# Selecting Strategies to Foster Economists' Critical Thinking Skills: A Quantile Regression Approach

*Costas Siriopoulos and Gerasimos Pomonis*

## Abstract

We consider three models of teaching strategies and their effect on developing economics graduates' 'analysis', 'deduction' and 'induction' skills. For each model we compute quantile regression estimates for total sample, male, and female graduates separately. Results show that enriched lectures have a different effect on each critical thinking skill, while their effect differs for low, medium and high quantiles. Student-engaging strategies help more low-to-medium achievers. The third model is more explanatory, especially for low and high achievers. Male and female graduates respond differently to the use of each model. In conclusion, suggestions for strategy selection and further research are made.

## Introduction

The economics profession emphasises the development and application of critical thinking skills and many academic institutions incorporate the assessment of student critical thinking skills in their assessment plans (e.g. the Assessment Plan of Indiana-Purdue University-Fort Wayne, BA Major in Economics and BSB Concentration in Economics Programmes, 2007, where in this case a scoring rubric is used for critical thinking skills assessment). The importance of critical thinking skills acquisition by economics students is also shown by their inclusion in the subject benchmark statement for economics (Draft for consultation, August 2006) of the Quality Assurance Agency (QAA) for Higher Education. In this statement, 'analysis', 'deduction' and 'induction' are noted among the subject specific skills economics graduates should attain through their studies.



Such skills are well known to economics departments instructors. Critical judgement and analytical skills have long been mentioned as desirable proficiencies for economists (Hansen, 1986; 1991) and together with several other proficiencies should be integrated into the economics curriculum and be assessed as well (Hansen, 2001). The nature of economics way of thinking requires the development of the aforementioned three skills. Economic theory propositions are deductions from postulates, the chief one being the scarcity of goods. Inductive reasoning relates to real-world facts that need to be explained. Economic problems can be identified, analysed, explained and solved by the use of analytical tools, which consist of the economic concepts and principles (Ping, 2003).

Regarding the issue if critical thinking as a generic phenomenon or not, the instrument we use for assessment purposes is based on the Delphi Report (American Philosophical Association, 1990), which considers critical thinking as generic. Woodhouse (1991), commenting on a book of Robin Barrow's, discusses this debate. He proposes that it is the framework underlying the various disciplines and the questioning of these that makes for critical inquiry and he does not advocate the generic aspect of critical thinking. Schommer and Walker (1995) investigate college undergraduates' epistemological beliefs, i.e. their beliefs about the nature of knowledge and learning, and document that they are domain independent. This means that part of acquired knowledge and meta-learning is inter-disciplinary. If economics teaching stresses the acquisition of analytical, deductive and inductive skills, these should be easily identified and assessed by either discipline specific measures or generic ones. What might make a difference is the time span let for the impact to be discernible. Meyer and Shanahan (2001) and Shanahan and Meyer (2003) document that previous knowledge and meta-learning have relatively long-term (first semester) effects on economics studies learning outcomes. As economics graduates (four-year University studies) participating in our survey are students in Master's programmes, it is most likely that they have acquired the aforementioned critical thinking skills and they should be capable of demonstrating them as well.

Instructors of economics insistently, at least for the previous ten years in the USA, as documented by Becker and Watts (1996; 2001) and Watts and Becker (2006), select and implement lecture-based teaching strategies. This consecutive finding stands in contrast to students' expectations; students who '… now expect to be engaged in the learning process and appear unwilling to sit passively through lectures' (Becker, 2000: 113). Moreover, many economics instructors and researchers experiment with various teaching strategies in order to engage students in learning and foster their critical thinking skills. Active student engagement in learning is often achieved by the use of case studies and can lead to critical thinking and problem solving skills development (Buckles, 1998), while purposefully designed open-ended problems, assignments and classroom discussions can also be used to foster critical thinking skills (Wolcott, 2000).

Traditionally economics is taught in a deductive theory-first approach and this may relate to the predominance of lecture-based teaching strategies. An alternative inductive problem-first teaching approach may lead to the adoption and implementation of constructivist teaching methods that engage students actively in the learning process (Reimann, 2004).

In a broad perspective, as teaching for student critical thinking skills development requires learners' consent, small-group discussion is considered a very suitable teaching strategy, while instructors should function as facilitators (Maudsley and Strivens, 2000). This facilitating role of the instructor can be undertaken in teaching the subject matter of a discipline to enhance critical thinking by 'scaffolding' learners' attempts to understand and use concepts and reflect on the process of their thinking. In this way, 'good thinking' acquired by learners may become a generalised and transferral skill (Pithers and Soden, 2000).

A modern way to engage students in the learning process is by using computers. Although computer-based learning is not suitable for teaching every individual student (Leuthold, 1999), many instructors try out modern educational technology. Simkins (1999) suggests that the incorporation of web-based instructional technologies into teaching pedagogies helps students practise economic concepts and enhances their learning. Greenlaw and DeLoach (2003) use electronic discussion for teaching critical thinking to groups of students and they consider this technological instrument captures the best features of traditional writing assignments and in-class discussions; thus it provides a natural framework for teaching this skill.

Sloffer *et al*. (1999) report on two implementations of a web-based asynchronous conferencing tool they use to create opportunities for student small-group collaboration and critical thinking skills development. The first implementation refers to a graduate seminar in Instructional Systems Technology and the second to an upper-level course in Sociology of the Workplace. Authors report that in both cases students displayed better critical thinking skills than in past semesters, but they do not provide details about scores and assessment method. Beckman and Sterling (2005) consider three different pedagogical strategies, namely simulation, service learning and active learning exercises, which engage students more actively in learning and may be used to promote critical thinking in economics education. They provide practical examples of successful use for each strategy and report that such techniques lead students to better choices in their lives.





Whatever teaching methods are implemented by economics instructors to foster critical thinking skills and whether critical thinking skills are assessed by scoring rubrics, written exams (both context specific) or by standardised questionnaires (usually generic), one consideration is either missing or not thoroughly examined: the impact that implemented teaching strategies may have on critical thinking skills development, other than differences in mean scores.

Our purpose in this paper is to examine the impact of the frequency of use of several teaching strategies in fostering economics graduates' critical thinking skills and to suggest effective strategy selections for instructors. To serve this purpose we use a questionnaire to gather data on the frequency of use of teaching methods and we use a standardised questionnaire to assess the above-mentioned three critical thinking skills for economics graduates (the California Critical Thinking Skills Test – CCTST, Form B). In order to examine the impact of the use of teaching methods, we construct three models of teaching strategies based on the frequency of use of each teaching method and we use quantile regression (QR) to compute $\beta$ coefficients. Depending on the learning environment each teaching strategy forms, each teaching method is not likely to have a similar effect on the development of each critical thinking skill for all students. By distinguishing between different elements of critical thinking and analysing students by achievement level and gender we are able to identify differential impacts of teaching methods on different aspects of critical thinking for different types of individual students.

The remainder of this paper is structured as follows. In the next section we present the methodology. Then we present the survey sample and data, followed by the discussion of quantile regression analysis of results. In the following section we discuss some interpretative remarks on the quantile regression approach and in the final section we conclude the paper along with some suggestions for further research.

## Methodology

The standard methodology for analysing the effect of an independent variable on a depended one is the Ordinary Least Squares (OLS) regression. This is based on the *mean* of the conditional distribution of the dependent variable and may not sufficiently explain the relative effect if the independent variable influences parameters of the conditional distribution of the dependent one other than the *mean*. In such a case the analysis that disregards this possibility is flawed and leads to false conclusions (Koenker and Bassett, 1978; Koenker and Hallock, 2001). Contrary to standard OLS regression that renders only one coefficient for the whole conditional distribution, quantile regression allows the estimation of the effect of explanatory variables on the whole conditional distribution of the dependent variable, as it renders as many coefficients as the pre-determined quantiles of the conditional distribution. In this way, QR results shed light on aspects of the effects of the independent variable that are not discernible when conditional mean models are applied (Koenker, 2005). QR coefficients localise the effect of the explanatory variable(s), while the whole range of estimated coefficients provide a general view of the relative impact.

According to Koenker and Bassett (1978) any $\theta th$ regression quantile, for $0< \theta <1$, is defined as any solution to the minimisation problem:

$$\underset{\beta \in \Re^{K}}{Min} \left[ \sum_{t \in \{t: y_t \geq x_t\beta\}} \theta \left| y_t - x_t\beta \right| + \sum_{t \in \{t: y_t < x_t\beta\}} (1-\theta) \left| y_t - x_t\beta \right| \right] \quad (1)$$

where $y^t$ is the dependent variable, $x^t$ is the vector of independent variables, and $\beta$ is the coefficient vector which will be different for any estimated quantile, depending on the particular effect of the independent variable on the dependent one for that quantile. Our dependent variables are graduates' scores for 'analysis', 'deduction' and 'induction', as assessed by the use of the CCTST, Form B. The independent variables are the frequencies of use of the relative teaching methods, as reported by the participants in our survey (see later).

With regard to the applications of quantile regression (QR) analysis in several scientific fields we mention the works of Eide and Showalter (1998) on the effect of school quality on student performance, Martins and Pereira (2004) regarding the impact of education on wage inequality, Ng *et al*. (2005) regarding the analysis of a business statistics course encompassing diverse teaching and learning styles, and Tian (2006) regarding the family background factor effects on mathematical achievement. In all these cases, the use of QR, instead of standard regression, gives a more detailed explanation of the impact of the independent variable(s) on the dependent one and provides information for better decision making.

As mentioned above, the standardised instrument used for the assessment of critical thinking skills is the CCTST, Form B, which has been developed to evaluate the skills identified by the Delphi Report (American Philosophical Association, 1990). This instrument has 34 multiple-choice questions requiring a range of critical thinking skills such as analysing the meaning of a sentence, drawing the correct inference from a set of assumptions, or evaluating objections to stated inference, as well as deductive and inductive thinking skills. One point is given for each correct answer and the higher the overall points an individual scores, the higher his/her ability in critical thinking. Total score ranges from 0 to 34. Gained scores are distributed in five subscales, which are analysis (score range 0–9), deduction (score range 0–16), induction (score range 0-14), inference (score range 0–11), and evaluation (score range 0–14). The first three scales are the ones we assess and analyse for the economics graduates in this paper (Table 2).





The results of several studies (Giancarlo and Facione, 2001; Facione *et al*., 2002) suggest that university education improves critical thinking. Other studies have documented that significant critical thinking skills development coincides specifically with first year college studies (Pascarela, 1999; Terenzini *et al*., 1995).

## Sample and data

### *Sample and performance in critical thinking skills*

Our sample consists of 161 economists who have graduated from nine Greek major universities (Table 1). They are part of 587 graduates in various disciplines who have participated in our survey, carried out in 2006, regarding the assessment of student critical thinking skills development, learning preferences and implemented teaching strategies. Classes to be surveyed were selected by chance on a cluster-sampling basis and students were surveyed during class sessions, pre-approved and pre-arranged in cooperation with programme directors and instructors. The usual student selection procedure for these Master's programmes is based on acquired degree GPA, exams regarding maths, statistics and micro, as well as an interview. No critical thinking skills test is applied that might lead to a selection bias. Furthermore, the great majority of these graduates have not acquired work experience of more than two years (68.3% reported work experience of up to one year, total sample mean value is 1.53, median is 0.30 and mode is 0.0), thus eliminating the impact of work experience on the development of their critical thinking skills.

Gender participation leans in favour of females, who represent 54% of the total, although the gender balance varies between universities (panel A). Young economists aged less than 24 years represent 46.7% of the total, with the majority of the remainder in the 24 to 29 age group. This age structure of our sample is expected and is due to the fact that all of these graduates were students in Master's programmes at the time of our survey being carried out.

Graduates' scores for the three critical thinking skills under consideration are shown in Table 2. Generally, these economics graduates scored lower than reported scores in relevant literature[1] and we also identify some differences between male and female scores. Female graduates score higher in 'analysis', while male graduates score higher in 'induction' both in mean and median terms. Results are a bit mixed as regards 'deduction': although minimum and maximum scores are the same for

**Table 1:** Gender and age per university of graduation

| | | UNIVERSITY OF GRADUATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Aristotle University of Thessaloniki | National and Kapodistrian University of Athens | University of Thessaly | University of Crete | Athens University of Economics and Business | University of Macedonia | Panteion University | University of Piraeus | University of Patras | Total |
| Panel A: Gender | | | | | | | | | | | |
| Male | Count | 10 | 12 | 2 | 3 | 16 | 6 | 2 | 13 | 10 | 74 |
| | % of Total | 6.2 | 7.5 | 1.2 | 1.9 | 10.0 | 3.7 | 1.2 | 8.1 | 6.2 | 46.0 |
| Female | Count | 17 | 4 | 4 | 0 | 18 | 10 | 3 | 16 | 15 | 87 |
| | % of Total | 10.5 | 2.5 | 2.5 | 0.0 | 11.2 | 6.2 | 1.9 | 10.0 | 9.2 | 54.0 |
| Total | Count | 27 | 16 | 6 | 3 | 34 | 16 | 5 | 29 | 25 | 161 |
| | % of Total | 16.7 | 10.0 | 3.7 | 1.9 | 21.2 | 10.0 | 3.1 | 18.1 | 15.4 | 100.0 |
| Panel B: Age | | | | | | | | | | | |
| <24 | Count | 9 | 6 | 5 | 2 | 19 | 9 | 1 | 11 | 13 | 75 |
| | % of Total | 5.6 | 3.7 | 3.1 | 1.2 | 11.9 | 5.6 | 0.6 | 6.9 | 8.1 | 46.7 |
| 24–29 | Count | 16 | 8 | 0 | 1 | 13 | 7 | 3 | 17 | 12 | 77 |
| | % of Total | 9.9 | 5.0 | 0.0 | 0.6 | 8.1 | 4.3 | 1.9 | 10.6 | 7.5 | 47.9 |
| 30 + | Count | 2 | 2 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 9 |
| | % of Total | 1.2 | 1.2 | 0.6 | 0.0 | 1.2 | 0.0 | 0.6 | 0.6 | 0.0 | 5.4 |
| Total | Count | 27 | 16 | 6 | 3 | 34 | 16 | 5 | 29 | 25 | 161 |
| | % of Total | 16.7 | 9.9 | 3.7 | 1.8 | 21.2 | 9.9 | 3.1 | 18.1 | 15.6 | 100.0 |

male and female graduates, the median score is higher for male than female and the mean score is higher for female than male graduates. Although none of these differences is statistically significant and further examination might be given up, the QR analysis of results (see later) shows that male and female students are differently affected by various teaching strategies in developing critical thinking skills.





**Table 2:** Critical thinking skills scores

| GENDER | | ANALYSIS | DEDUCTION | INDUCTION |
|---|---|---|---|---|
| Male | N | 74 | 74 | 74 |
| | Mean | 4.2297 | 7.2162 | 5.7973 |
| | Median | 4.0000 | 7.5000 | 6.0000 |
| | Minimum | 1.00 | 2.00 | 1.00 |
| | Maximum | 8.00 | 12.00 | 11.00 |
| | Std. Deviation | 1.44817 | 2.33068 | 2.35238 |
| Female | N | 87 | 87 | 87 |
| | Mean | 4.5057 | 7.2644 | 5.3218 |
| | Median | 5.0000 | 7.0000 | 5.0000 |
| | Minimum | 1.00 | 2.00 | 1.00 |
| | Maximum | 8.00 | 12.00 | 10.00 |
| | Std. Deviation | 1.41317 | 1.93775 | 2.25417 |
| Total | N | 161 | 161 | 161 |
| | Mean | 4.3789 | 7.2422 | 5.5404 |
| | Median | 4.0000 | 7.0000 | 6.0000 |
| | Minimum | 1.00 (0) | 2.00 (0) | 1.00 (0) |
| | Maximum | 8.00 (9) | 12.00 (16) | 11.00 (14) |
| | Std. Deviation | 1.43154 | 2.12066 | 2.30487 |

### *Use of teaching methods*

Supplementary to the administered CCTST questionnaire was one that included questions regarding the teaching-learning procedure, relating to the use of the ten teaching methods and technology instruments shown in Table 3. Students were asked to report analytically on the frequency of use of teaching methods as they have experienced them in their undergraduate studies on a scale from 1 to 5 relating to 'never', 'seldom', 'often', 'almost always' and 'always' (Table 3, Panel B). As students finish high school at the age of 18 and university studies last for four years, the usual Master's programme entry student age is at least 22–23 years. Student age analysis for our sample renders a mean value of 24.45 years, and mode for Q1 = 23 years, Q2 = 24 and Q3 = 25 years. This age structure means that, for the great majority of students in our sample, there is a relatively small time lapse between acquiring their degree and attending a Master's programme for their teaching experience to be appropriately reported. This age structure may also explain students' low level of work-experience.

The higher mean value with the lower standard deviation value among all reported teaching methods comes for lectures (Table 3, Panel A). This unfortunately corroborates the findings of Becker and Watts (1996, 2001) and Watts and Becker (2006) about the frequency of use of lectures in teaching economics. The frequencies of use of overhead projectors and power point presentations are high enough so as to conclude that economics instructors are more likely to accompany their lectures with some sort of educational technology instruments, while they use some of the time on discussing in class. 'In-class discussion', if used very often, may be a way of in-class student engagement in learning, but its reported frequency of use is between 2 = 'seldom' and 3 = 'often' (mode for Q1 = 2, median for Q2 and Q3 = 3). This suggests that small group 'tutorials' are used as a supplementary means for better explaining theoretical issues, although there is a high degree of variation between institutions. More or less all of these methods, as they are implemented, do not require active student involvement in the teaching-learning process.

Contrary to the first five methods shown in Table 3, the following five require active student involvement, either in a group or on an individual basis. We should notice here that 'dissertation' is usually on a volunteer basis, so the relative question is 1 = 'is not a part of the learning process', 2 = 'is volunteer', and 3 = 'is a prerequisite for graduation' (mode for Q1 = 1, median for Q3 = 2). Dissertation writing is a highly demanding learning task, but the way it is used means that few students have had the experience, and hence the learning benefits, of writing one. Obviously, for dissertations to offer their best in the teaching-learning process they must be on a 'prerequisite' basis so that every student is involved in this sort of learning experience, something not reported in our sample. The most frequently used methods to involve students in learning are 'individual project assignment' and 'group project assignment', while 'case studies' and 'laboratory exercises' are used less often.

Generally, the teaching-learning environment that economics graduates of our sample have reported is a passive rather than active one. The mean frequency value for 'lectures' is between 'almost always' and 'always' and lectures are 'often' accompanied by 'overhead projectors', as the mean frequency value for this instrument is very close to the value of 3 = 'often'. For all other teaching methods reported frequencies are between 2 = 'seldom' and 3 = 'often'. Some of them are more close to 'seldom', e.g. 'laboratory exercises', while others are more close to 'often', e.g. 'individual project assignment'. This environment may have played a role in the low scores that have been achieved relative to international scores.





**Table 3:** Frequency of use of teaching methods

Panel A: Descriptive statistics

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Lectures | 161 | 2.00 | 5.00 | 4.3540 | 0.66530 |
| Overhead Projectors | 161 | 1.00 | 5.00 | 2.9503 | 0.96696 |
| In-class discussion | 161 | 1.00 | 5.00 | 2.6398 | 0.81817 |
| PowerPoint Presentations | 161 | 1.00 | 5.00 | 2.4969 | 0.95606 |
| Tutorials | 161 | 1.00 | 5.00 | 2.4658 | 0.99393 |
| Individual project assignment | 161 | 1.00 | 5.00 | 2.7702 | 0.84593 |
| Group project assignment | 161 | 1.00 | 5.00 | 2.6149 | 0.88078 |
| Case Studies | 161 | 1.00 | 5.00 | 2.1863 | 0.80004 |
| Laboratory exercises | 161 | 1.00 | 5.00 | 2.1242 | 0.80435 |
| Dissertation | 161 | 1.00 | 3.00 | 1.7329 | 0.78865 |
| Valid N (listwise) | 161 | | | | |

Panel B: Percentages

| | | Never | Seldom | Often | Almost always | Always | Total |
|---|---|---|---|---|---|---|---|
| Lectures | % | 0.0 | 1.2 | 6.8 | 47.3 | 44.7 | 100 |
| Overhead Projectors | % | 4.3 | 29.2 | 40.4 | 19.3 | 6.8 | 100 |
| In-class discussion | % | 3.7 | 43.5 | 41.0 | 8.7 | 3.1 | 100 |
| PowerPoint Presentations | % | 12.4 | 41.6 | 34.2 | 7.5 | 4.3 | 100 |
| Tutorials | % | 14.9 | 41.0 | 31.1 | 8.7 | 4.3 | 100 |
| Individual project assignment | % | 3.7 | 35.4 | 44.1 | 13.7 | 3.1 | 100 |
| Group project assignment | % | 6.8 | 40.5 | 41.6 | 6.8 | 4.3 | 100 |
| Case Studies | % | 18.0 | 50.9 | 26.2 | 4.3 | 0.6 | 100 |
| Laboratory exercises | % | 18.6 | 56.5 | 20.5 | 2.5 | 1.9 | 100 |
| A Dissertation* | % | 47.8 | 31.1 | 21.1 | – | – | 100 |

* 1= is not a part of the learning process, 2 = is volunteer, 3 = is a prerequisite

To test the effects of this learning environment we consider three teaching models, the construction of which is based on data gathered by the use of the aforementioned supplementary questionnaire and presented in Table 3:

a) The first model is based on lectures accompanied by the two educational technology instruments of overhead projectors and PowerPoint Presentations, the use of in-class-discussions and the use of tutorials.

b) The second model is a synthesis of the five methods that require student involvement in the teaching-learning process, as shown in Table 3.

c) The third model is derived from the reported frequencies for all ten teaching methods. This model is synthesised by ranking the relative frequencies and thus we select 'lectures', 'overhead projectors' use, 'individual project assignments', 'in-class discussions' and 'group project assignments'. This model seems to be more realistic as it combines teaching methods according to reported frequencies of use.

In the next section we discuss the results of the computed quantile regression coefficients in order to estimate the relevant effects2 of the use of the various teaching methods on the development of the three critical thinking skills.

## Results and discussion

Relative to the simple bivariate regression model

$$y_i = \beta_0 + x_i\beta_i + u_i ,$$

the conditional quantile functions of $y$ are

$$Q_y(\tau \mid x) = \beta_0 + x\beta_1 + F_u^{-1}(\tau) ,$$

where $F_u$ denotes the common distribution function of the errors. In the case of more covariates, as is the case of the aforementioned teaching models, a family of conditional quantile functions can be computed and the model is written as

$$Q_Y(\tau \mid x) = \beta_0(\tau) + X_1\beta_1(\tau) + X_2\beta_2(\tau) + \ldots + \beta_k X_{ki} + F_u^{-1}(\tau) .$$

The $\beta$ coefficients can be estimated for any $\tau \in (0,1)$ by solving the minimisation problem (1), mentioned in section 2 (Koenker, 2005: 12-21). This solution requires linear programming, which is done by using the R programme codes.[3]

For each of the three models, the dependent variables are CCTST scores for each critical thinking skill, i.e. analysis, deduction and induction, and the explanatory variables are the frequencies of use of each teaching method comprised in each model. For example, the QR model for the estimation of the impact of the third teaching model on analysis is

$$Q_{Anal} = \beta_0(?) + Lect\beta_1(\tau) + OvHeadP\beta_2(\tau) + IndPAss\,\beta_3(\tau) + InClDis\,\beta_4(\tau) + GrPAss\,\beta_5(\tau)$$

The number of $\beta$ coefficients that will be computed depends on the determination $\tau$ of values. This can be determined for all quantiles from 0.01 to 0.99, or for selected quantiles. The more quantiles are determined, the more coefficients will be



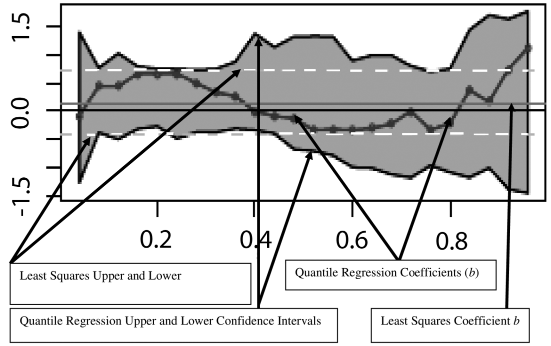


computed and the more explicitly the association between dependent and explanatory variable(s) will be examined. For the examination of the association between dependent and explanatory variables for the present study, we have computed 32 coefficients, from the 0.03 to the 0.96 quantile, per 0.03.

Quantile regression coefficients for all three models of teaching strategies have been computed[4] and figures have been plotted by using the R programme codes. In Figure 1 we show what each line and dot in the following figures mean. The horizontal line above or under (or in some cases coinciding with) the line passing through zero shows the value for the least squares coefficient – ($b$) – and the hyphenated lines show its upper and lower confidence intervals. Dots on the solid zig-zag line show quantile regression coefficients – ($b$) – for each percentile and solid zig-zag lines above and under this line (making up the shaded area) show the relative upper and lower confidence intervals. The exception to this depiction is Figure 2 in which we show the intercepts – coefficient $a$ – for least squares and regression quantiles for each model. The horizontal axis shows percentiles of frequency of use of each method in each teaching strategy and the vertical axis shows changes in critical thinking skills scores. Moving from lower to higher quantiles the frequency of use of teaching methods under consideration becomes higher and the relevant coefficients show the effect on lower-to-higher scores for each critical thinking skill for each quantile.

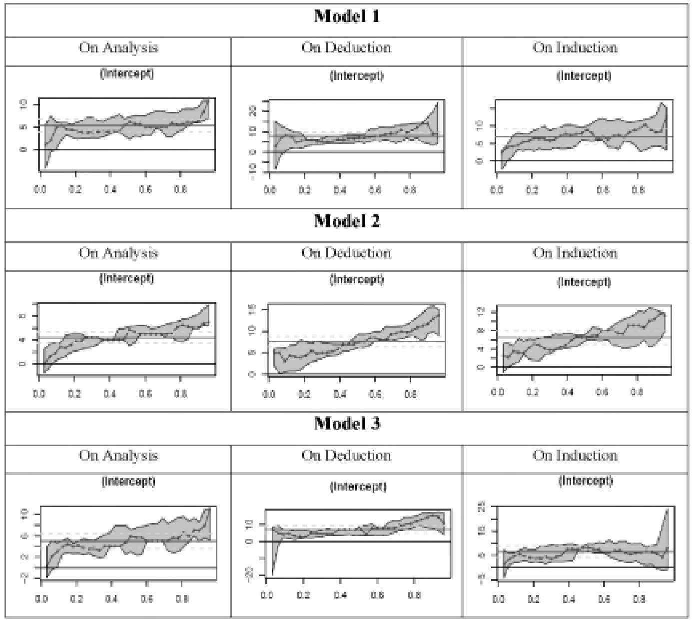
As there cannot be a single hypothesis to be tested for a range of QR coefficients, the interpretation of the effects shown by QR coefficients is based on their signs and their values, as well as their evolvement while moving from lower to higher quantiles. Coefficients smaller than zero show negative effects, larger than zero show positive effects (i.e. the effect is 'helpful') and very close to zero show neutral effects, while very high or very low values show strong positive and strong negative effects respectively.

**Figure 1:** What lines and dots mean



Before going on to the discussion of the specific effects of each teaching method on student critical thinking skills performance, we first consider the effect of each teaching strategy as a whole. In Figure 2 we show the quantile regression intercepts – coefficients $a$ – for each model. In most of the cases, intercepts around the middle percentiles – 0.4 to 0.6 – are very close to the least squares intercept and within its upper and lower intervals. Observing the values of the intercepts for lower and upper percentiles we notice not only that many intercepts are out of the intervals of the least squares coefficient – especially for Model 2 – but also lower percentile intercepts are lower and higher percentile intercepts are higher than the value as well as the boundaries of the least squares coefficient. We also notice that the effects of Model 2 regarding lower and upper percentiles are more intense, relative to the effects of Model 1. As Model 3 is a synthesis of teaching methods of Models 1 and 2 its effects show a combination of the effects of its constituent models. In general, each model seems to have a different effect on the development of each critical thinking skill, especially as regards lower and upper percentiles of performance scores. Thus, the use of quantile regression and the computation of coefficients for each percentile provide detailed information about the effect of each model of teaching strategy on student critical thinking skills development.

**Figure 2:** Effect of each teaching strategy model

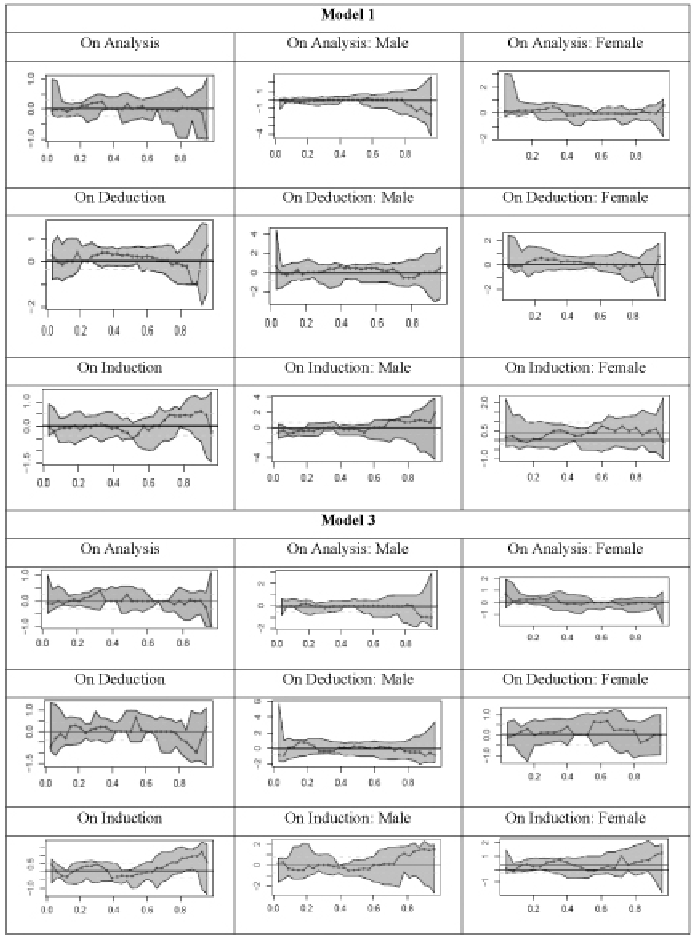







For the contrastive analysis of the effects of each teaching method comprised in the models under consideration, in the following five figures we show the effects of the five teaching methods that synthesise Model 3 and which are taken from Models 1 and 2. In Figure 3 we show the effect that lectures have on the development of 'analysis', 'deduction' and 'induction' skills for Models 1 and 3 in which lectures are considered. Besides the overall effect for each critical thinking skill, we also show the effect for male and female students separately. Despite the fact that lectures are widely used in economics classes, their contribution to the

**Figure 3:** Effect of lectures



development of critical thinking skills is not analogous to this use. Their effect is negative in many cases, such as on upper percentiles of 'analysis' for males for

Models 1 and 3 and on upper percentiles of 'deduction' for Models 1 and 3. The use of lectures helps the development of 'induction' for upper percentiles for both Models 1 and 2, albeit it is more helpful for males than females in the development of this skill for both models. It also helps in the development of middle percentiles 'deduction' for Model 1 but not for Model 2. Furthermore the effect is different on the development of 'deduction' for females in Model 1 than in Model 2. These results show that the reported use of lectures corresponds to its traditional teacher-centred format. This format may facilitate the delivery of large amounts of information about a subject, but it is difficult to foster student critical thinking skills with its use (Saunders and Welsh, 1998; Duron *et al*., 2006).

The most frequently used instrument to accompany 'lectures' is 'overhead projectors', which we consider in Models 1 and 3 (Figure 4), although this does not seem to be of any help to 'lectures' in the development of critical thinking skills, as in most of the cases it shows a negative effect, with the exceptions of middle to upper percentiles for 'induction' for Model 1 and upper percentiles for 'induction' for females for Model 3. Furthermore the effect is different for 'analysis' and 'induction' for males and females for Model 1, as well as for 'induction' for males and females for Model 3, while there is also a different effect on 'deduction' for females for Models 1 and 3. Adding to the above comment about lectures, the use of overhead projectors as a presentation facility to accompany lectures may be more flexible than chalkboards, but does not seem to be an effective combination with teacher-centred lectures. Overhead projectors are considered a traditional instrument that is less effective for presentations (Lawler *et al*., 2007) and less helpful to instructors in fostering student critical and creative thinking (Apperson *et al*., 2006) than computer-based software (e.g. PowerPoint). Furthermore, the effectiveness of these visual teaching aids may not be taken for granted, as it is dependent on student preferences (Beets and Lobingier, 2001).

The next in frequency-rank teaching method is 'individual project assignments', which is a student engaging in learning one and is considered in Models 2 and 3. The effects on the three critical thinking skills development by the use of this method are shown in Figure 5. The use of this method is helpful for lower percentiles for 'deduction' for both Models 2 and 3, for females for lower percentiles for 'deduction' and 'induction' for Models 2 and 3 respectively, and for upper percentiles for 'analysis' for Model 3 but not for Model 2. It also has for females stronger effects for lower percentiles for 'deduction' for Model 2 than for Model 3 and for 'induction' for Model 3 than for Model 2. This method also seems to have a

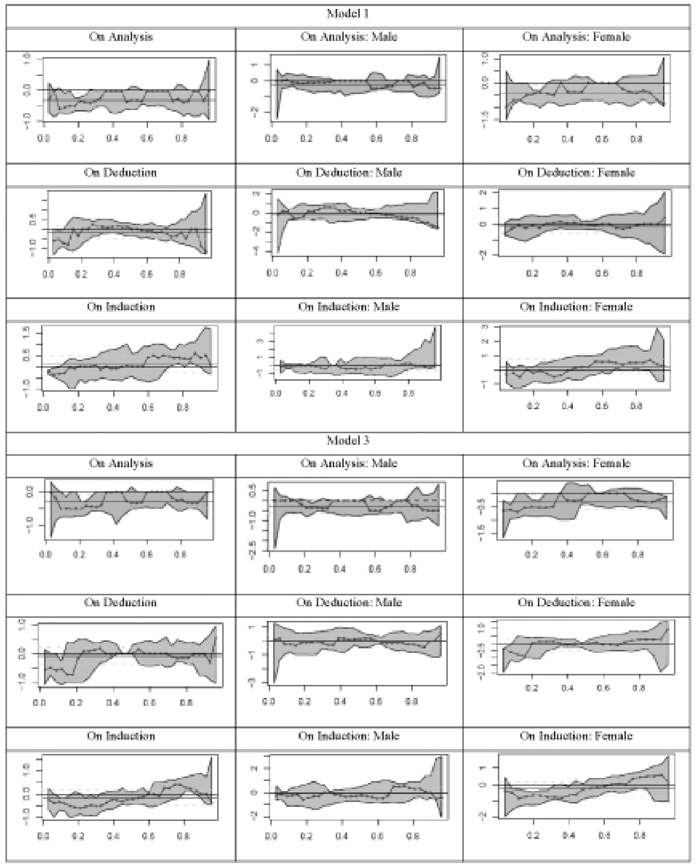




different effect: (i) for males for Model 2 than for Model 3 for all three critical thinking skills, (ii) for 'deduction' for males and females for Model 2, and (iii) for 'analysis' and 'induction' for males and females for Model 3.

The fourth in frequency-rank teaching method is 'in-class discussions', which is considered in Models 1 and 3. The effects of its use are shown in Figure 6. This is the only teaching method, among the considered ones, that shows negative effects for so many cases for the whole range of computed quantile regression – ($b$) – coefficients. This is so for 'induction' for both Models 1 and 3, for males 'deduction' and 'induction' for Model 1 and 'deduction' for Model 3, and for females for 'induction' for both Models 1 and 3. It has different effects for males and females for

**Figure 4:** Effect of overhead projectors use

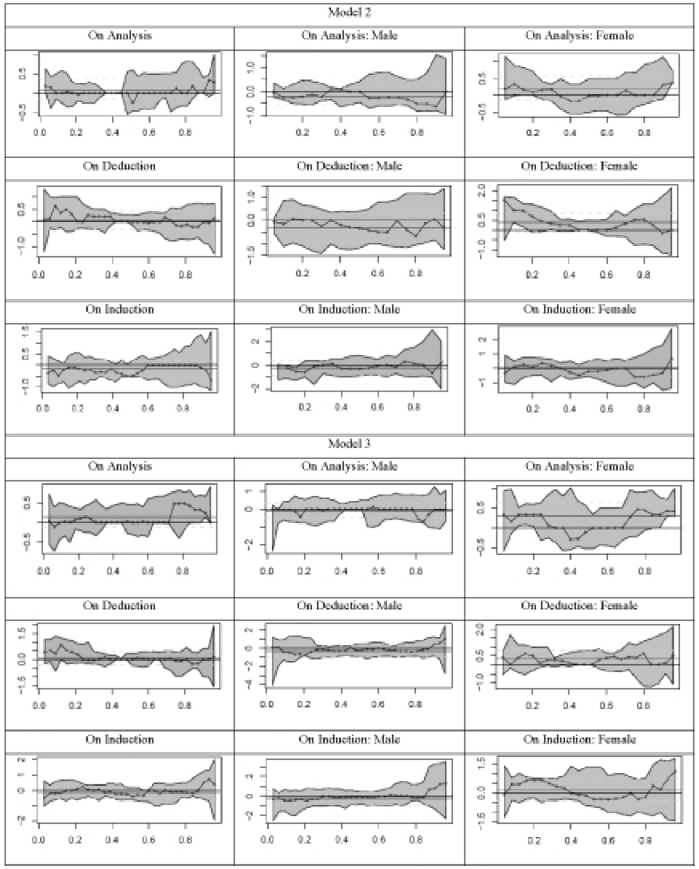


'analysis' and 'deduction' for Model 1 and for 'deduction' for Model 3, while it seems to be helpful for lower percentiles for 'deduction' for females for both Models 1 and 2.

These results indicate that in-class discussion, is neither used as a regular student-engaging-in-learning method, as mentioned earlier, nor is it effectively implemented in the way Salemi and Hansen (2005: 1–56) propose for economics instruction.[5]

The fifth in frequency-rank teaching method is 'group project assignments' (an example of a method defined here as engaging students in learning), considered in Models 2 and 3 and the effects of its use are shown in Figure 7.

**Figure 5:** Effect of individual project assignments








This teaching method is helpful for lower to middle percentiles and neutral for middle to upper percentiles for 'induction' for Model 2, but when it is considered in Model 3 for the same critical thinking skill it remains helpful for lower to middle percentiles but has negative effects for upper percentiles. It seems that this method loses its effectiveness in some cases when considered in Model 3 against Model 2, e.g. for upper percentiles for 'analysis' for males as well as for lower percentiles for 'analysis' and 'induction' for females. As regards its effectiveness for males and females for the same critical thinking skills, it seems to be helpful for upper percentiles for 'analysis' for males but for lower percentiles for females, while it is helpful for lower percentiles for 'deduction' for males but for upper percentiles for females, both for

**Figure 6:** Effect of in-class discussions

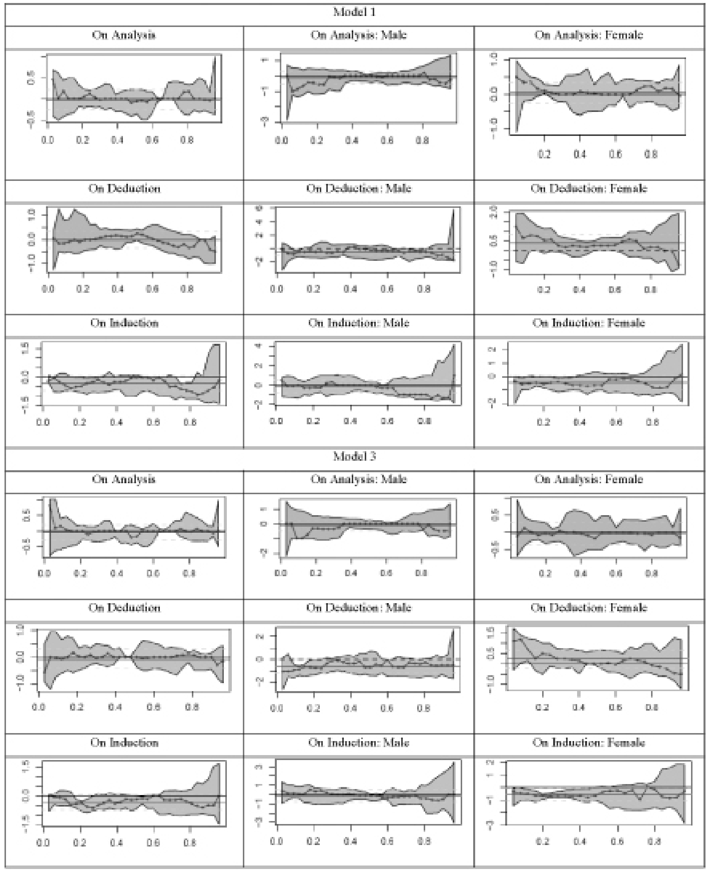
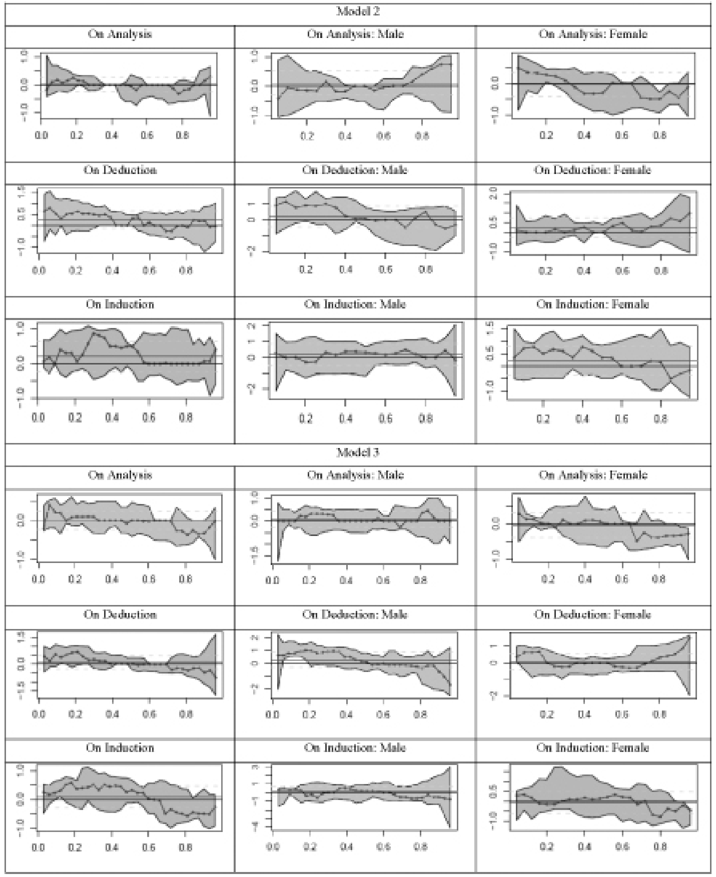


**Figure 7:** Effect of group project assignments




Model 2. A similar opposite effect is shown for upper percentiles for 'deduction' for males and females for Model 3, where it is helpful for females but not for males.

## Interpretative remarks on the QR approach

The preceding QR analysis of the effects of the frequency of use of teaching methods (and overhead projectors that accompany lectures) on critical thinking skills development, based on the computation of 32 $\beta$ coefficients, has shown that each teaching method does not have identical effects, independently of when and in what way it is used. The learning environment created by each of the three models of teaching strategies seems to affect the way each teaching method contributes in the development of critical thinking skills. Even student active-involvement methods, which are considered to foster critical thinking skills, seem to be affected by the context of the relative learning environment and do not produce the expected positive effects. Moreover, each teaching method does not have the same effect on every quantile of the distribution, as there are changes in QR coefficient signs (and values) along the conditional distributions for many cases. Furthermore, each teaching method affects differently male and female critical thinking skills development. This is consistent with literature on learning styles documenting gender differences in learning styles, which affect student learning preferences (Philbin *et al*., 1995; Shaw and Marlow, 1999; Sadler-Smith and Smith, 2004; Tanner and Allen, 2004; Wehrwein *et al*., 2007). What comes as new information from the above analysis about male and female learning preferences is the extent of the effect of the relationship between learning preferences and implemented teaching methods on critical thinking skills development. QR coefficients show explicitly the effects for every part of the conditional distribution and not just the 'on average' effect. An additional aspect of the overall estimation of the effects of each teaching model on the development of each critical thinking skill is to search for the positive or negative effects that each model may have. This can be done by considering the signs of the relative quantile regression $\beta$-coefficients for each model. For all cases we have selected three lower quantiles falling within the first quartile (0.05, 0.15 and 0.25), the median quantile and three upper quantiles falling within the fourth quartile (0.75, 0.85 and 0.95) and have counted the negative effects. Results are summarised in Table 4. Although counts of negative effects would be larger if we added more quantiles and the relevant coefficients, numbers shown are indicative of the whole range of results. Results show that negative effects for Model 2 are fewer than for Model 1. This means that a student-engaging-in-learning model can be more effective in the development of student critical thinking skills. Furthermore, the decrease of negative effects is due to fewer negative effects for the lower quantiles, as negative effects for the median quantile and the upper quantiles show a small increase. Negative effects for the third model are even fewer than Model 2 and again this is due to fewer negative effects for the lower quantiles, as there is a small decrease for the median quantile and no change for the upper quantiles against Model 1.

Searching for different effects of the three models on male and female critical thinking skills development, we identify a steady decrease in negative effects for males for 'analysis' and a steady decrease in negative effects for females for 'deduction' while moving from Model 1 to Model 3. Overall, Model 3 seems to be more effective than Models 1 and 2. However, we do not consider this model to have better characteristics than the other two, as its synthesis is taken out of Models 1 and 2. As Model 3 is constructed on the basis of the ranking of the frequency of use of the teaching methods, this combination is more realistic and, in

**Table 4:** Overall negative effects for each model (selected quantiles)

| | | | **Overall** | | **Male** | | **Female** | | **Totals** | | **Model Total** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model 1 | Analysis | Low | 8 | | 12 | | 8 | | 28 | | | | |
| | | Median | 3 | 21 | 4 | 27 | 4 | 19 | 11 | 67 | Low | 85 | |
| | | Upper | 10 | | 11 | | 7 | | 28 | | | | |
| | Deduction | Low | 8 | | 8 | | 7 | | 23 | | | | |
| | | Median | 2 | 21 | 2 | 21 | 3 | 16 | 7 | 58 | Median | 28 | 195 |
| | | Upper | 11 | | 11 | | 6 | | 28 | | | | |
| | Induction | Low | 12 | | 10 | | 12 | | 34 | | | | |
| | | Median | 5 | 26 | 3 | 22 | 2 | 22 | 10 | 70 | Upper | 82 | |
| | | Upper | 9 | | 9 | | 8 | | 26 | | | | |
| Model 2 | Analysis | Low | 6 | | 9 | | 5 | | 20 | | | | |
| | | Median | 4 | 19 | 3 | 22 | 4 | 17 | 11 | 58 | Low | 65 | |
| | | Upper | 9 | | 10 | | 8 | | 27 | | | | |
| | Deduction | Low | 6 | | 8 | | 7 | | 21 | | | | |
| | | Median | 3 | 22 | 3 | 23 | 3 | 14 | 9 | 59 | Median | 29 | 178 |
| | | Upper | 13 | | 12 | | 4 | | 29 | | | | |
| | Induction | Low | 8 | | 9 | | 7 | | 24 | | | | |
| | | Median | 3 | 21 | 2 | 18 | 4 | 22 | 9 | 61 | Upper | 84 | |
| | | Upper | 10 | | 7 | | 11 | | 28 | | | | |
| Model 3 | Analysis | Low | 5 | | 7 | | 6 | | 18 | | | | |
| | | Median | 2 | 17 | 2 | 19 | 5 | 22 | 9 | 58 | Low | 61 | |
| | | Upper | 10 | | 10 | | 11 | | 31 | | | | |
| | Deduction | Low | 5 | | 8 | | 4 | | 17 | | | | |
| | | Median | 2 | 19 | 2 | 22 | 2 | 11 | 6 | 52 | Median | 26 | 169 |
| | | Upper | 12 | | 12 | | 5 | | 29 | | | | |
| | Induction | Low | 8 | | 9 | | 9 | | 26 | | | | |
| | | Median | 4 | 21 | 4 | 20 | 3 | 18 | 11 | 59 | Upper | 82 | |
| | | Upper | 9 | | 7 | | 6 | | 22 | | | | |

this way, more explanatory of what the results show. After all, what graduates of our sample have gained relevant to the three critical thinking skills in consideration is owed to this model but, as has previously been mentioned, their scorings fall short of their international peers' scorings. Moreover, overall results indicate that instructors may select and implement diversified strategies for fostering critical thinking skills for less ambitious students, as well as for male and female students. Much work is still ahead for improvement.





## Conclusion

In this paper we have utilised quantile regression analysis (Koenker and Bassett, 1978) to give a more complete picture of the relationship between economics graduates' critical thinking skills development and the implemented teaching strategies during their studies. Quantile regression allows the estimation of the effect of the independent variable on the whole conditional distribution of the dependent variable. This enabled us to identify specific pros and cons from the implementation of each teaching strategy model on critical thinking skills development on a whole range of quantiles and not just on the mean-based analysis of standard regression analysis (Koenker, 2005). Our results show that each teaching model has a different effect on student critical thinking skills development. Teaching methods cannot be indiscriminately implemented for fostering student critical thinking skills, as different syntheses of teaching strategies affect in different ways the fulfillment of such a teaching objective. The learning environment formed by the implementation of a teaching strategy seems to lead to the development of interactions, which affect the critical thinking skills fostering potentiality of each teaching method. For example, if lectures are more or less frequently used to promote in-class discussion, the use of several presentation-technology instruments affects their effectiveness in developing student critical thinking skills. On the other hand, if lectures are more or less frequently combined with active student learning methods, such as individual or group project assignments, their effectiveness is again affected by this learning environment. In all these cases, QR results have shown that there are different effects for different groups of students, as shown by the different effects for the various distribution quantiles. The use of QR enables an economics instructor to identify exactly which students benefit and by the use of which teaching method, instead of estimating the 'on average' impact of his/her teaching endeavours. Furthermore, male and female students do not respond to each teaching model in similar ways, as the effect of a certain teaching method comprised in a model is different on male and female student critical thinking skills development. It comes as *sine qua non* that economics instructors, after setting their teaching objectives, should try to find out who their students are in order to modify 'what' and 'how' they teach (Bartlett, 1996); to support their teaching with relevant assessment strategies as this influences student learning approaches (Johnston *et al.*, 2001; Walstad, 2001) and student learning strategies relate to critical thinking skills development (Siriopoulos and Pomonis, 2007); and to use the methodology introduced in this paper to obtain a more complete view of the effects of their teaching strategies on student learning outcomes (Ng *et al.*, 2005). This setting may be considered as a field for further research on effective economics teaching.

## Acknowledgements

A greatly valued contribution of many instructors of Greek universities who cooperated in carrying out our survey is acknowledged.

The positive revision suggestions of two anonymous referees are also acknowledged.

## Notes

1 Total CCTST mean score for Economics Graduates is 14.35 (not reported in table 2). Mean norm values for CCTST total score is 15.89 for college students and 19.01 for Master's level students (Facione *et al*., 2002). Noreen Facione (2000) reports mean scores for total CCTST, analysis, deduction and induction for senior nursing students of 16.4, 4.59, 7.25 and 6.93 respectively. For the same CCTST scales, Miller (2003) reports mean scores of 20.96, 5.34, 9.89 and 8.97 for graduate pharmacy students. Wessel and Williams (2004) report a mean total score of 20.7 for Master's entry-level physical therapy programme students.

2 Although in discussing regression results it is usual to refer to 'effects' or 'impacts' of the explanatory variable(s) on the dependent variable, in the following analysis of results 'effects' may be considered as 'associations' between explanatory and dependent variables, as our sample originates from nine universities and the various teaching strategies implemented by instructors are not considered to be coordinated towards achieving pre-determined teaching objectives.

3 R is a language and environment for statistical computing and graphics available as free software from the Comprehensive R Archive Network – CRAN (http://www.r-project.org).

4 Full tables of computed coefficients are available from the authors upon request.

5 If implemented according to their proposal, in-class discussion must be highly structured and carefully planned, so that instructors lead students to investigate and, finally, master economic ideas at higher cognitive levels of Bloom's taxonomy.

## References

Apperson, Jennifer M., Laws, Eric L. and Scepansky, James A. (2006) The impact of presentation graphics to students' experience in the classroom, *Computers and Education*, Vol. 47, pp. 116–126.

Bartlett, Robin L. (1996) Discovering Diversity in Introductory Economics, *The Journal of Economic Perspectives*, 10(2), pp. 141–153.

Becker, William E. (2000) Teaching Economics in the 21st Century, *The Journal of Economic Perspectives*, 14(1), pp. 109–119.

Becker, William E. and Watts, Michael (1996) Chalk and Talk: A National Survey on Teaching Undergraduate Economics, *The American Economic Review*, 86(2), pp. 448–453.

Becker, William E. and Watts, Michael (2001) Teaching Economics at the Start of the 21st Century: Still Chalk-and- Talk, *The American Economic Review*, 91(2), pp. 446–451.

Beckman, Mary and Sterling, Kate (2005) Promoting Critical Thinking in Economics Education, *Working paper*, http://www.ups.edu/econ/working_papers/00-5.pdf.

Beets, S. Douglas and Lobingier, Patricia G. (2001) Pedagogical Techniques: Student Performance and Preferences, *Journal of Education for Business*, Vol.76, No.4, March/April, pp. 231–235.





Buckles, Stephen (1998) Using Cases as an Effective Active Learning Technique. In W. E. Becker and M. Watts (Eds) *Teaching Economics to Undergraduates, Alternatives to Chalk and Talk*, Cheltenham, UK: Edward Elgar Publishing Ltd.

Delphi Report 1990, op.cit. Facione, Peter A., 1990

Duron, Robert, Limbach, Barbara and Waugh, Wendy (2006) Critical Thinking Framework for Any Discipline, *International Journal of Teaching and Learning in Higher Education*, Vol. 17, No 2, pp. 160–166.

Eide, Eric and Showalter, Mark H. (1998) The effect of school quality on student performance: A quantile regression approach, *Economics Letters*, 58, pp. 345–350.

Facione, Noreen C. (2000) Critical Thinking Assessment in Nursing Education Programs: *An Aggregate Data Analysis*, Millbrae, CA: The California Academic Press.

Facione, Peter A. (1990) *Critical Thinking: A statement of Expert Consensus for Purposes of Educational Assessment and Instruction. Research Findings and Recommendations (Delphi Report)*. Sponsored by the American Philosophical Association, Newark, DEL., USA.

Facione, Peter A., Facione, Noreen C., Blohm, Stephen W., Giancarlo, Carol Ann. (2002) *The California Critical Thinking Skills Test CCTST*, Test Manual Updated Edition, Millbrae, CA: The California Academic Press/Insight Assessment.

Giancarlo, Carol Ann and Facione, Peter A. (2001) A Four-Year Look at the Disposition Toward Critical Thinking Among Undergraduate Students, *The Journal of General Education*, 50(1), pp. 29–55.

Greenlaw, Steven A. and DeLoach, Stephen B. (2003) Teaching Critical Thinking with Electronic Discussion, *Journal of Economic Education*, (Winter): 36–52.

Hansen, W. Lee (1986) What Knowledge Is Most Worth Knowing – For Economics Majors? *American Economic Review*, 76(2), pp. 149–152.

Hansen, W. Lee (1991) The Education and Training of Economics Doctorates: Major Findings of the Executive Secretary of the American Economic Association's Commission on Graduate Education in Economics, *Journal of Economic Literature*, XXIX (September), pp. 1054–1087.

Hansen, W. Lee (2001) Expected Proficiencies for Undergraduate Economics Majors, *Journal of Economic Education*, Summer, pp. 231–242.

Indiana-Purdue University-Fort Wayne, Assessment Plan, BA Major in Economics and BSB Concentration in Economics Programmes, 2007, http://www.ipfw.edu/vcaa/assessment/PDFs/AssessmentPlans/EconAssessmentPlans/EconAssessPlanFeb2007.pdf (Accessed 3/26/2007)

Johnston, Carol, McDonald, Ian and Williams, Ross (2001) The Scholarship of Teaching Economics, *Journal of Economic Education*, Summer, pp. 195–201.

Koenker, Roger. (2005) *Quantile Regression, Econometric Society Monographs*, New York, Cambridge University Press.

Koenker, Roger and Bassett, Gilbert Jr. (1978) Regression Quantiles, *Econometrica*, 46(1), pp. 33–50.

Koenker, Roger and Hallock, Kevin F. (2001) Quantile Regression, *Journal of Economic Perspectives*, 15(4), pp. 143–156.

Lawler, Ellen M., Chen, Mara X. and Venso, Elichia A. (2007) Student Perspectives on Teaching Techniques and Outstanding Teachers, *Journal of the Scholarship of Teaching and Learning*, Vol. 7, No.2, pp. 32–48.

Leuthold, Jane H. (1999) Is Computer-Based Learning Right for Everyone? *Proceedings of the 32nd Hawaii International Conference on System Sciences*, 0-7695-0001-3/99, IEEE.

Martins, Pedro S. and Pereira, Pedro T. (2004) Does education reduce wage inequality? Quantile regression evidence from 16 countries, *Labour Economics*, 11, pp. 355–371.

Maudsley, Gillian and Strivens, Janet (2000) Promoting professional knowledge, experiential learning and critical thinking for medical students, *Medical Education*, 34, pp. 535–544.

Meyer, Jan H.F. and Shanahan, Martin P. (2001) A Triangulated Approach to the Modelling of Learning Outcomes in First Year Economics, *Higher Education Research & Development*, Vol. 20, No. 2, pp. 127–145.

Miller, Donald R. (2003) Longitudinal Assessment of Critical Thinking in Pharmacy Students, *American Journal of Pharmaceutical Education*, 67(4), Article 120, pp. 1–8.

Ng, Pin, Pinto, James and Lockwood, Chris A. (2005) An Interpretive Business Statistics Course Encompassing Diverse Teaching and Learning Styles, *Working Paper Series 05–04 – March 2005*, College of Business Administration, Northern Arizona University.

Pascarella, Ernest T. (1999) The Development of Critical Thinking: Does College Make a Difference? *Journal of College Student Development*, Sep/Oct, 40(5), pp. 562–569.

Philbin, Marge, Meier, Elizabeth, Huffmann, Sherri and Boverie, Patricia (1995) A Survey of Gender and Learning Styles, *Sex Roles*, Vol. 32, Nos. 7/8, pp. 485–494.

Ping, Lim Cher (2003) Information and Communication Technologies (ICT) Addressing the Challenges of Economics Education: To Be or Not to Be? *International Review of Economics Education*, Vol.2, Issue 1, pp. 25–54.

Pithers, R.T. and Soden, Rebecca (2000) Critical thinking in education: a review, *Educational Research*, Vol.42, No.3, Winter, pp. 237–249.

Quality Assurance Agency (QAA) for Higher Education, Economics, Draft for consultation, August 2006.

Reimann, Nicola (2004) First-year Teaching-Learning Environments in Economics, *International Review of Economics Education*, Vol. 3, Issue 1, pp. 9–38.

Sadler-Smith, Eugene and Smith, Peter J. (2004) Strategies for accommodating individuals' learning styles and preferences in flexible learning programmes, *British Journal of Educational Technology*, Vol. 35, No.4, pp. 395–412.

Salemi, Michael K. and Hansen, W. Lee (2005) *Discussing Economics, A Classroom Guide to Preparing Discussion Questions and Leading Discussion*, Cheltenham, UK: Edward Elgar.

Saunders, Phillip and Welsh, Arthur L. (1998) Lectures as an Instructional Method. In W. B. Walstad and P. Saunders (Eds), *Teaching Undergraduate Economics: A Handbook for Instructors*, Boston, MA: Irvin/McGraw-Hill.

Schommer, Marlene and Walker, Kiersten (1995) Are Epistemological Beliefs Similar Across Domains? *Journal of Educational Psychology*, Vol. 87, No.3, pp. 424–432.

Shanahan, Martin P. and Meyer, Jan H.F. (2003) Measuring and Responding to Variation in Aspects of Students' Economic Conceptions and Learning Engagement in Economics, *International Review of Economics Education*, Vol. 1, No. 1, pp. 9–35.

Shaw, Graham and Marlow, Nigel (1999) The role of student learning styles, gender, attitudes and perceptions on information and communication technology assisted learning, *Computers and Education*, 33, pp. 223–234.

Simkins, Scott P. (1999) Promoting Active-Student Learning Using the World Wide Web in Economics Courses, *Journal of Economic Education*, Summer, pp. 278–291.

Siriopoulos, Costas and Pomonis, Gerasimos (2007) Learning Style Changes and their Relationship to Critical Thinking Skills, *Journal of College Teaching and Learning*, 4(1), pp. -45–60.

Sloffer, Susan, Dueber, Bill and Duffy, Thomas M. (1999) Critical Thinking Asynchronous Conferencing, *Proceedings of the 32nd Hawaii International Conference on System Sciences*, 0-7695-0001-3/99, IEEE.

Tanner, Kimberly and Allen, Deborah (2004) Approaches to Biology Teaching and Learning: Learning Styles and the Problem of Instructional Selection – Engaging all Students in Science Courses, *Cell Biology Education*, Vol. 3, Winter, pp. 197–201.

Terenzini, Patrick T., Springer, Leonard, Pascarella, Ernest T., Amaury, Nora (1995) Influences Affecting the Development of Students' Critical Thinking Skills, *Research in Higher Education*, Vol. 36, No. 1, pp. 23–39.

Tian, Maozai (2006) A Quantile Regression Analysis of Family Background Factor Effects on Mathematical Achievement, *Journal of Data Science*, 4, pp. 461–478.

Walstad, William B. (2001) Improving Assessment in University Economics, *Journal of Economic Education*, Summer, pp. 281–294.

Watts, Michael and Becker, William E. (2006) A Little More Than Chalk and Talk: Results from a Third National Survey of Teaching Methods in Undergraduate Economics Course. *AEA/ASSA Annual Meeting 2006/Teaching and Testing In Undergraduate Economics*, http;//www.aeaweb.org/annual_mtg_papers/2006/0106_0800_1201.pdf.

Wehrwein, Erica A., Lujan, Heidi L. and DiCarlo, Stephen E. (2007) Gender differences in learning style preferences among undergraduate physiology students, *Advances in Psysiology Education*, Vol. 31, June, pp. 153–157.

Wessel, Jean and Williams, Renee (2004) Critical thinking and learning styles of students in a problem-based, master's entry-level physical therapy program, *Physiotherapy Theory and Practice*, 20, pp. 79–89.

Wolcott, Susan K. (2000) Designing Assignments and Classroom Discussions to Foster Critical Thinking at Different Levels in the Curriculum, *Educational Innovation in Economics and Business* V, pp. 231–251.

Woodhouse, Howard (1991) A Critical Notice on: *Understanding Skills: Thinking, Feeling, and Caring*, by Robin Barrow, London, ON: The Althouse Press, 1990: Is Critical Thinking Just a Generic Skill? *Interchange*, Vol. 22/4, pp. 108–114.

## Contact details

Costas Siriopoulos
University of Patras
Department Of Business Administration
University Campus
26500 Rion
Greece

Email: siriopoulos@upatras.gr

Gerasimos Pomonis
University of Patras
Department of Business Administration

Email: gpomonis@upatras.gr