Challenges in the teaching of econometrics: the lesson of Pietro Balestra

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Challenges in the teaching of econometrics:
the lesson of Pietro Balestra

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This paper considers the challenges for the teaching of econometrics that are implied by some major transformations characterizing current research in econometrics. The focus is on the increasing mathematical sophistication and technicality, as well as on the strong growth of the literature in this field. The paper discusses how the teaching experience of Pietro Balestra may suggest some strong guiding principles to face these important challenges.

teaching - econometrics - mathematics - econometrics literature

Relever les défis de l’enseignement de l’économétrie:
la leçon de Pietro Balestra

Cet article analyse les défis que posent pour l’enseignement de l’économétrie les transformations majeures qui ont marqué l’évolution récente de la recherche dans cette discipline. L’accent est mis sur la sophistication et la technicité mathématique accrues, ainsi que sur la forte croissance de la littérature dans ce champ. Nous montrons que l’expérience d’enseignant de Pietro Balestra peut suggérer quelques principes fondamentaux susceptibles de nous aider à relever ces défis.

enseignement - économétrie - mathématiques - littérature économétrique

Classification JEL: A12, A20, A29.

After more than seventy years since the foundation of the Econometric Society, Econometrics nowadays has become an established discipline, characterized by specific and well-identified aims, methodologies, fields of expertise and scientific journals for publication. The Journée Pietro Balestra is a great opportunity for a discussion among colleagues about the issues related to a fundamental aspect of an econometrician’s professional life, namely the teaching of Econometrics. It is not by chance that such a fruitful exchange of views is made possible by a workshop dedicated to the memory of a person, who not only gave great contributions to the research in our field but also devoted major efforts to teaching excellence.

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The aim of my contribution to this Journée is twofold. On the one hand, I would like to consider some important challenges that we face today when we teach econometrics, from the view point of a young researcher starting the profession in these years. On the other hand, I would like to share some of the lessons from the teaching experience of Pietro Balestra, which I had the fortune to benefit from while being one of his PhD students and teaching assistants at the University of Lugano. Combining these two reflections, my goal is to understand what we can learn from Pietro’s way of teaching about how to address the new challenges.

In the first section of the paper I consider some major features that characterize current econometrics, namely the rapidly growing literature and the high mathematical sophistication. I will discuss how these features imply some new challenges for the teaching of econometrics. Among the most important ones, we can mention the search for an appropriate way to teach advanced mathematical tools and the lost of the unified pictures offered by traditional econometric approaches. The second section of the paper is devoted to the main lessons that we can draw from the teaching experience of Pietro Balestra. Trying to summarize it in few words, we can say that Pietro suggests us the search for simplicity and essentiality in exposition, the predominance of quality over quantity, the use of well-chosen examples to illustrate the general theory. I highlight the importance of Pietro’s suggestions as guidelines to address the new challenges in the teaching of econometrics. The main conclusion is that the way indicated by Pietro and his general message become today even more relevant than they have been in the past.

1. Some new challenges in teaching econometrics

In the last decades, the research in econometrics has experienced a tremendous growth. A good indicator to quantify this phenomenon is the number of pages published yearly by scientific journals. Data are displayed in Figure 1 for the three main econometrics journals, namely Econometrica, Journal of Econometrics and Econometric Theory. In 1932, the newly born Econometric Society founded its official journal, Econometrica. For almost 20 years, the number of pages published yearly by this journal was approximately constant, about 400 pages per year. After 1950, and until the late 70’s, the publication amount of Econometrica featured an upward trend, to reach a plateau around 1500 pages per year. In the meantime, a new major international journal specialized in econometrics appeared in 1973, the Journal of Econometrics. This journal featured a strong and almost steady increase in the publication amount, going from about 400 to about 2400 pages per year over the 30 years of its life. The picture is completed by Econometric Theory, a journal founded in 1985 and reaching more than 1000 pages published per year after 2000.
A global account for the growth of research is given in Figure 2, which displays the total number of pages published per year by Econometrica, Journal of Econometrics and Econometric Theory together. We see that since 1970 the total amount of research has increased by a factor about ten. Our analysis clearly underestimates the phenomenon, since many specialized econometrics journal have been founded in the last decades, such as the Journal of Time Series Analysis [1980], Econometric Reviews [1982], the Journal of Applied Econometrics [1986] and the Journal of Financial Econometrics [2000].

This growth of the research in econometrics has been accompanied by several profound changes, some of them common with other domains of economic theory, some others specific to our discipline. In this paper, I focus on one major transformation that econometrics has undergone in recent years, concerning the role of mathematics.\(^1\) My discussion pretends in no way to be an accurate historiographical analysis, but rather a discussion of a couple of facts that, in my opinion, have important implications for teaching.

\(^1\) Of course, several other transformations have been relevant, for instance the use of computer technology in econometric practice.
The role of mathematics in econometrics, and in general in economic theory, is at the center of a long debate in the profession. For my analysis, the interesting observation is that the average degree of mathematical sophistication in econometric papers appears to be higher today than, say, 30 years ago. By mathematical sophistication I mean the relevance of advanced mathematical tools in many fields of current econometric research and the predominance of very technical mathematical arguments in the proofs of theorems. Of course, the presence of advanced mathematics in some econometrics papers (or, in general, in some economic theory papers) is by no way something specific of the last decades. Think for instance to the contributions of R. Jennrich and E. Malinvaud at the end of the sixties on the asymptotic properties of the Nonlinear Least Squares (NLS) estimator, or to the pioneering use of differential topology for general equilibrium theory. Here, what I refer to is the fact that today advanced mathematics is relevant for a major part of econometrics papers, for which the proofs of theorems very often involve technical and lengthy mathematical arguments. To have a rough idea of the extent of the phenomenon, we can consider the number of pages devoted to technical appendices in published papers. In Figure 3 I display box plots of the distribution of the number of pages in appendix, and

Figure 2. Total number of pages published yearly by Econometrica, Journal of Econometrics and Econometric Theory.

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of the total paper length, for econometrics papers published in Econometrica in the period January 1971 – December 1975 (left Panel) and January 2001 – December 2005 (right Panel). For the econometrics papers appeared in Econometrica between January 2001 and December 2005, the median (and average) paper length is about 30 pages, while the median (resp. average) number of pages in appendices is 6 (resp. 8) per paper. This means that, on average, about one fourth of the paper is devoted to appendices. The quantities for econometrics papers published in Econometrica between 1971 and 1975 are very different, namely 11.4 pages of average paper length and 0.4 pages of appendices on average (basically, very few papers contained an appendix in this period). Thus, the percentage of pages in appendices was less than 4% in the early 70's. To reinforce this evidence, it is important to remark that since 2004 Econometrica allows the authors of a paper to publish on its web-site additional material, which often concerns technical developments and proofs. A similar phenomenon happens with other journals, since the authors often put technical appendices of published papers on their personal homepages.

At the roots of the increasing mathematical sophistication of econometrics in the last decades there are several causes. Among the major ones, there is certainly the strong interest for enlarging the horizon from the traditional linear regression setting towards more general specifications. From the modeling viewpoint, these extensions mainly involve the introduction of non-linear specifications (e.g. nonlinear regression functions, models for qualitative and limited dependent variables, nonlinear asset pricing models in finance, etc.) and more advanced models for time series dependence (e.g. ARCH volatility models, continuous-time diffusions, mixing processes, near epoch dependent process, etc.). Compared to classical regression setting, the analysis of the theoretical properties of these more complex models have necessitated the use of more advanced tools in mathematical analysis and probability theory. The estimation methodologies have also been extended accordingly. Maximum-Likelihood estimators for qualitative models, the Generalized Method of Moments, the Pseudo Maximum Likelihood, the simulation-based estimation approaches for Indirect Inference and Efficient Method of Moments have become nowadays wide-spread in econometrics and many papers build on their paradigms. The analysis of the theoretical properties of these estimators is mathematically involved, since in general these estimators are not available in closed form but only defined as solution of an optimization problem. Besides, recognizing the scarce guide of

3. The identification of the articles in Econometrica belonging to the category of « econometrics papers » relies on subjective criteria of the author, based on the topic and the methodology of the paper. Basically, an article has been assigned to the category of « econometrics papers » if its main topic was econometrics and the paper contained methodological developments in econometrics.

4. In a box plot, the box indicates the quartiles and the median of the distribution, while the dashed line extends over the main part of the distribution. Outliers are identified by crosses.

5. e.g. Gouriéroux and Monfort [1995].
6. e.g. Davidson [1994].
7. See for instance Newey and McFadden [1994].
economic theory in suggesting parametric specifications in a nonlinear setting, nonparametric methods have also become popular in econometrics. They introduce a further mathematical background, especially in the recent literature on nonparametric instrumental variable regression, which is related to the theory of ill-posed inverse problems.

The discussion whether the increasing mathematical sophistication of econometrics is a desirable phenomenon or not, is beyond the scope of this paper (but certainly an interesting topic of discussion). Here, I accept it as a fact and I focus my contribution on its implications for the teaching of econometrics. However, before turning to this point, I observe that in my opinion the mathematical sophistication of much current econometric research is simply necessary to achieve within modern estimation methods the same degree of rigor achieved in the past in traditional settings such as linear simultaneous equations systems.

What are the implications of the increasing mathematical sophistication for the teaching of econometrics? A first natural issue is related to the

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8. e.g. Haerdle and Linton [1994].
9. Carrasco, Florens and Renault [2006].
selection of the relevant domains, concepts and results to put in evidence in a given lecture. At the graduate level, this task is not easy to achieve due to the specificity of several advanced methodologies – a given chapter of the literature may well be crucial for the research in certain econometric fields but irrelevant for others. Thus, the teacher is often confronted with the trade-off between ensuring a wide background and achieving a specific education tailored to research interests. Concerning the undergraduate level, it is sometimes argued that the best training for studying econometrics is... a degree in mathematics or physics. Although such a statement is certainly exaggerated and is probably to be understood as a provocation, nonetheless it signals some real tensions. These tensions are induced by the increasing gap between the level of traditional undergraduate programs in economics and modern research.

Besides these general reflections, I would like to point out a more specific implication of the increasing mathematical sophistication for the teaching of econometrics. This is related to the fact that modern modelling approaches offer a more fragmented picture compared to traditional econometrics. To explain this point, let me mention that a major beauty of classical paradigms such as Simultaneous Equations Systems (SES), Vector Autoregressive Moving Average (VARMA) models and cointegration theory, is precisely their feature of unified frameworks for modelling and statistical inference. SES, VARMA and cointegrated systems are amenable to in-depth mathematical study of their properties in full generality. The associated econometric theory is strongly structured. These features are intimately related to the linear nature of these methodologies.

This unified picture is somewhat lost when we move from the linear world to the essentially non-linear world of most modern modelling approaches. A unique paradigm is often replaced by several distinct lines of research. As already remarked above, sophisticated tools are developed, which are specific to a typology of models, but maybe irrelevant for others. The mathematical complexity often prevents tractability at a general level and forces to a case-by-case analysis. In many situations, estimation methodologies heavily depend on the specific models under investigation, thus making the modeling step and the estimation step less integrated. The example of non-linear time series analysis illustrates well the point. In the last decades, the research has advanced along several distinct directions, leading to ARCH models, switching regimes and latent factor models, autoregressive models with thresholds and smooth transitions, nonparametric modelling approaches, and many others. Although remarkable results have been obtained in each of these streams of research, for none of them the theory has achieved a level of completeness and integration comparable to, for instance, ARMA models.

Within a fragmented picture, teaching becomes more problematic, because it is more difficult to identify a structure for the lecture or to highlight the fundamental ideas. This suggests that organizing a lecture as an overview of the different models in a given field of research may not be appropriate, at least in some cases. In my opinion, in current econometrics the unifying pictures are provided by the estimation methods. Indeed, general paradigms such as the GMM or the likelihood-based approaches allow for
estimation and inference under assumptions that encompass large classes of models. In this way, we can abstract from the peculiarities of the different models, and focus on the general estimation principles. Of course, such an approach implies a cost to be paid, in particular an increase in the level of abstraction required to the students.

2. What we learn from the lesson of Pietro Balestra

During my PhD study I had the great opportunity to see Pietro Balestra teaching econometrics. I can say that my perspective was two-fold, being both that of the student – Pietro has been co-director of my thesis – and that of an « external observer » – I was teaching assistant for some of his courses.

When trying to fit the style of a person within the rigid categories allowed by words, we always incur in a risk of mis-specification. Accepting this risk, let me say that (at least) three main lessons are the legacy of the teacher Pietro Balestra.

The first is the search for simplicity and essentiality. Both words have a rather clear meaning each on its own. But in my opinion it is only by combining them that we can understand the real significance in the case of Pietro’s ideas. The message is that the teacher should identify and highlight the essential elements – the key point, the heart of the topic – and explain it in a simple, clear way. This implies that all unnecessary details, which may confuse the student without giving him a sensible help, should be avoided in the explanation.

The second lesson points to the predominant role of quality over quantity. In Pietro’s mind, it is better to explain in an accurate and detailed way the fundamental aspects of a theory than to give a superficial overview of all points. At the root of this conviction, there is the belief that a student, who has received sound bases on the fundamental points from the teacher, can work out the further steps on his own. At the contrary, a student who has heard about many things but in a superficial way, is not able to solve a new problem alone.

The third lesson of Pietro concerns the power of the example to illustrate to core of the general theory. He was used to prepare for his courses very well-chosen and elaborated examples, which had the characteristic to encompass the main points of the theory put in a concrete and simplified setting. These examples were either presented during the lecture, or formulated as guided exercises for the students. This strategy was also used by Pietro for himself to understand a new econometric method when discussing about research. Indeed, he was used to say: « I need to work out a simple example on my own » – meaning an OLS-type of example to see how the method looks like in such a setting.

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The teaching style of Pietro Balestra may give us some important suggestions about how to address the new challenges in teaching econometrics. The remaining part of this section is dedicated to a re-consideration of the issues raised by the developments in our profession in the light of what we can learn from Pietro's lesson.

In this perspective, a striking duality emerges between some features of modern econometrics and the guiding principles put forward by Pietro. The duality consists in the link between mathematical sophistication and simplicity on the one hand, vastness of the literature and essentiality on the other hand. How should we interpret these pairs of apparently opposing concepts? At a first level of analysis, the increasing mathematical sophistication of modern econometrics may suggest that the search for simplicity is a hard task when teaching nowadays. Similarly, the vast literature may make difficult to identify a small number of essential topics to cover in the lecture. These difficulties are certainly real. However, at the same time, these observations also point out that the call for simplicity and essentiality is nowadays even more important than in the past. It is precisely because the level of sophistication in our research is increasing that the teachers should put a major effort to achieve simplicity in the lectures. Similarly, it is a primal task of the teacher to identify a route through the literature and highlight the essential points, and this task becomes more crucial as the literature gets vaster.

To conclude, the increasing level of complexity and technicality characterizing modern research, together with the ever increasing literature, do raise a difficult challenge for teaching econometrics. The reliance on simplicity and essentiality suggested by Pietro's experience appears to be a strong guiding principle to face this challenge. It will be important in the future to discuss how the principles of simplicity and essentiality can be adequately put into practice in our econometric lectures.

References


