

# Measurement of University Effectiveness through a Multilevel Model<sup>1</sup>

*Misura dell'Efficacia Universitaria attraverso un Modello Multilivello*

Silvia Bacci

Department of Statistics "G. Parenti", University of Florence,

e-mail: [s.bacci@ds.unifi.it](mailto:s.bacci@ds.unifi.it)

**Riassunto:** Oggetto del contributo è l'analisi, attraverso un modello di regressione multilivello, di uno degli elementi che concorrono a definire l'efficacia della formazione universitaria: vale a dire il grado d'impiego sul luogo di lavoro delle competenze acquisite durante il corso di studi da parte dei neo-laureati dell'Ateneo fiorentino.

**Keywords:** university effectiveness, university-learned skills, multilevel models, ordered logistic regression.

## 1. Introduction

A way to evaluate the quality of the formative services offered by universities is to measure them in terms of internal and external efficiency and effectiveness. In particular, when one talks about external effectiveness, he or she is referring to the "capacity" that the university qualification has for meeting requirements coming from the working world. As indicators of this capacity, we can use, for example, the neo-employment rate, the period of time after obtaining the degree until the moment of entry into the working world, the real usefulness of the qualification for development of the job, the use in the work place of the skills acquired at university by employed graduates, and so forth.

In this paper, attention is focused on the use of the skills acquired at university in the work place, with the aim of identifying possible determinants of the studied phenomenon taking into account the different capacities of each degree course to create skills consistent with the requirements of the working world.

## 2. A two-level ordered logistic regression model

In order to identify the possible determinants of the phenomenon studied and to measure their net effect, a multilevel ordered logistic regression model (Goldstein, 2003; Fielding, Yang & Goldstein, 2003; Hedeker, 2004) was applied. In it, the outcome variable,  $Y = \textit{degree of use in the work place of the skills acquired at university}$ , is an

---

<sup>1</sup> The present paper is financially supported within the PRIN 2002, co-financed by the MIUR "Transizioni Università-lavoro e valorizzazione delle competenze professionali dei laureati: modelli e metodi di analisi multidimensionali delle determinanti". The national coordinator is L. Fabbris; coordinator of the Florence group is B. Chiandotto (project title of the local research unity is "Valutazione del processo formativo universitario, sbocchi professionali e pianificazione dei percorsi formativi: modelli e metodi").

ordered categorical variable with three possible categories: considerably ( $Y=1$ ), a little ( $Y=2$ ), not at all ( $Y=3$ ).

The choice of the multilevel approach was suggested by the hierarchical structure of the analysed data<sup>2</sup>: the first-level units are represented by the 2882 graduates of the University of Florence during the year 2000 who had a job at the moment of the interview, while the second-level units are formed by the 39 degree courses over which this contingent was spread.

The two-level random coefficient regression model, built in terms of *cumulative logit*, has the following structure:

$$\left\{ \begin{array}{l} \log\left(\frac{P_{23ij}}{P_{1ij}}\right) = \log\left(\frac{P(Y_{ij} > 1)}{P(Y_{ij} \leq 1)}\right) = \text{intercept} + \sum_{k=1}^m \beta_{kj} \cdot x_{kij} + U_{0j} \\ \log\left(\frac{P_{3ij}}{P_{12ij}}\right) = \log\left(\frac{P(Y_{ij} > 2)}{P(Y_{ij} \leq 2)}\right) = \text{intercept} - \text{threshold} + \sum_{k=1}^m \beta_{kj} \cdot x_{kij} + U_{0j} \end{array} \right.$$

where:  $j$  indicates a generic degree course,  $i$  indicates a generic graduate coming from the course  $j$ ,  $x_{k.}$  is the  $k$ -th covariate,  $U_{0j}$  represents the second-level residuals,  $Pr(Y=1)=P_1$ ,  $Pr(Y=2)=P_2$ ,  $Pr(Y=3)=P_3$ ,  $P_1 + P_2 = P_{12}$  and  $P_2 + P_3 = P_{23}$ .

### 3. Estimate of the random intercept model

The model was fitted by adopting the maximum log-likelihood method, by means of the PROC NLMIXED procedure, from SAS-software, with the use of the Dual Quasi-Newton optimisation algorithm and adaptive Gaussian quadrature<sup>3</sup>.

As for the model selection strategy, it proceeded to a preliminary estimate of the empty model, in which the explanatory variables did not figure, and then to the selection of the first- and second-level covariates, as well as of possible quadratic terms and interaction effects. As first-level covariates, variables that indicated individual characteristics of the graduates and their work were used; the second-level covariates were built through aggregation (according to the degree course) of some first-level variables, so as to obtain explanatory quantities of the various characteristics of each course<sup>4</sup>.

<sup>2</sup> The data used were gathered by means of appropriate surveys on graduates and holders of a diploma in 2000 and ranging to about a year/two years and half after obtaining the degree or qualification. This approach was supported by the values assumed by statistics V of Cramer and Chi-square, equal to 23.60% and 299.32, respectively (with a p-value less than 0.0001), which highlight a strong association between use of the skills and the degree course in which the qualification was obtained. The qualifications to which a greater use of university-learned skills corresponds have a prevalently "technical" nature: that is, their purpose is to provide specific knowledge that can be directly used in particular work sectors, whereas the humanistic or non-specialised qualifications (such as Political science) have greater difficulty in finding an ad hoc job in the working world. For further details, see Chiandotto, Bacci, Bertaccini (2004).

<sup>3</sup> Having agreed that the "absolutely best" optimisation algorithm for estimating non linear hierarchical models does not exist, the choice of Dual Quasi-Newton was suggested by its capacity to create an appropriate balance between calculation speed and stability.

<sup>4</sup> One variable at a time was included to select the model, beginning with the first-level covariates, continuing with the second-level covariates, and retaining only the significant variables. In every phase,

The final result was a two-level ordered logistic model with random intercept and with only first-level explanatory variables, as no random coefficient was found to be significant and no second-level covariate was selected. This last result can probably be attributed to the building process of the second-level covariates.

Table 1 shows the estimates of the regression coefficients, the intercept, the threshold and the second-level residual component, with their respective standard errors and results of the univariate Wald test (the significance level comprised is 10%). The second column shows the reference category for each discrete covariate (the category with the highest frequency), so that the point at which all the covariates have value 0 represents the value assumed by the response variable for "the basic individual", i.e. the individual with the most widespread characteristics. The last column of Table 1 shows the changes which the probability of making considerable use ( $P_1$ ) of university-learned skills undergoes with respect to the probability of using them a little or not at all ( $P_{23}$ ) in correspondence with a unitary increase in each explanatory variable:

$$\Delta\left(\frac{P_1}{P_{23}}\right) = \frac{\exp\left(\text{intercept} + \sum_{k \neq h} \beta_k x_{kij} + \beta_h x_{hij} + U_{0j}\right)}{\exp\left(\text{intercept} + \sum_{k \neq h} \beta_k x_{kij} + \beta_h (x_{hij} + 1) + U_{0j}\right)} = \exp(-\beta_h)$$

**Table 1: Random intercept model**

|                               | Reference category               | Estimate | Standard Error | t value | p-value | $\Delta(P_1/P_{23})$ |
|-------------------------------|----------------------------------|----------|----------------|---------|---------|----------------------|
| <b>FIXED EFFECT</b>           |                                  |          |                |         |         |                      |
| Intercept                     | --                               | 0.0863   | 0.9022         | 0.10    | 0.9243  | --                   |
| Threshold                     | --                               | 2.1287   | 0.0804         | 26.47   | <0.0001 | --                   |
| Male                          | Female                           | 0.1962   | 0.0948         | 2.07    | 0.0453  | 0.8218               |
| Self-employed worker          | Subordinate worker               | 0.5353   | 0.1552         | 3.45    | 0.0014  | 0.5855               |
| Post-degree training activity | No post-degree training activity | -0.2008  | 0.0888         | -2.26   | 0.0296  | 1.2224               |
| Manager or professional       | Employee or worker               | -0.7452  | 0.1460         | -5.11   | <0.0001 | 2.1069               |
| Useful qualification          | Compulsory qualification         | 1.0146   | 0.0994         | 10.20   | <0.0001 | 0.3625               |
| Useless qualification         | Compulsory qualification         | 3.1033   | 0.1726         | 17.98   | <0.0001 | 0.0449               |
| Sufficiently satisfied        | Very satisfied                   | 0.7012   | 0.0948         | 7.40    | <0.0001 | 0.4960               |
| Not very satisfied            | Very satisfied                   | 1.3428   | 0.1540         | 8.72    | <0.0001 | 0.2611               |
| Graduating marks              | -- (continuous variable)         | -0.0172  | 0.0086         | -2.01   | 0.0521  | 1.0174               |
| <b>RANDOM EFFECT</b>          |                                  |          |                |         |         |                      |
| St.Dev.(II level residual)    | --                               | 0.2904   | 0.06473        | 4.49    | <0.0001 |                      |

To complete the analysis, the odds ( $P_1/P_{23}$ ) for each degree course were computed, and a list of merit for the 39 degree courses was drawn up to explain the different capacities of each course to create skills and specialised knowledge that could be directly used in the work market (see Figure 1).

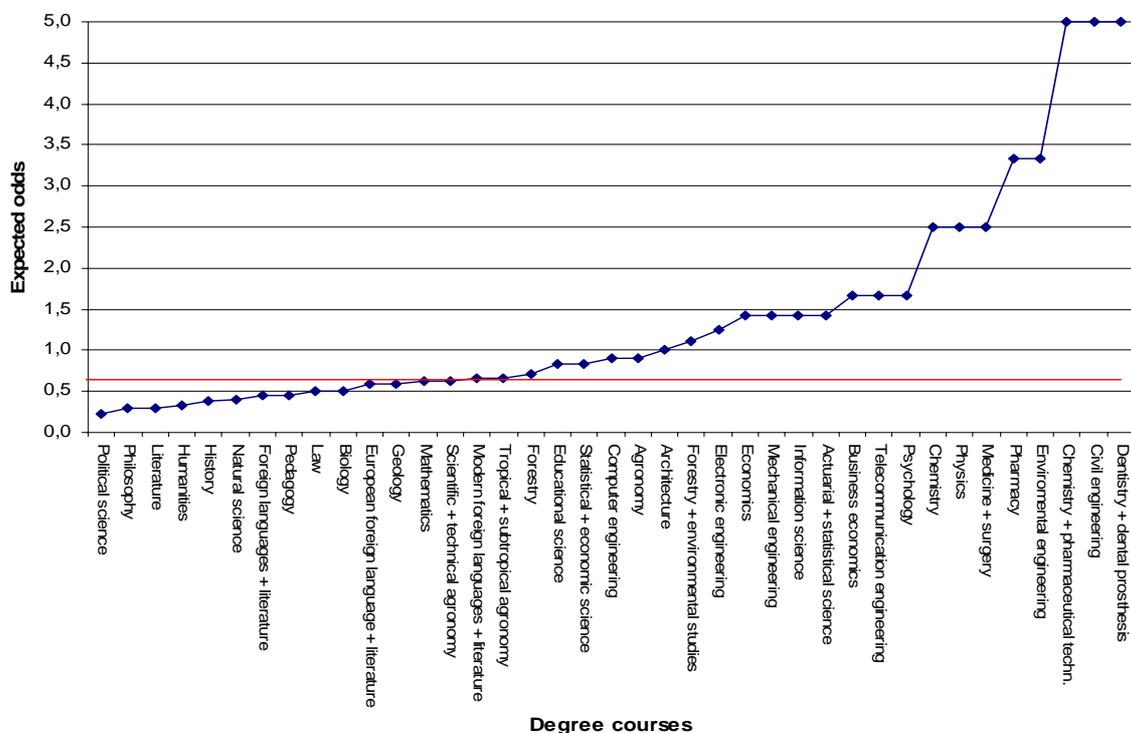
In conclusion, the analysis shows that the probability of considerable use of university-learned skills with respect to the probability of little use is greater: for females more than for males; for subordinate workers more than for self-employed workers; for those holding professional positions of greater responsibility compared to those who perform more menial tasks; for those who concluded at least some post-degree training activity.

the fitted model was evaluated on the basis of: i) univariate and multivariate Wald tests, for an assessment of the significance of each covariate, and ii) maximum likelihood ratio test and AIC and BIC statistics, for a comparison between the new model and the preceding ones. In the end, all the variables rejected during the previous phases were reinserted in the model so as to confirm their not having significance.

Furthermore, the higher this probability ratio is, the higher the graduating marks are, the more satisfied the graduate is about his job, and the more he/she thinks that his/her qualification is useful to the tasks required of him or her. No statistically significant influence was found to be exercised by several other variables relative both to the graduate's profile and the job characteristics .

As for the use of the skills learned, remarkable differences were registered between degree courses that belonged also to the same faculty. Lastly, the list of Figure 1 confirms the conclusions which were already reached during the descriptive analysis: the degree courses which offer skills most used on the job are Dentistry and dental prosthesis, Civil engineering, and Chemistry and pharmaceutical technology. On the contrary, the degree courses in which such a use was found to be much more limited are those of Political science, Philosophy, Literature, the Humanities and History.

**Figure 1:** *Expected odds for each degree course*



## References

- Chiandotto B., Bacci S., Bertaccini B. (2004), *I laureati e diplomati dell'Ateneo Fiorentino dell'anno 2000: profilo e sbocchi professionali*, Università degli Studi di Firenze, Firenze.
- Fielding A., Yang M., Goldstein H. (2003), Multilevel ordinal models for examination grades, *Statistical modelling*, vol. 3, n. 2: 127 - 153.
- Goldstein H. (2003), *Multilevel statistical models*, Arnold Publishers, London.
- Hedeker D. (2004), *Multilevel Models for Ordinal and Nominal Variables*, <http://tigger.uic.edu/~hedeker/ml.html>.