	0.1276
Public	-	-	-0.0881	0.0860
No support	-	-	-0.0772	0.1892-
Other	-	-	-	-
TRAINING	-	-	0.3804***	0.1064
TIME	-	-	0.0035	0.0035
DENSITYRD	-	-	-0.0012	0.0034
Correlation parameter	-	-	-0.1342**	0.0524

Note : *** 1%, ** 5%, * 10% levels of significance. $F(14,1249)=15.66$ for Ols estimates. $X^2(df=15)=40.07$ for the selection model.

It partially appears in the FINANCIAL SUPPORT variable. Those who benefited from a private support are more probably attracted to the private sector while there is no effect in the participation equation. Also doctorates who where trained in a firm during their PhD have more chances to hold a job in the private sector. These elements support the hypothesis according to which intensity of relationship with firms is a strong factor explaining trajectories of doctorates. In addition, we remark that those who benefited from a public support attend more often a post-doctoral program, and that the effect in the other equation is insignificant.

It is important to notice that whether it concerns participation to a post-doctoral program or attraction to the private sector, the FIELD dummies have always a significant effect. Mainly, doctorates graduated in nature and life sciences are attracted to a public career, as far as estimated coefficient is negative in the first equation and positive in the participation to post-doctoral program. On the other hand, disciplines as mathematics or chemistry have different connections with participation and private trajectory: doctorates of the both disciplines more often go through post-doctoral positions and turn to the private sector afterwards. In the chemistry sector for instance, firms often use post-doctoral positions as temporary jobs (Lanciano and Nohara, 2002), deviating of post-doctoral program as a first step for an academic career.

A still insignificant effect of post-doctoral participation on wage

In the estimation of the wage equation when controlling for bivariate selection, the two parameters $\lambda1$ and $\lambda2$ measuring the selection effect become insignificantly different from zero, whereas the dummy variable PRIVE depart significantly from zero (in a positive way) in the uncorrected wage equation (Table 5). Finally, the POSTDOC variable are no more effect on wage: those who participated to a post-doctoral training do not benefit from their experience, when we controlled for unobservable explaining at the same time participation to a program and recruitment in the private sector. This model confirms our first finding in which POSTDOC did not significantly improved wage of participant.

However, time to graduation play a significant role on the wage earned, as far as time to graduation is greater than the average, that means, more than four years. Human capital accumulated during the thesis is then valued on the private sphere while post-doctoral participation does not, so that we could conclude that post-doctoral position yields an anti-screening device compared to the effect of PhD experience itself. This is reinforced indirectly by FINANCIAL SUPPORT effect: doctorates having had financial support from Ministry of Research -supposed to pursue an academic career and participating more often to post-doctoral programs- have wages lower than those having had other financial supports. Note also that a private support has no effect on wages, giving a larger weight to the negative effect of the aforementioned public support.

The variable indicating discipline of PhD dissertation (FIELD) are no more significant in the wage equation. Field of education play a huge effect in the determination of career choice (public/private) and also on the participation to post-doctoral program, nevertheless, when controlled for the selection effect of these two variables, academic discipline has no more effect, so that wage returns are similar across doctorates in the different fields of education.

These findings point out that the way the thesis is carried out have a strong impact at the same time on the participation to a post-doctoral position and to the position on the labour market in terms of sector, public or private, but that these effects disappear on wages as far as they are controlled for in the selection model.

Two factors remain durably significant on wages: TIME and FINANCIAL SUPPORT as we underlined before. Concerning variables related to job description, size of the company and seniority become insignificant as the bivariate selection rule is implemented – we compare here with the simple OLS model -. A robust finding is emerging in the estimation: jobs of researchers – RESEARCHER – have comparable wage levels as other functions in firms or public institutions. We emphasize again a result of the section 3 according to which there is no wage premium for doctorates working as researchers.

5. Conclusion

In this paper, we attempt to highlight a rather dark part of literature on doctorates first-stage careers concerning post-doctorates effect on job hold afterwards. In particular, this paper focus on post-doctorates who did not attend the public sector as it is however traditionally expected. More than a quarter of doctorates get through a post-doc and around 20% of them were attracted to the private sector afterwards. Using longitudinal data carried out by the French Ministry of Education on higher education graduates (graduated in 1996 and surveyed in 1999), we estimated first a treatment effect model in which the endogenous variable is participation to a post-doctoral program. Willing to control for the possible effect of type of orientation (public versus private) we estimated then a wage equation with bivariate selection rule.

The main finding of the treatment effect model is that when controlling for the endogenous nature of post-doctoral participation, the positive effect on wages disappear, leading to a insignificant effect of post-doctoral participation. This finding is largely consolidated with the bivariate selection rule. On one hand we observe a negative correlation of the unobservable between post-doctorate participation and private sector orientation, and on the other hand selection parameter relative to post-doctorate participation is insignificant. We might conclude that doctorates with post-doctorate experience do not find wage premium of their experience, invalidating in that way the traditional economic relation between education, experience and wage. In the model of labour market circulation we sketched, the transition from post-doctorate to private sector is then not valued. At a time when national research policies tend to improve fixed-term contracts on one hand and investment in private research on the other hand, our findings should minor the possible effect of such policies and should lead to improvements of doctoral training in order to better suits doctorates to the private sector. A promising direction could be international comparison, especially with the US labour market for doctorates, in which there are traditionally more exchanges between the academic and the private sphere.

Appendix

Table 4 –Regressors used in the treatment effect model, description and statistics

Name	Description	Mean (std-error)
WAGE	Wage earned in 1999 (€)	2250 (2260)
MALE	1 if male	0.61 (0.48)
POSTDOC	1 if participation to a post doctoral program	0.18 (0.39)
FIELD	1 if PhD in mathematics	0.20 (0.40)
	1 if PhD in mechanics engineering sciences	0.29 (0.45)
	1 if chemistry	0.22 (0.41)
	1 if natural sciences	0.29 (0.46)
ENGINEER	1 if graduated from an engineering school before	0.19 (0.39)
FINANCIAL SUPPORT	1 if private financial support for doctoral training	0.28 (0.44)
	1 if public financial support for doctoral training	0.34 (0.47)
	1 if other sources of financial support (job…)	0.34 (0.47)
	1 if no financial support	0.04 (0.19)
TRAINING	1 if training in a company during doctoral training	0.37 (0.48)
TIME	Time to doctorate graduation (in months)	42.93 (10.4)
SEASON	1 if graduation during the 1st quarter of 1996	0.19 (0.38)
	1 if graduation during the 2nd quarter of 1996	0.24 (0.41)
	1 if graduation during the 3rd quarter of 1996	0.17 (0.37)
	1 if graduation during the 4th quarter of 1996	0.40 (0.48)
AGE	Age at time of graduation (in 1996)	28.6 (1.9)
PLACE	1 if doctoral training in a university	0.49 (0.50)
	1 if doctoral training in a firm	0.20 (0.40)
	1 if doctoral training in a lab	0.28 (0.45)
RESEARCHER	1 if industrial researcher for the job held in 1999	0.03 (0.17)
SIZE	1 if size of the company < 50	0.21 (0.40)
	1 if size of the company between 50 and 200	0.14 (0.35)
	1 if size of the company between 200 and 500	0.14 (0.35)
	1 if size of the company ≥ 500	0.31 (0.46)
	1 if size missing	0.20 (0.41)
UNEMPLOYMENT	Number of unemployment spells between graduation and job held in 1999	0.69 (0.80)
SENIORITY	Number of months employed in a company for the job held in 1999	22.6 (16.3)
SENIORITY2	SENIORITY squared	778 (1534)

Table 5 - Regressors used in the sample selection model with bivariate selection rule, description and statistics

Name	Description	Full sample (obs=1264)	Private sector (obs=685)	Participation to a program (obs=284)
		Mean (std-error)	Mean (std-error)	Mean (std-error)
WAGE	Wage earned in 1999 (€)	2126.2 (1959)	2250 (2260)	2042.19 (2188.54)
MALE	1 if male	0.61 (0.49)	0.61 (0.48)	0.58 (0.49)
POSTDOC	1 if participation to a post doctoral program	0.22 (0.42)	0.18 (0.39)	1
FIELD	1 if PhD in mathematics	0.22 (0.42)	0.20 (0.40)	0.23 (0.42)
	1 if PhD in mechanics engineering sciences	0.26 (0.44)	0.29 (0.45)	0.14 (0.35)
	1 if chemistry	0.18 (0.38)	0.22 (0.41)	0.25 (0.43)
	1 if natural sciences	0.34 (0.47)	0.29 (0.46)	0.38 (0.49)
ENGINEER	1 if graduated from an engineering school before	0.18 (0.38)	0.19 (0.39)	0.15 (0.39)
FINANCIAL SUPPORT	1 if private financial support for doctoral training	0.19 (0.39)	0.28 (0.44)	0.11 (0.31)
	1 if public financial support for doctoral training	0.41 (0.49)	0.34 (0.47)	0.55 (0.49)
	1 if other sources of financial support (job…)	0.36 (0.48)	0.34 (0.47)	0.34 (0.48)
	1 if no financial support	0.04 (0.20)	0.04 (0.19)	0.01 (0.12)
TRAINING	1 if training in a company during doctoral training	0.27 (0.44)	0.37 (0.48)	0.12 (0.33)
TIME	Time to doctorate graduation (in months)	42.78 (10.87)	42.93 (10.4)	41.67 (9.07)
TIME4	Time to doctorate graduation over 4 years	0.23 (0.42)	0.24 (0.43)	0.22 (0.42)
SEASON	1 if graduation during the 1st quarter of 1996	0.19 (0.39)	0.19 (0.38)	0.20 (0.40)
	1 if graduation during the 2nd quarter of 1996	0.22 (0.41)	0.24 (0.41)	0.24 (0.43)
	1 if graduation during the 3rd quarter of 1996	0.15 (0.36)	0.17 (0.37)	0.20 (0.39)
	1 if graduation during the 4th quarter of 1996	0.40 (0.49)	0.40 (0.48)	0.36 (0.48)
AGE	Age at time of graduation (in 1996)	28.6 (2.0)	28.6 (1.9)	28.18 (1.75)
PLACE	1 if doctoral training in a university	0.52 (0.49)	0.49 (0.50)	0.58 (0.49)
	1 if doctoral training in a firm	0.12 (0.32)	0.20 (0.40)	0.04 (0.19)
	1 if doctoral training in a lab	0.32 (0.46)	0.28 (0.45)	0.38 (0.48)
RESEARCHER	1 if researcher for the job held in 1999	0.42 (0.49)	0.03 (0.17)	0.55 (0.49)
SIZE	1 if size of the company < 50	0.16 (0.36)	0.21 (0.40)	0.14 (0.35)
	1 if size of the company between 50 and 200	0.16 (0.37)	0.14 (0.35)	0.16 (0.37)
	1 if size of the company between 200 and 500	0.14 (0.35)	0.14 (0.35)	0.13 (0.39)
	1 if size of the company ≥ 500	0.35 (0.48)	0.31 (0.46)	0.35 (0.48)
	1 if size missing	0.17 (0.38)	0.20 (0.41)	0.22 (0.41)
SENIORITY	Number of months employed in a company for the job held in 1999	21.92 (19.07)	22.6 (16.3)	12.53 (9.3)
DENSITYRD	Density of private researchers for 10,000 habitants by region	17.21 (10.68)	17.11 (10.18)	17.57 (11.52)

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