**2nd INTERNATIONAL SYMPOSIUM ON ECONOMIC THEORY, POLICY AND APPLICATIONS 6-7 AUGUST 2007, ATHENS, GREECE**

**MICROECONOMETRIC EVALUATION OF UNDERGRADUATE STUDENTS'
RESULTS A MATCHING METHODOLOGY APPLICATION TO A PORTUGUESE POLYTECHNIC**

Nunes, Alcina - Professor*        Fernandes, Paula - Professor*
( alcina@ipb.pt)                              (pof@ipb.pt)

* School of Technology and Management - Polytechnic Institute of Bragança, Campus de Sta Apolónia, Apartado 134, 5301-857 Bragança, Portugal. Phone: +351.273.313.050

## Abstract

During the academic years of 2004/05 and 2005/06 a new teaching methodology, inspired in the Bologna's Treaty, was implemented in one of the nine undergraduate programmes offered by the School of Technology and Management of *Bragança (Portugal).* The aim was to increase the positive results for the students, concerning the acquisition of knowledge and skills.

To expose one undergraduate programme to a treatment – this is the teaching methodology - without expose the others created the conditions to a process of microeconometric evaluation that aims to quantify the causal effect of the exposition to the treatment. Following the lessons of the evaluation literature, the present paper adopts a propensity score matching methodology choosing as the interest parameter the average treatment on the treated (ATT). To compare only what is comparable, the evaluation was carried out on those subjects that were common among all the undergraduate programmes, like mathematics or statistics, or subjects that were common among the undergraduate programmes in the management's scientific area, like accounting or marketing.

Results show a positive effect of the treatment on those students who had been exposed to the teaching philosophy in 2004/05. Indeed the treated students present a bigger percentage of positive results comparing with the non treated colleagues. However, the results in terms of the grades' quality are less obvious. Even if the treated students achieve a positive grade, this grade is often smaller than the grade achieved by the colleagues. Results for 2005/06 are not so clear.

## 1-Introduction

The 2004/05 academic year was characterized, in the School of Technology and Management of the Polytechnic Institute of *Bragança (ESTIG-IPB)*, by the implementation of the Bologna's Treaty in one of the nine undergraduate courses offered by the institution - the undergraduate course of *Informática de Gestão (IG)* which combines computer science and management. The changes in the course comprised not only a different structure but also a new teaching philosophy, namely at the methodological level, aiming to improve the positive results for the students. The main methodological changes included the compulsory obligation for students to participate in the classes, the continuous student's results evaluation and a more personal follow-up of the student. The methodology continued to be implemented only in that undergraduate programme in the 2005/06 academic year having been only extended to the remaining undergraduate courses two years after its introduction.

The authors intend to give their contribution to the discussion related to the teaching methodological methods. The discussion does not apply only to the institution where they work but also in the university system, in general. Therefore they present an impact microeconometric evaluation of the methodological changes in the results of those who where subject to them. The evaluation and the consequent outcome is the result of an objective assessment. It adopts a scientific methodology that allows us to conclude about the effectiveness of the introduction of a new teaching philosophy and offers the political makers a powerful analysis tool.

The introduction of a new teaching methodology – which in the future we will call treatment – to one undergraduate course leaving the others unchangeable creates the conditions to quantify the causal effect of the exposure to the treatment in the results.

Usually, the statistical methods applied to quantify the effects of an exposition to a treatment refer to statistical measures of association like the correlation coefficient between the treatment variable and the result variables. The association between two variables, however, does not always mean causality. Thus, we will apply an evaluation method suggested in the international literature of causal effects to empirically evaluate the impact of social programmes – the propensity score matching methodology. This methodology is very intuitive. It is a technique that for the elements in the group of treatment elements in the group not subject to the treatment, with the same observable characteristics, will be found. The matched elements will present only one difference – the participation on the treatment – so, the difference between their results can be caused by the treatment.

The majority of the observable characteristics for the students in the different undergraduate courses offered by *ESTiG-IPB* are administrative data, registered by the institution's information system and made available for the present evaluation. Other characteristics, personal and not objective, could be only obtained by questionnaire which was impossible to apply since this is an *ex-post* evaluation process.

Each academic year was evaluated independently. It aim to confirm, or not, the results obtained. For the 2004/05 academic year we found positive results in terms of approval rates especially when undergraduate courses in the neighbourhood of the scientific are analysed. However the same positive results were difficult to find when the quality of the approval rates where analysed. The treated students presented, on average, positive classifications lower than the ones obtained by their non treated colleagues. One year after the introduction of the teaching methodology the results are not as good. They are however positive, in general, and the quality of the positive results seemed to improve.

The present work is divided as follows. In the next section the econometric methodology will be presented and explained. The empirical application of the econometric methodology, to the problem under evaluation, is presented in section 3. Section 4, concludes.


## 2. The evaluation problem and the matching solution

### 2.1 – The evaluation problem

The evaluation problem of social programmes has been widely publicised and it is generally presented as a missing data problem. It can be formalized in a simple way. At a given moment in time, one student is in one of two potential situations (D), each one of them gives rise to a result (Y): in situation 1, the student participates in the treatment; in situation 0 he does not participate. The result of this formulation is presented in the Rubin Model:

$$Y = DY_1 + (1 - D)Y_0 \qquad (1)$$

So it makes sense to associate both the results and think of their difference as the impact of the programme participation on the student, that is, the causal effect of the programme participation on him is given by the expression:

$$\Delta = Y_1 - Y_0 \qquad (2)$$

The evaluation problem arises because for a particular student, in a particular moment in time, it is impossible to observe his participation in the treatment (D=1) and, at the same time, his non-participation (D=0). The individual either participates in the programme under evaluation or not! This means that only one of the results is observed giving rise to the evaluation problem in social policies. It is not possible to know the causal effect of a programme for a given individual because there is no opposite evidence (the counterfactual corresponding to what would have happened in the absence of treatment). The estimation of a treatment effect relies on the artificial construction of the counterfactual result. This means the inference of a potential result that would have been observed if the individual had not been treated (Rubin, 1974; Rosenbaum & Rubin, 1983).

To understand the impact of the introduction of a new teaching philosophy, on the probability of those who had been treated, one needs to infer about the same probability if they had not participated. So, like in several other international research works, the interest parameter is the average treatment

effect on the treated (ATT). This parameter estimates the average impact among those participating in the programme under evaluation:

$$\Delta P \equiv E(\Delta|D=1) = E(Y_1 - Y_0|D=1) = E(Y_1|D=1) - E(Y_0|D=1) \qquad (3)$$

## 2.2. The matching method

The matching method has been extensively refined in the most recent evaluation literature. It became now a valuable tool in empirical methodology, namely in non-experimental evaluations. The method is intuitively appealing. A student who participates in the programme is matched with a non-participant student who presents the same observational characteristics, so the difference between their results could be attributed to the programme Deheija & Wahba (2002). However, in a non-experimental evaluation the matching process could be a complex one due to selection problems that could bias the results. Therefore the matching process must rest on strong assumptions. One of these assumptions of identification is the Conditional Independence Assumption (CIA) that assumes that treatment assignment (D), conditional on observables (X), is independent of the potential results (Y). In formal notation the assumption corresponds to:

$$(Y_1, Y_0) \perp D|X \qquad (4)$$

Under the CIA, the treatment and comparison groups are comparable, on average, when conditioning on X.

$$E(Y_1|D=1, X) = E(Y_0|D=0, X) = E(Y_0|X) \qquad (5)$$

A practical implementation problem arises when the vector X is highly dimensional and contains continuous variables. But Rosenbaum and Rubin (1983) showed that match with a scalar function, such as the propensity score, $P(X)$, is sufficient to balance the covariates X, between the treatment and comparison individuals. $P(X)$ is one uni-dimensional variable defined as the conditional probability of participation given the vector of observed characteristics. Therefore, if CIA is conditional on X, it will also be conditional on the propensity score:

$$(Y_1, Y_0) \perp D|P(X), \text{ with } P(X) = \Pr(D=1|X) \qquad (6)$$

The alternative matching estimators comprise the definition of a closeness criterion, a neighbourhood, and the selection of a suitable weight function to associate the comparison individual to each treated individual. In this paper the choice of the comparison group lies in matched control observations which consist in the most similar non-participants – the nearest neighbour matching.

## 3. Empirical evaluation process

### 3.1. Selection of subjects and outcomes

From the presentation of the propensity score matching methodology it becomes clear that the adaptation of the econometric theory to this particular evaluation requires comparing only what is comparable. In the *ESTiG-IPB*

institution, in the two academic years of reference, nine undergraduate courses with several specificities were offered. Nonetheless they had many similarities. The IG course had some subjects in common with the other eight courses some subjects. Therefore only the results of those subjects were evaluated. The subjects were: Algebra, Mathematics I, Mathematics II, Statistics, Operational Research, Introduction to Computer Science, Accounting I, Accounting II and Marketing.

The school success was measured: (i) by the percentage of students with classifications equal or higher than 10, and (ii) by the average of the positive classifications. The goal is not only to assess the success using the number of positive classifications but also assess the quality of that positive value to better understand the real impact of the introduction of the Bologna's Treaty.

*3.1 – Causal Effect of the introduction of a new teaching methodology in the rate of positive classification*

From the available data the observable variables described in the following Tables were selected.

In Table 1 is presented the distribution of the selected characteristics by the selected subjects, for the treatment group (TG) and for the comparison groups (CG), in the 2004/05 academic year. The Table 2 presents the same distribution for the academic year of 2005/06.

The different distribution of observable characteristics, as we can detect in Table 1 and Table 2, shows the importance of a matching process among the students to understand what is the real causal effect of the programme in the IG students. Indeed, the difference among the students in terms of observable characteristics could be in the origin of the difference among the results. So, to affirm the difference among the results of the students from different undergraduate courses is a consequence of the introduction of the policy in the IG course and not in the others is abusive and can originate interpretation mistakes.

As a result of the observed differences in the variables a *logit* binomial model was estrimated to compute the probability of a student being a IG student[1]. This is, to estimate the propensity score that will allow the matching among students. From the *logit* estimation we conclude that, although, not all the variables are statistically significant at the individual level they present joint statistical significance. These results show they are relevant to determine the probability of a student apply to the IG course. Actually it is possible to show (Table 3) the results of the rate of correct prediction[2] for participation obtained from the *logit* model. We considered that the rate of correct prediction is, in general, pretty good denoting that the selected variables are an excellent departure to find in the comparison groups good matches to the IG students,

---

[1] The results of the *logit* models will not be presented due to their extension.
[2] The models do not produce correct prediction rates equal to 100% and we do not expect that since we believe the models could be improved with subjective information not available for this particular research study.

according to the propensity score conditioned in a vector of selected observable characteristics.

After estimating the propensity score the matching methodology was implemented and the matches for the treated students were found in the comparison groups. Now the average of the IG students' results, in each subject, can be compared with the average of the results of the matched comparison students. The average of the results for the students in the comparison groups represents the results the IG students would have obtained if they had not been subject to the new teaching methodology. So, it is possible to estimate a more rigorous approximation to the real causal effect of the introduction of the policy on those who were subject to it.

The results of the matching methodology are presented in Table 5. However before we comment it is important to make reference to the quality of the matching procedure. Table 4 shows the results for the standardized absolute average bias[3] for the set of observable characteristics, between the treatment group and each comparison group before and after the matching procedure. The values are relatively high before matching but decrease after the procedure. Such reduction is a good indicator of the quality of the matching procedure and in practice means that it was possible to find in the comparison groups students equal to the treatment students, concerning the selected characteristics.

In Table 5 we can start to observe the causal effect of the teaching methodology on the IG students during the introduction year, the academic year of 2004/05, assuming the possibility that the student is attending the subject in any of the other undergraduate courses offered by the institution. With the exception of Statistics, Marketing and Accounting I the IG students would had obtained better results. In Algebra, Mathematics I and Operational Research they would have obtained a larger number of positive classifications if they were registered in another course of the institution. However if we compare the treated students only with the colleagues in the management courses the results show they benefited from being an IG student rather than a student from another management course. Analysing the academic year of 2005/06, the results appeared to be less positive for both groups of comparison. The results estimated for the previous year were not confirmed.

*3.2 – Causal effect of the introduction of a new teaching methodology in the average value of positive classifications*

To estimate the quality of the success the students with a positive classification were the only ones selected. For these students the distribution of observable characteristics among groups can be observed in Table 6 and Table 7 for the academic years of 2004/05 and 2006/07, respectively. The number of

---

[3] Standardized Bias: $\dfrac{\left(\overline{X}_1 - \overline{X}_0\right)}{\sqrt{\left(V_1(X_1)+V_0(X_0)\right)\big/2}}$, where $\overline{X}_1\left(V_1\right)$ is the average (variance) in the treatment group and $\overline{X}_0\left(V_0\right)$ is the same for the comparison group.

student decreased and consequently the matching procedure did not perform as well. It is possible to observe in Table 8 a worse adjustment among treated students and comparison ones.

The results of the matching procedure are presented in Table 9. The first perception with only a few exceptions is that the IG students have a smaller probability to obtain better positive classifications than their colleagues attending the subjects in other courses. If the results for the 2004/05 academic year are not good for the treated students the results for the following year are even poorer if they are compared with colleagues from all scientific areas. Still they improve if they are compared with the colleagues in the management scientific area.

## 4. Conclusions

The estimations allow us to conclude that for the introduction year the teaching philosophy, as defended by the Bologna's Treaty, was important to improve the rates of positive classifications of those who where subjected to it. This result is not totally confirmed by the results of the second year of implementation. The second year results could be the consequence of a time dilution of the positive results for those who where subject to the new methodology. They could also be the result of positive externalities that where extended to the institution as an all and only arise in the second year of implementation of a new teaching methodology. When analysing the average value of the positive classifications the results were not satisfactory for 2004/05 but have improved over time for the neighbouring scientific study area of the treated students.

## Bibliography

Dehejia, R. H. & Wahba, S. (2002). 'Propensity Score-Matching Methods for Nonexperimental Causal Studies' *The Review of Economics and Statistics* 84(1): 151-161.

Leuven, E. & Sianesi, B. (2003). 'PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing'. Available at
http://ideas.repec.org/c/boc/bocode/s432001.html.Version 1.2.3.

Rosenbaum, P. R. & Rubin, D. B. (1983). 'The Central Role of the Propensity Score in Observational Studies for Causal Effects'. *Biometrika* 70(1): 41-55.

Rubin, D.B. (1974). 'Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies'. *Journal of Educational Psychology* 66: 688-701.

**Annex: Tables**

**Table 1** *Distribution of the observable characteristics for the 2004/05 year*

| Subjects | Groups | Observable Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Students | Age | % Sex (Male) | % Region (North) | % Nationality (Portuguese) | % Tuition Fee (No) | % Student Union (Yes) | % Scholarship (Yes) |
| Algebra | TG | 49 | 25.3 | 71.4 | 20.4 | 77.6 | 4.1 | 18.4 | 6.1 |
| | CG – All Courses | 525 | 24.8 | 71.0 | 27.2 | 85.5 | 2.1 | 26.5 | 22.3 |
| | CG - Management | 118 | 26.1 | 41.5 | 29.7 | 85.6 | 0.8 | 47.5 | 33.1 |
| Mathematics I | TG | 59 | 24.7 | 67.8 | 18.6 | 78.0 | 5.1 | 20.3 | 8.5 |
| | CG – All Courses | 794 | 24.9 | 64.2 | 24.4 | 85.3 | 2.0 | 27.6 | 22.2 |
| | CG - Management | 299 | 25.6 | 41.8 | 23.4 | 83.9 | 1.3 | 35.1 | 27.8 |
| Mathematics II | TG | 62 | 24.9 | 69.4 | 21.0 | 77.4 | 4.8 | 17.7 | 9.7 |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 321 | 25.8 | 43.6 | 24.3 | 83.8 | 0.9 | 34.3 | 26.2 |
| Statistics | TG | 47 | 25.4 | 48.9 | 25.5 | 89.4 | 2.1 | 34.0 | 25.5 |
| | CG – All Courses | 621 | 25.7 | 57.5 | 27.2 | 85.7 | 1.3 | 41.1 | 28.5 |
| | CG - Management | 217 | 26.2 | 37.8 | 27.2 | 86.6 | 1.4 | 46.5 | 34.1 |
| Operational Research | TG | 26 | 25.4 | 50.0 | 34.6 | 92.3 | 3.8 | 19.2 | 26.9 |
| | CG – All Courses | 419 | 26.1 | 55.6 | 27.9 | 88.5 | 1.2 | 39.4 | 28.4 |
| | CG - Management | 167 | 26.2 | 38.3 | 27.5 | 86.8 | 1.2 | 49.1 | 36.5 |
| Introduction computer science | TG | 23 | 25.6 | 73.9 | 21.7 | 73.9 | 4.3 | 4.3 | 21.7 |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 150 | 25.4 | 36.7 | 20.0 | 80.0 | 0.7 | 13.3 | 24.7 |
| Marketing | TG | 43 | 25.0 | 39.5 | 27.9 | 79.1 | 0.0 | 20.9 | 37.2 |
| | CG – All Courses | 78 | 26.6 | 25.6 | 29.5 | 76.9 | 0.0 | 39.7 | 35.9 |
| | CG - Management | 71 | 26.7 | 28.2 | 31.0 | 74.6 | 0.0 | 40.8 | 32.4 |
| Accounting I | TG | 40 | 25.1 | 65.8 | 13.2 | 71.1 | 0.0 | 18.4 | 7.9 |
| | CG – All Courses | 78 | 24.5 | 47.4 | 20.5 | 80.8 | 0.0 | 14.1 | 19.2 |
| | CG - Management | 71 | 24.7 | 50.7 | 22.5 | 80.3 | 0.0 | 14.1 | 14.1 |
| Accounting II | TG | 57 | 25.8 | 63.6 | 25.5 | 76.4 | 0.0 | 18.2 | 7.3 |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 97 | 24.9 | 44.3 | 18.6 | 79.4 | 0.0 | 22.7 | 16.5 |

**Table 2** *Distribution of the observable characteristics for the 2005/06 year*

| Subjects | Groups | Observable Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Students | Age | % Sex (Male) | % Region (North) | % Nationality (Portuguese) | % Tuition Fee (No) | % Student Union (Yes) | % Scholarship (Yes) |
| Algebra | TG | 25 | 26.2 | 80 | 12.0 | 80.0 | 8.0 | 20.0 | ----- |
| | CG – All Courses | 331 | 24.6 | 66.5 | 25.4 | 86.1 | 6.3 | 27.8 | ----- |
| | CG - Management | 110 | 25.7 | 38.2 | 27.3 | 88.2 | 5.5 | 39.1 | ----- |
| Mathematics I | TG | 35 | 24.9 | 65.7 | 11.4 | 85.7 | 8.6 | 22.9 | ----- |
| | CG – All Courses | 423 | 25.0 | 64.8 | 24.6 | 84.6 | 6.1 | 28.8 | ----- |
| | CG - Management | 190 | 25.7 | 44.7 | 24.7 | 83.7 | 6.3 | 35.3 | ----- |
| Mathematics II | TG | 39 | 24.8 | 64.1 | 17.9 | 87.2 | 10.3 | 20.5 | ----- |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 210 | 25.7 | 47.1 | 27.6 | 83.8 | 6.2 | 36.7 | ----- |
| Statistics | TG | 45 | 24.9 | 60.0 | 28.9 | 91.1 | 6.7 | 31.1 | ----- |
| | CG – All Courses | 626 | 25.1 | 56.1 | 27.2 | 85.3 | 5.0 | 37.1 | ----- |
| | CG - Management | 217 | 25.5 | 39.2 | 29.0 | 86.2 | 3.7 | 45.2 | ----- |
| Operational Research | TG | 29 | 24.9 | 48.3 | 24.1 | 82.8 | 6.9 | 20.7 | ----- |
| | CG – All Courses | 361 | 25.4 | 55.4 | 27.1 | 86.7 | 6.1 | 36.8 | ----- |
| | CG - Management | 41 | 25.6 | 41.1 | 30.5 | 85.1 | 4.3 | 45.4 | ----- |
| Introduction computer science | TG | 9 | 24.9 | 55.6 | 0.0 | 66.7 | 11.1 | 0.0 | ----- |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 70 | 26.1 | 32.6 | 0.0 | 81.4 | 9.3 | 0.0 | ----- |
| Marketing | TG | 16 | 24.8 | 43.8 | 50.0 | 100.0 | 6.3 | 31.3 | ----- |
| | CG – All Courses | 71 | 24.8 | 32.8 | 23.0 | 100.0 | 3.3 | 42.6 | ----- |
| | CG - Management | 63 | 25.0 | 33.3 | 25.9 | 100.0 | 3.7 | 42.6 | ----- |
| Accounting I | TG | 21 | 25.1 | 66.7 | 9.5 | 71.4 | 9.5 | 14.3 | ----- |
| | CG – All Courses | 110 | 24.8 | 45.5 | 23.6 | 80.0 | 10.9 | 16.4 | ----- |
| | CG - Management | 99 | 25.1 | 44.4 | 24.2 | 79.8 | 10.1 | 17.2 | ----- |
| Accounting II | TG | 27 | 25.6 | 77.8 | 14.8 | 81.5 | 11.1 | 14.8 | ----- |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 92 | 25.1 | 43.5 | 28.3 | 82.6 | 5.4 | 30.4 | ----- |

**Table 3** *Correct Prediction Rate for participation of students in the IG course.*

| Rate of Correct Prediction (%) | Undergraduate Courses | Subjects | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Algebra | Mathematics I | Mathematics II | Statistics | Operational Research | Introduction Computer Science | Marketing | Accounting I | Accounting II |
| All | 2004/05 | 77.55 | 62.71 | ----- | 63.83 | 73.08 | ----- | 72.09 | 76.32 | ---- |
| All | 2005/06 | 76 | 71.43 | ----- | 64.44 | 72.41 | ----- | 62.5 | 76.19 | ----- |
| Management | 2004/05 | 71.43 | 67.8 | 66.13 | 57.45 | 76.92 | 69.57 | 74.42 | 76.32 | 61.82 |
| Management | 2005/06 | 80 | 62.86 | 56.41 | 55.56 | 72.41 | 88.89 | 68.75 | 76.19 | 74.07 |

**Table 4** *Average Absolute bias between the treatment group and the comparison groups before and after the matching procedure.*

| GC | | Bias | Algebra | Mathematics I | Mathematics II | Statistics | Operational Research | Introduction Computer Science | Marketing | Accounting I | Accounting II |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Courses | 2004/05 | Before | 18.58 | 16.87 | ----- | 9.86 | 17.58 | ----- | 21.35 | 23.6 | ----- |
| | | After | 0.54 | 6.58 | ----- | 9.94 | 12.6 | ----- | 5.82 | 10.98 | ----- |
| | 2005/06 | Before | 24.55 | 10.85 | ----- | 9.48 | 13.93 | ----- | 19.52 | 19.67 | ----- |
| | | After | 13.63 | 6.22 | ----- | 9.8 | 14.6 | ----- | 15.77 | 16.78 | ----- |
| Management Courses | 2004/05 | Before | 39.92 | 30.06 | 29.66 | 14.83 | 25.45 | 23.68 | 23.87 | 19.95 | 21.03 |
| | | After | 8.43 | 4.81 | 8.37 | 13.14 | 10.07 | 22.83 | 13.43 | 18.35 | 14.37 |
| | 2005/06 | Before | 36.45 | 23.32 | 23.35 | 19.27 | 19.5 | 18.86 | 19.12 | 18.98 | 30.08 |
| | | After | 15.25 | 11.4 | 9.57 | 8.2 | 10.33 | 0.45 | 1.37 | 13.23 | 12.75 |

**Table 5** *Percentage of students with a positive classification.*

| | Comparison Courses | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Courses | | | | | | Management Courses | | | | | |
| | GT | | GC | | Difference $(\Delta)$ | | GT | | GC | | Difference $(\Delta)$ | |
| | Academic year | | Academic year | | Academic year | | Academic year | | Academic year | | Academic year | |
| | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 |
| Algebra | 26.5 | 24.0 | 30.6 | 8.0 | – 4.1 | 16.0 | 26.5 | 26.1 | 16.3 | 8.7 | 10.2 | 17.4 |
| Mathematics I | 18.6 | 17.1 | 30.5 | 28.6 | – 11.9 | – 11.4 | 19.0 | 17.1 | 13.8 | 17.1 | 5.2 | 0.0 |
| Mathematics II | ----- | ----- | ----- | ----- | ----- | ----- | 27.9 | 30.8 | 11.5 | 10.3 | 16.4 | 20.5 |
| Statistics | 53.2 | 46.7 | 46.8 | 40.0 | 6.4 | 6.7 | 53.2 | 46.7 | 19.1 | 33.3 | 34.0 | 13.3 |
| Operational Research | 34.6 | 6.9 | 53.8 | 34.5 | – 19.2 | – 27.6 | 34.6 | 7.1 | 23.1 | 21.4 | 11.5 | – 14.3 |
| Introduction Computer Science | ----- | ----- | ----- | ----- | ----- | ----- | 30.4 | 33.3 | 26.1 | 22.2 | 4.3 | 11.1 |
| Marketing | 92.9 | 86.7 | 73.8 | 100.0 | 19.0 | – 13.3 | 95.1 | 86.7 | 65.9 | 93.3 | 29.3 | – 6.7 |
| Accounting I | 73.0 | 36.8 | 27.0 | 21.1 | 45.9 | 15.8 | 73.0 | 36.8 | 29.7 | 21.1 | 43.2 | 15.8 |
| Accounting II | ----- | ----- | ----- | ----- | ----- | ----- | 56.4 | 25.0 | 16.4 | 12.5 | 40.0 | 12.5 |

**Table 6** *Distribution of the observable characteristics for the 2004/05 year*

| Subjects | Groups | Observable Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Students | Age | % Sex (Male) | % Region (North) | % Nationality (Portuguese) | % Tuition Fee (No) | % Student Union (Yes) | % Scholarship (Yes) |
| Algebra | TG | 13 | 23.8 | 30.8 | 23.1 | 92.3 | 0.0 | 30.8 | 7.7 |
| | CG – All Courses | 125 | 23.3 | 57.6 | 32.0 | 93.6 | 0.0 | 27.2 | 49.6 |
| | CG - Management | 43 | 24.0 | 30.2 | 34.9 | 93.0 | 0.0 | 44.2 | 58.1 |
| Mathematics I | TG | 11 | 23.6 | 36.4 | 27.3 | 63.6 | 0.0 | 27.3 | 18.2 |
| | CG – All Courses | 229 | 23.9 | 56.3 | 23.1 | 88.6 | 0.0 | 31.0 | 39.7 |
| | CG - Management | 62 | 24.3 | 24.2 | 25.8 | 85.5 | 0.0 | 50.0 | 56.5 |
| Mathematics II | TG | 8 | 23.9 | 37.5 | 37.5 | 62.5 | 0.0 | 25.0 | 25.0 |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 57 | 24.5 | 24.6 | 21.1 | 84.2 | 0.0 | 42.1 | 47.4 |
| Statistics | TG | 13 | 25.2 | 38.5 | 23.1 | 92.3 | 0.0 | 30.8 | 46.2 |
| | CG – All Courses | 71 | 24.8 | 39.4 | 26.8 | 87.3 | 0.0 | 38.0 | 43.7 |
| | CG - Management | 16 | 24.5 | 0.0 | 31.3 | 93.8 | 0.0 | 31.3 | 68.8 |
| Operational Research | TG | 9 | 24.4 | 33.3 | 33.3 | 88.9 | 0.0 | 11.1 | 55.6 |
| | CG – All Courses | 179 | 25.0 | 52.0 | 24.6 | 91.1 | 0.0 | 37.4 | 36.9 |
| | CG - Management | 55 | 24.6 | 16.4 | 23.6 | 96.4 | 0.0 | 47.3 | 56.4 |
| Introduction computer science | TG | 7 | 26.1 | 85.7 | 42.9 | 85.7 | 0.0 | 0.0 | 42.9 |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 49 | 23.7 | 40.8 | 10.2 | 81.6 | 0.0 | 18.4 | 40.8 |
| Marketing | TG | 39 | 24.9 | 33.3 | 25.6 | 76.9 | 0.0 | 20.5 | 35.9 |
| | CG – All Courses | 56 | 25.9 | 23.2 | 30.4 | 82.1 | 0.0 | 46.4 | 46.4 |
| | CG - Management | 49 | 26.0 | 26.5 | 32.7 | 79.6 | 0.0 | 49.0 | 42.9 |
| Accounting I | TG | 13 | 24.5 | 53.8 | 23.1 | 84.6 | 0.0 | 30.8 | 7.7 |
| | CG – All Courses | 23 | 23.4 | 30.4 | 17.4 | 87.0 | 0.0 | 17.4 | 39.1 |
| | CG - Management | 18 | 23.4 | 33.3 | 22.2 | 83.3 | 0.0 | 16.7 | 27.8 |
| Accounting II | TG | 19 | 25.2 | 36.8 | 26.3 | 84.2 | 0.0 | 26.3 | 10.5 |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 32 | 23.9 | 37.5 | 18.8 | 78.1 | 0.0 | 37.5 | 25.0 |

**Table 7** *Distribution of the observable characteristics for the 2005/06 year*

| Subjects | Groups | Observable Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Students | Age | % Sex (Male) | % Region (North) | % Nationality (Portuguese) | % Tuition Fee (No) | % Student Union (Yes) | % Scholarship (Yes) |
| Algebra | TG | 6 | 25.3 | 50.0 | 16.7 | 66.7 | 0.0 | 16.7 | ----- |
| | CG – All Courses | 65 | 23.3 | 52.3 | 26.2 | 26.2 | 0.0 | 33.9 | ----- |
| | CG - Management | 25 | 24.0 | 28.0 | 32.0 | 80.0 | 0.0 | 36.0 | ----- |
| Mathematics I | TG | 6 | 24.5 | 33.3 | 16.7 | 83.3 | 0.0 | 50.0 | ----- |
| | CG – All Courses | 118 | 23.9 | 69.5 | 24.6 | 81.4 | 1.7 | 31.4 | ----- |
| | CG - Management | 32 | 25.0 | 50.0 | 25.0 | 71.9 | 0.0 | 40.6 | ----- |
| Mathematics II | TG | 12 | 24.3 | 25.0 | 33.3 | 83.3 | 0.0 | 25.0 | ----- |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 35 | 25.5 | 37.1 | 31.4 | 71.4 | 0.0 | 51.4 | ----- |
| Statistics | TG | 10 | 24.6 | 50.0 | 50.0 | 100.0 | 0.0 | 30.0 | ----- |
| | CG – All Courses | 101 | 24.6 | 50.5 | 30.7 | 86.1 | 1.0 | 40.6 | ----- |
| | CG - Management | 39 | 24.7 | 33.3 | 25.6 | 87.2 | 0.0 | 53.8 | ----- |
| Operational Research | TG | 2 | 28.5 | 100.0 | 0.0 | 50.0 | 0.0 | 0.0 | ----- |
| | CG – All Courses | 94 | 24.5 | 57.4 | 23.4 | 87.2 | 4.3 | 36.2 | ----- |
| | CG - Management | 16 | 24.3 | 43.8 | 12.5 | 75.0 | 0.0 | 37.5 | ----- |
| Introduction computer science | TG | 3 | 23.7 | 0.0 | 0.0 | 66.7 | 33.3 | 0.0 | ----- |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 17 | 26.9 | 23.5 | 0.0 | 88.2 | 0.0 | 0.0 | ----- |
| Marketing | TG | 13 | 24.2 | 38.5 | 46.2 | 100.0 | 0.0 | 23.1 | ----- |
| | CG – All Courses | 50 | 24.6 | 36.0 | 24.0 | 100.0 | 2.0 | 46.0 | ----- |
| | CG - Management | 44 | 24.8 | 36.4 | 27.3 | 100.0 | 2.3 | 45.5 | ----- |
| Accounting I | TG | 8 | 25.4 | 62.5 | 12.5 | 62.5 | 12.5 | 25.0 | ----- |
| | CG – All Courses | 47 | 24.7 | 40.4 | 19.1 | 78.7 | 6.4 | 19.1 | ----- |
| | CG - Management | 44 | 24.9 | 40.9 | 20.5 | 79.5 | 4.5 | 18.2 | ----- |
| Accounting II | TG | 7 | 24.1 | 57.1 | 0.0 | 71.4 | 14.3 | 14.3 | ----- |
| | CG – All Courses | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| | CG - Management | 33 | 23.9 | 27.3 | 36.4 | 78.8 | 0.0 | 30.3 | ----- |

**Table 8** *Average Absolute bias between the treatment group and the comparison groups before and after the matching procedure.*

| GC | | Bias | Algebra | Mathematics I | Mathematics II | Statistics | Operational Research | Introduction Computer Science | Marketing | Accounting I | Accounting II |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Courses | 2004/05 | Before | 35.96 | 29.21 | ----- | 9.85 | 30.2 | ----- | 25.87 | 38.2 | ----- |
| | | After | 1.38 | 24.50 | ----- | 28.37 | 20.68 | ----- | 10.57 | 32.53 | ----- |
| | 2005/06 | Before | 36.18 | 29.48 | ----- | 22.3 | 78.3 | ----- | 22.57 | 24.22 | ----- |
| | | After | 59.24 | 1.05 | ----- | 25.03 | 74.88 | ----- | 14.8 | 33.88 | ----- |
| Management Courses | 2004/05 | Before | 31.43 | 39.03 | 36.28 | 25.53 | 29.73 | 54.47 | 24.35 | 30.35 | 24.18 |
| | | After | 17.25 | 39.50 | 40.81 | 51.25 | 34.35 | 30.43 | 18.9 | 19.8 | 40.68 |
| | 2005/06 | Before | 38.26 | 18.50 | 23.55 | 31.3 | 69.75 | 46.43 | 22.31 | 25.67 | 46.72 |
| | | After | 36.44 | 38.28 | 23.55 | 11.65 | 48.33 | 29.28 | 6.12 | 21.08 | 15.08 |

**Table 9** *Average value of positive classifications.*

| | All Courses | | | | | | Management Courses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GT | | GC | | Difference $(\Delta)$ | | GT | | GC | | Difference $(\Delta)$ | |
| | Academic year | | Academic year | | Academic year | | Academic year | | Academic year | | Academic year | |
| | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 | 2004/05 | 2005/06 |
| Algebra | 11.50 | 11.67 | 11.50 | 12.83 | 0.00 | − 1.16 | 11.38 | 11.67 | 11.38 | 12.83 | 0.00 | − 1.16 |
| Mathematics I | 11.27 | 11.17 | 11.91 | 11.83 | − 0.64 | − 0.66 | 11.27 | 11.17 | 11.45 | 11.00 | − 0.18 | 0.17 |
| Mathematics II | ----- | ----- | ----- | ----- | ----- | ----- | 11.75 | 10.58 | 12.13 | 14.50 | − 0.38 | − 3.92 |
| Statistics | 10.73 | 12 | 10.45 | 11.4 | 0.27 | − 1.16 | 10.73 | 12.00 | 10.18 | 11.70 | 0.55 | 0.30 |
| Operational Research | 11.00 | 10.50 | 11.33 | 10.50 | − 0.33 | 0.00 | 11.00 | 10.50 | 13.22 | 12.50 | − 2.22 | − 2.00 |
| Introduction Computer Science | ----- | ----- | ----- | ----- | ----- | ----- | 12.33 | 10.33 | 10.67 | 12.67 | 1.67 | − 2.34 |
| Marketing | 11.31 | 11.77 | 11.54 | 12.77 | − 0.23 | − 1.00 | 11.31 | 11.77 | 11.51 | 11.69 | − 0.21 | 0.08 |
| Accounting I | 10.45 | 11.14 | 11.00 | 11.14 | − 0.55 | 0.00 | 10.45 | 11.14 | 10.91 | 11.29 | − 0.45 | − 0.14 |
| Accounting II | ----- | ----- | ----- | ----- | ----- | ----- | 11.21 | 12.00 | 11.84 | 10.83 | − 0.63 | 1.17 |

Comparison Courses