ECONOMETRICS AND MACHINE LEARNING IN BUSINESS AND ECONOMICS EDUCATION: FACTS AND A GUIDELINE ON TEACHING PRACTICES

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Abstract

Econometrics, and related courses, are often thought of as the most challenging courses for many undergraduate economics, business, and management students. Using a large international dataset of business and economics syllabi, I show an upward trajectory in including machine learning topics within business syllabi, with a discernible shift of emphasis from econometrics topics. With the growing number of undergraduate students from diverse backgrounds, there is a growing need to improve the teaching of econometrics and make it more inclusive and applicable. I discuss and formalize actionable guidelines for practices and interventions that can improve econometrics teaching and make it accessible and relevant to increasingly diverse students in economics, business, and management schools.

Keywords:

JEL Classifications:

Introduction

Econometrics is a crucial component of economics education, helping students understand and analyze real-world economic phenomena. However, the complexity and technicality of econometric concepts can sometimes make it a challenging subject for many undergraduate students to grasp (Conaway et al., 2018a). As the number of undergraduate students from diverse backgrounds continues to increase, there is a growing need to improve the teaching of econometrics and make it more inclusive. Another challenge is the growing importance of machine learning in the field of economics and the labor market demand (Athey, 2019; Ishhakov et al., 2020). It is imperative to offer a robust and nuanced education framework in econometrics and related courses such as data analytics and quantitative methods, and in business and economics education for pedagogical purposes and student employability. In this paper, I analyze data from a large number of syllabi from international sources to discuss the current trends of econometrics topics being taught in business and economics programs in comparison with the popular machine learning topics. Recognizing the disparities between the taught topics and an increasingly diverse cohort of economics and business students, I formulate guidelines for practices and interventions that can enhance the teaching of econometrics and promote a sense of belonging for diverse cohorts of undergraduate students.

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To explore key topics in econometrics and machine learning introduced to economics and business students, I explored data from Open Syllabus to identify key topics in econometrics being taught in business and economics curricula worldwide. I focus the analysis on five keywords: “machine learning”, “causality”, “prediction”, “diversity” and “econometrics”, to identify the key trends in the economics curriculums around the world and particularly in English-taught courses. Considering the present-day requirements of economics students seeking to enter the labor market equipped with a robust set of analytical competencies for handling frequently unstructured data derived from businesses, I present an analysis of the pragmatic measures necessary to integrate these topics into econometrics syllabi. The data demonstrates an upward trajectory in the inclusion of machine learning topics within business syllabi, while there is a decline in the presence of econometrics-related subjects across all countries. A discernible shift of emphasis from econometrics to machine learning emerges within the business curriculum.

I then evaluate my own experiences in delivering undergraduate econometrics courses in different programs at two leading universities in the UK. Despite the increasing importance of econometrics in recent years, the way it is taught in introductory courses has remained largely unchanged. The stagnation perhaps is due to a lack of balance in econometric education, where teaching is often focused on techniques rather than problem-solving. There is a belief that understanding data is relatively easy, and the greatest intellectual challenge lies in the mathematical part of econometrics. Drawing from the best practice frameworks established by Angrist & Pischke (2017), Bayer et al. (2019); and Al-Bahrani (2022), I discuss two overarching principles and approaches: (1) to enhance intuitiveness and interest in econometrics, and (2) to facilitate the process of making econometrics more inclusive and applicable for undergraduate students. I formalize the approach by using a framework of five principles with an aim to improve inclusiveness and sense of belonging in econometric classes: namely, (i) creating accessible and applicable content; (ii) choosing and delivering content that addresses the diversity of the real world; (iii) setting students' expectations clearly; (iv) promoting relevance, a sense of belonging, and a growth mindset; (v) and being welcoming and supportive. I discuss actionable practices and interventions that worked and have been highly commended by students.

The article represents a valuable addition to the growing body of literature on econometrics education at the undergraduate level, as exemplified by Colander (2019). Building on the framework established by Al-Bahrani (2022), I contribute to the series of principles for creating an interactive and inclusive classroom environment that supports effective economics education, aligned with the data-based teaching advocated for in recent literature (Conaway et al., 2018b, Angrist and Pishke, 2017). The approach concurs with the notion that students must be prepared to engage in real-world data analysis work, navigating the complexities of unstructured business and economic realities, as emphasized in Kennedy’s (2008) "commandments of applied econometrics.” Drawing on data from Open Syllabus, the analysis contributes to the existing evidence on the lack of diversity and inclusivity in economics (Al-Bahrani, 2022), and expands on research trends in undergraduate economics programs in the United States (Siegfried, 2018) by exploring key econometrics topics taught in major English-speaking countries and around the world from 2010 to 2022. My focus remains on documenting my experiences and principles in econometrics teaching, rather than engaging in the broader pedagogical debate surrounding the econometrics paradigm, as addressed in Kassens (2019) and Swann (2019). It is worth noting that, beyond the commonly taught topics in undergraduate

courses, several studies have examined the use of Bayesian econometric methods in undergraduate education, which may be particularly relevant to students studying fields such as finance, marketing, agricultural economics, and business economics, among others (Koop et al., 2007). Additionally, the emergence of high-frequency finance has given rise to a new area of inquiry known as "high-frequency econometrics," which may be of interest to undergraduate students.

Trends in Economics and Business Curricula: Econometrics vs Machine Learning

The first topic centres around discovering how the economics and business syllabi around the world adapt to the growing importance of machine learning techniques. The key challenge to this quest is data. I first describe the data source and then provide a stylised set of facts on how economics and business syllabi incorporate key topics of econometrics and machine learning over the last ten years.

The Open Syllabus data.

Open Syllabus (https://analytics.opensyllabus.org/) is a comprehensive database of syllabi that provides valuable insight into the trends and patterns in course offerings across various academic disciplines. As a tool for economics research, it allows scholars to analyze the coverage and prominence of specific topics within economics curriculums around the world. With its extensive collection of syllabi from universities and colleges, Open Syllabus provides a valuable source of information for identifying the key topics in econometrics being taught in undergraduate economics programs. As of 2023, there is a set of nearly 16 million syllabi (including 8 million from the US, 1.5 million from the UK, and 1.1 million from Australia) from 62 academic fields from 7337 universities in 114 countries. The archive of books and reading materials covers more than 3 million titles from 2 million authors and nearly 74000 publishers. It is a comprehensive dataset and contextualizes the trends in teaching and program designs from universities, particularly in the three largest English-taught education markets, the US, the UK, and Australia.

Table 1. The Number of Syllabi as of March 2023, and the rank by field by syllabus popularity

Rank of Field	Field	Number of Syllabi (March 2023)
1	Business	1,582,268
2	Computer Science	951,981
3	Mathematics	948,611
5	Engineering	809,598
8	History	551,435
9	Psychology	523,364
11	Political Science	407,420
14	Economics	336,249
18	Sociology	275,806
19	Chemistry	275,482
23	Accounting	192,778
24	Philosophy	175,680
28	Marketing	152,105

Sources: Open Syllabus Analytics (accessed 28 March 2023). I report the fields that are likely to teach econometric concepts.

Table 1 provides a short summary of the current availability of the top fields by syllabus popularity that are related to Econometrics and Statistics. Business and Computer Science are heavily featured in the archive, reflecting their popularity in the education market, with Economics, Political Science, and related fields such as Psychology and Sociology amongst the top 10 – 20 most popular fields. For that reason, I focus on Business and Economics as the two academic fields of the analysis, apart from the growing integration of economics departments into business schools in the English-taught countries.

Analyzing the Trends in Topics Taught in Business and Economics Syllabi

To further understand the trends in teaching econometrics in economics and business education curriculum, I manually collect the trending data for each of the following keywords for Business and Economics: “econometrics,” “machine learning,” “causality,” “prediction,” and “diversity”. I leverage the available data and graphs provided through Open Syllabus Analytics from 2010 to 2022. For each keyword, I compute a raw count by aggregating syllabi including the keyword from the academic field, by each country (in this paper, I use the US, the UK, Australia, Canada, and All countries). The data tracks the appearance of specific concepts and

keywords in each dataset. To make the data comparable, I normalize the frequency of each keyword by the total number of syllabi for each year and interpret the number as the percentage of the annual syllabi that includes the keyword. This exercise provides an overview of the keyword popularity in business and economics curriculum around the world with a focus on the English-taught education market. By specifying the academic fields, I avoid the distribution bias as the analysis will only focus on these fields. One caveat is the use of English versions of the keywords in non-English courses, so that the analysis for All countries may be less representative. I account for such sample bias by also plotting the data for the four main English-taught markets.

Figure 1. The percentages of Business Syllabi that contain Econometrics and Machine Learning Keywords. *Sources*: Own illustration using data from Open Syllabi Analytics.

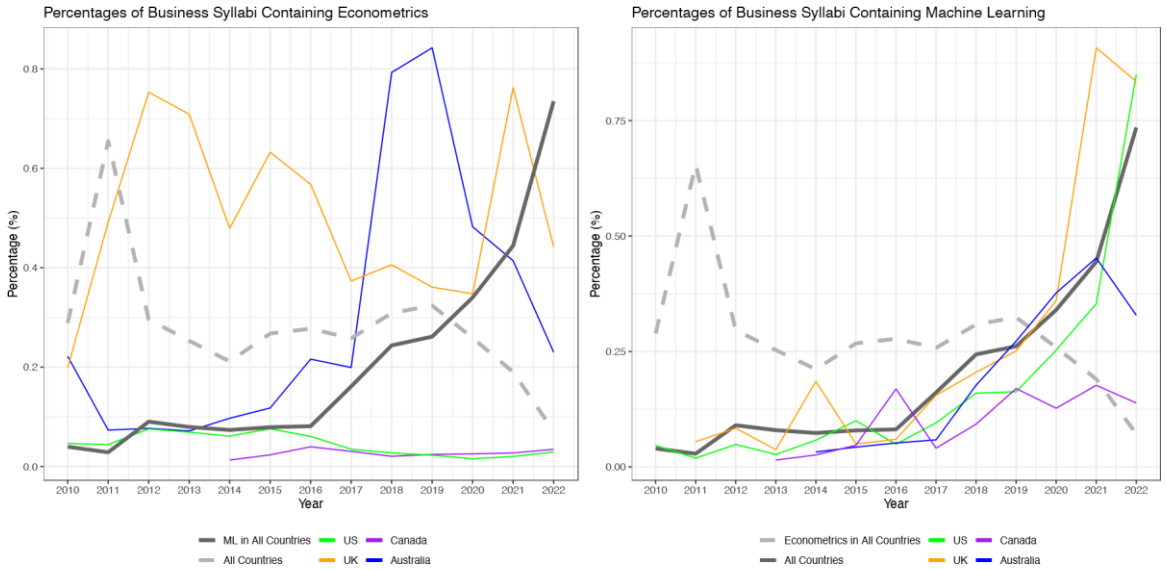


Figure 1 displays the temporal pattern in the proportion of business syllabi referencing econometrics or machine learning from the years 2000 to 2022. The data demonstrates an upward trajectory in the inclusion of machine learning topics within business syllabi, juxtaposed with a decline in the presence of econometrics-related subjects across all countries. A discernible shift of emphasis from econometrics to machine learning emerges within the business curricula. In 2000, machine learning was mentioned in less than 0.05% of business syllabi, whereas by 2022, this figure had escalated to nearly 0.75%. Conversely, notwithstanding a temporary surge in 2011, econometrics has experienced a marked decline in its incorporation within business education, constituting a mere 0.3% of syllabi towards the latter part of 2010. The graph further illustrates the variation in the inclusion of these topics across different countries, with the United States and the United Kingdom exhibiting the highest proportion of syllabi referencing machine learning, trailed by Australia. In contrast, the North American education markets have maintained a relatively steady and limited emphasis on econometrics-related subjects over the past decade, with less than 8% of their syllabi incorporating econometrics. This stands in stark contrast to the diminishing prominence of these topics within the educational landscapes of the United Kingdom and Australia.

Figure 2. The percentages of Economics Syllabi that contain Econometrics and Machine Learning Keywords. *Sources*: Own illustration using data from Open Syllabi Analytics.

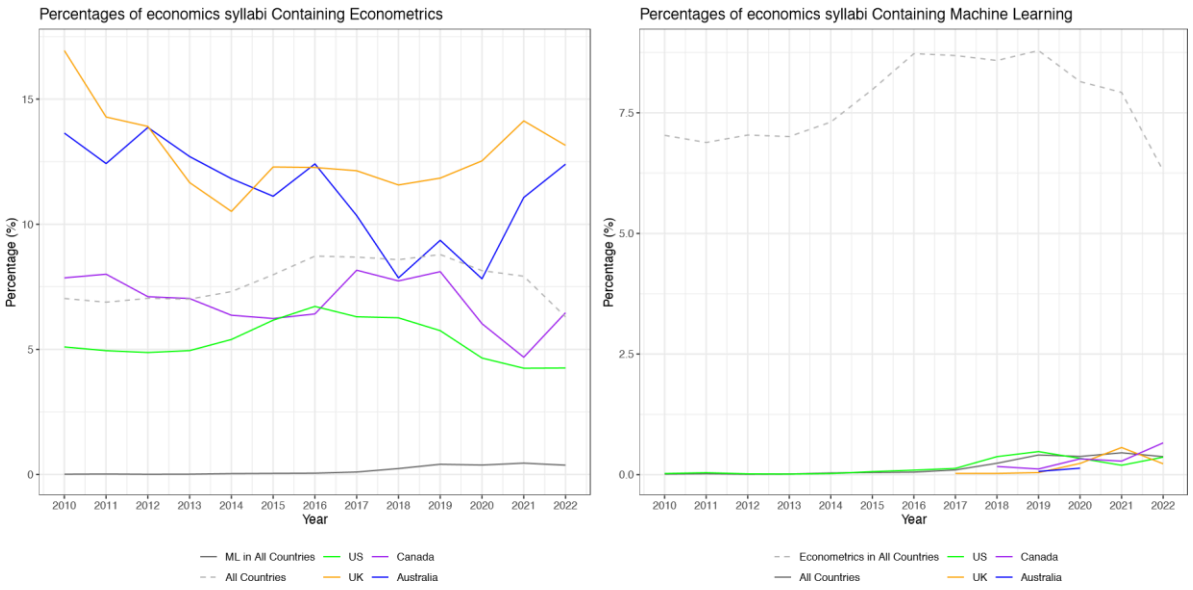


Figure 2 provides an alternative perspective on the prevailing trends in traditional economics education. Across all countries, econometrics continues to occupy a substantial and integral position within the realm of economics instruction, accounting for approximately 10% of the total number of syllabi. This proportion has remained relatively stable over the past decade, with the United Kingdom and Australia emerging as frontrunners in terms of their emphasis on econometrics training. Notably, a potentially concerning observation pertains to the limited mention of machine learning topics within economics education. Less than 1% of economics syllabi explicitly reference the key term "Machine Learning." This trend appears to inadequately reflect the significant impact that machine learning is already exerting on the field of economics (Athey, 2019). While both econometrics and machine learning share the common objective of constructing predictive models that relate explanatory variables (features) to an outcome variable of interest, such as the employment of least-squares methods or support vector machines (Charpentier et al., 2018), fundamental disparities persist. By further enhancing the comprehension of key topics in econometrics and economic modelling, as discussed in Athey & Imbens (2019) and Iskhakov et al. (2020), I provide a reflection on these disparities and promote a robust and nuanced educational framework.[2]

The overall analysis of the data indicates a discernible rise in the inclusion of machine learning-related topics within business syllabi, accompanied by a steady decline in the popularity of econometrics topics. This trend aligns with the prevailing conditions observed in the job market, wherein there has been a substantial increase in demand for labor equipped with machine learning and artificial intelligence skills, particularly within the US economy

[2] One reason, perhaps, for the lack of urgency for introducing more machine learning topics is the similarity in technical details and fundamental differences in the modelling approaches between the fields. Supervised statistical learning methods, an important part of machine learning education at the undergraduate level, are essentially similar to many topics introduced in econometrics but distinctively different in the modelling. While econometrics relies on economic theory and often parametric models in its modelling approach, non-parametric models often built exclusively on the richness of data without distribution assumptions are used in machine learning.

(Alekseeva et al., 2021). This finding underscores the imperative for significant changes in the approach to econometrics teaching and program design to ensure relevance and alignment with the current needs of business and economics students, as well as the labor market's evolving demands.

Causality and Prediction in Economics and Business Education

An ongoing discussion within the field of econometrics revolves around a renewed emphasis on the interpretation of causality and prediction within econometrics instruction, specifically targeting undergraduate education. To examine this phenomenon, I look into the prevalence of causality- and prediction-related topics in economics and business syllabi across various geographical locations. By plotting the trends of the keywords "causality" and "prediction" within both economics and business syllabi worldwide, I aim to shed light on the evolving landscape of instructional priorities in the disciplines.

Figure 3. The percentages of Business and Economics Syllabi that contain causality as a keyword. *Sources*: Own illustration using data from Open Syllabi Analytics.

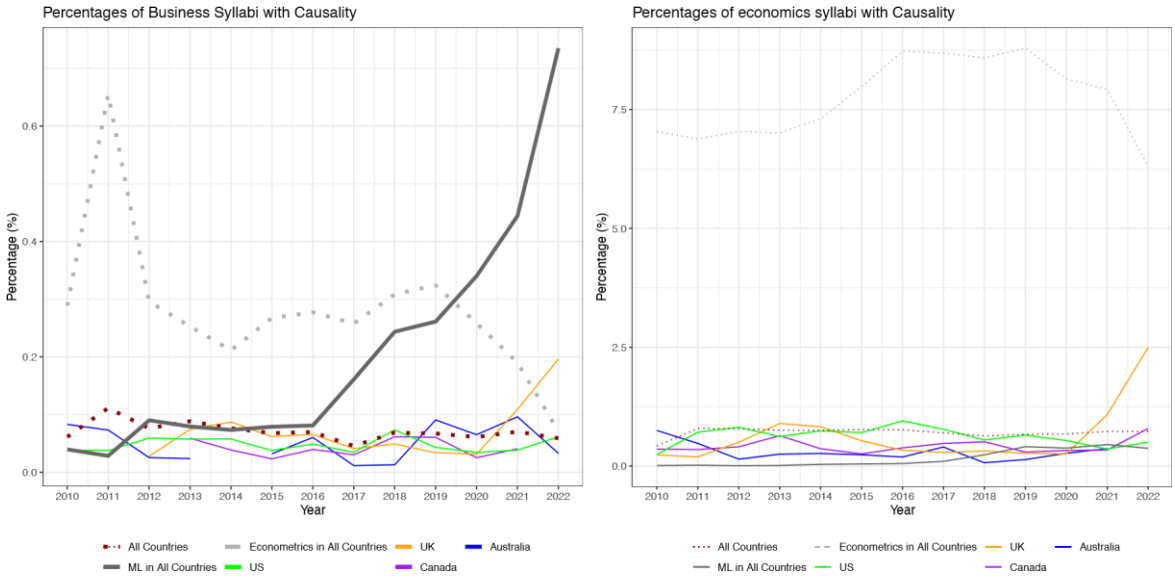


Figure 4. The percentages of Business and Economics Syllabi that contain prediction as a keyword. *Sources*: Own illustration using data from Open Syllabi Analytics.

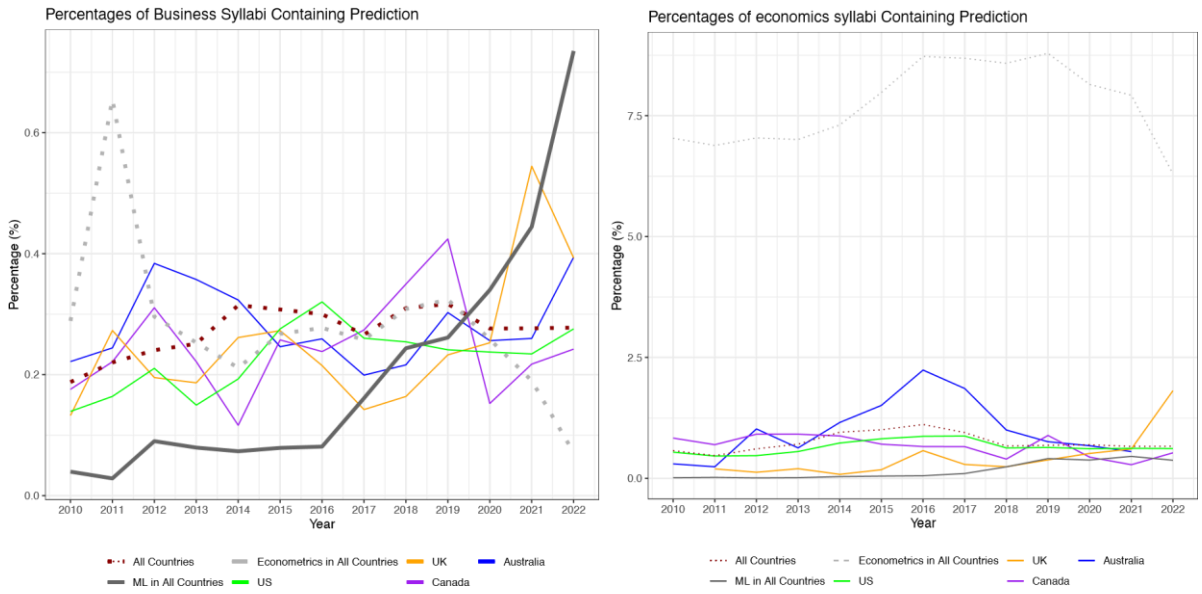


Figure 3 shows a persistent incorporation of causality within the realm of economics education, comprising approximately 0.5% of instructional content worldwide. Notwithstanding the waning popularity of econometrics, the inclusion of courses that address causality constitutes nearly 0.1% of business syllabi in the dataset. Notably, while business and economics departments in the United Kingdom have demonstrated an increased emphasis on causality since 2020, the percentages of curricula featuring causality in other regions of the world have remained relatively stable. Similarly, Figure 4 draws a comparable trend in the prevalence of topics pertaining to prediction within both business and economics education. Despite accounting for a larger proportion of business curricula (approximately 0.3%) and economics curricula (nearly 0.8%) relative to causality, prediction-related subjects have not experienced a significant surge in popularity like the rise of machine learning-focused courses.

In conclusion, this investigation highlights the ongoing transformation within the field of econometrics, with a renewed emphasis on the interpretation of causality and prediction in undergraduate education. By examining the prevalence of causality- and prediction-related topics in economics and business syllabi across different regions, I have gained valuable insights into the evolving landscape of instructional priorities in these disciplines. These findings underscore the need for ongoing adaptability and responsiveness within econometrics instruction. As the job market increasingly demands skills related to machine learning and artificial intelligence, there is a pressing call for econometrics teaching and programs to evolve to remain relevant and align with the needs of business and economics students. This includes incorporating a robust understanding of causality and prediction while exploring the potential synergies between econometrics and emerging paradigms such as machine learning and prediction-based models. By addressing these evolving instructional priorities, educators can equip students with the knowledge and skills necessary to navigate the complex and dynamic landscape of modern economics, fostering their preparedness for the challenges and

opportunities that lie ahead. I present the recommended principles and practices in the coming sections.

The Five Principles for Diverse and Inclusive Econometrics Teaching

Inspired by the best practice frameworks established by (Angrist & Pischke, 2017), Bayer et al. (2019); and (Al-Bahrani, 2022), I propose five major principles for the design of econometrics modules with a focus of improving inclusivity and diversity of the pedagogical approach and fostering a sense of belonging for econometrics learners.

Create Accessible and Applicable Content

First, I argue that econometrics educators must realize and consider the needs of students with diverse abilities, experiences, and mathematics and statistics background to *create accessible and applicable content*. Beyond standard classroom accessibility and learning management system, I argue for a more applicable approach in introductory econometrics teaching that emphasizes relevant, diverse, and real-world examples before introducing abstract and mathematical concepts.

To do this, instructors should use clear and concise language when explaining technical concepts, avoid unnecessary jargon, and provide real-world examples to illustrate how econometric methods are used in practice. Instructors should also make sure that students have the necessary background knowledge and skills before introducing new econometric concepts. Part of the process is to recognize the different needs of students with diverse abilities that are coming to study economics and business courses, in terms of the mathematics and statistics background, with different levels of economic intuition and coding capability. The students' experiences in different approaches to econometrics, between theoretical and empirical, between problem-solving and technique-based learning approaches would guide the focus on the courses at different levels. Digital technologies, at the institutional level with resources on study and skills support, and different flexible coursework components can be used to help improve students' mathematical skills and preparedness for an econometrics course.

In econometrics teaching, the goal is to implement best practices that enhance the learning experience and make the course more accessible to students. These practices are aimed at providing practical and relevant examples, reinforcing foundational knowledge, utilizing online resources, optimizing the learning management system, and maintaining effective communication channels.

One of the key practices is the incorporation of real-life datasets and econometric models derived from actual applications, published research, or own research. By exposing students to these real-world examples, I bridge the gap between theory and practice, enabling students to understand how econometric techniques are employed in different contexts and industries. This approach not only enhances their understanding but also cultivates their critical thinking and analytical skills. To ensure that students have a solid foundation in the mathematical and statistical concepts underlying econometrics, I employ a pre-term quiz focused on these key concepts. This assessment helps identify any knowledge gaps and allows us to provide suggested readings and resources tailored to individual student needs. By addressing these gaps early on, I promote a more inclusive learning environment and support students in their comprehension of complex econometric principles.

During lectures, I incorporate Multiple-Choice Questions (MCQs) that prompt students to recall relevant statistical and mathematical derivations and expressions. These in-lecture MCQs

serve as interactive learning tools, enabling students to actively engage with the material and reinforce their understanding of crucial concepts. By incorporating these interactive elements, I facilitate active participation and encourage students to think critically about the material presented.

In addition to in-class practices, I leverage online materials to supplement students' learning experiences. One valuable resource I utilize is the Econometrics YouTube playlist offered by Marginal Revolution University, featuring lectures by experts such as Angrist. These online resources provide additional explanations, visual aids, and examples that support students' comprehension of challenging econometric topics. By incorporating diverse learning modalities, I cater to different learning styles and enhance accessibility to the course content.

Furthermore, I recognize the importance of an effective learning management system (LMS) in promoting accessibility and organization. I redesign the LMS, such as Moodle or Blackboard, to ensure ease of navigation and clarity in course structure. By providing clear instructions, course materials, and resources within the LMS, I facilitate students' access to the necessary information, assignments, and deadlines. This streamlined approach improves students' experience and allows them to focus more on their learning. To foster open lines of communication and early identification of difficulties, I establish regular and effective channels of student engagement. This includes weekly communications via email or Q&A sessions, providing opportunities for students to seek clarification, share concerns, or ask questions. By promptly addressing student inquiries and concerns, I create a supportive learning environment that values students' needs and encourages their active participation.

In summary, best practices in econometrics teaching encompass incorporating real-life datasets and models, utilizing pre-term quizzes and suggestive readings, employing in-lecture MCQs, leveraging online resources, optimizing the learning management system, and maintaining effective communication channels. By implementing these practices, I aim to enhance accessibility, promote student engagement, and facilitate a deeper understanding of econometric principles, ultimately equipping students with the skills and knowledge necessary for success in the field of econometrics. All these exercises require a great deal of patience.

Choose and Deliver Contents that Address Diversity

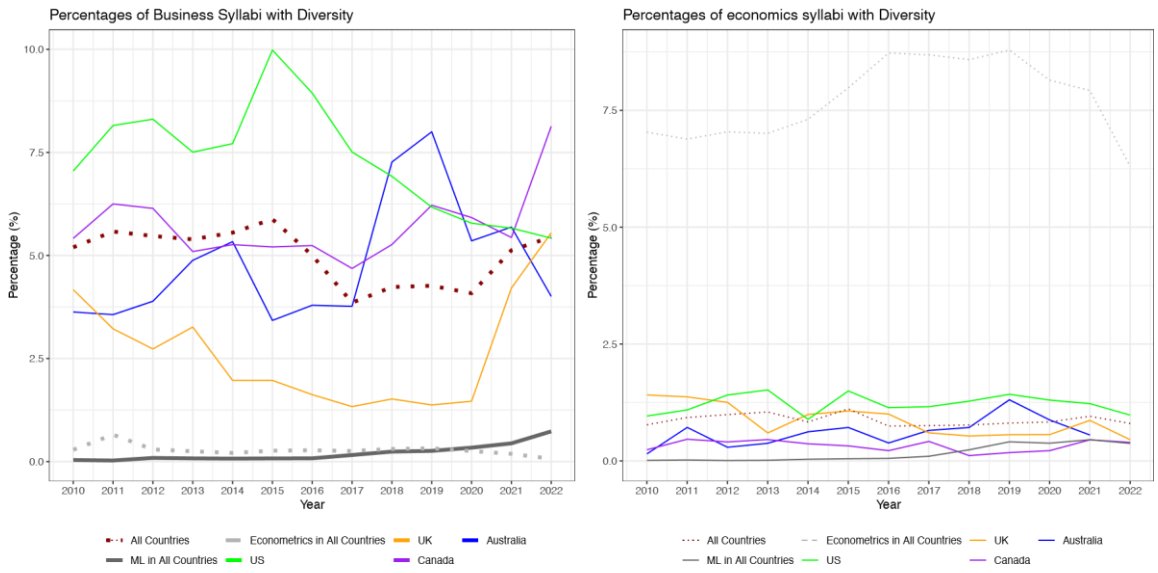
The second principle is to choose and deliver econometrics content that addresses diversity in terms of geographical coverage, economics sub-fields, and pedagogical delivery (visuals, texts, simulations). Instructors should strive to create a learning environment that is inclusive and recognizes the diversity of students' backgrounds, experiences, and learning styles. This can be achieved by using a variety of teaching methods and materials that cater to different learning preferences, as well as by using examples and case studies that reflect a diverse range of economic contexts. Key insights from the analysis of Open Syllabus data suggest an emergence of machine learning topics in business curricula, while topics surrounding causality and predictions remain an important part of economics education.

Instructors can enhance the sense of belonging within the classroom by carefully selecting examples that reinforce the principles of diversity and inclusion. A study conducted by Stevenson & Zlotnick (2018) illustrates the need for such efforts. They examined the representation of men and women in economic textbooks and discovered that the eight leading textbooks were three times more likely to focus on men or utilize male characters in their examples. When women were included, they were often depicted within stereotypical, female-dominated contexts. While this disparity is significant, it also signifies progress.

Figure 5 provides an overview of the current trajectory of diversity as a subject in business and economics education, drawing upon data from the Open Syllabus project. Notably, business courses demonstrate a significantly higher emphasis on diversity-related topics, with these topics being mentioned in over 5% of the analyzed syllabi. In contrast, the inclusion of diversity-related themes in economics courses lags, accounting for a mere 1% of the surveyed syllabi. These trends do not align with the profession's increasing emphasis on diversity and inclusivity. Furthermore, the decline in the proportion of US syllabi mentioning diversity topics since 2015 appears to be a driving force behind these trends, as other countries within the dataset are witnessing a growing interest in these topics.

As for econometrics teaching practices, a key approach is to present econometric concepts in multiple ways to enhance understanding. I employ a three-step approach, starting with real-world examples to illustrate the application of concepts, followed by mathematical notations to establish a solid theoretical foundation, and complemented by visualizations to enhance comprehension. Additionally, I incorporate coding demonstrations using software like Stata or R/Python to provide hands-on experience and practical implementation of the concepts and opportunities for students to familiarize with programming in different languages.

Figure 5. The percentages of Business and Economics Syllabi that contain diversity as a keyword. *Sources*: Own illustration using data from Open Syllabi Analytics.



To ensure diversity in teaching materials, I actively include examples from various fields and sectors. I draw upon datasets and examples from labor economics, macroeconomics, finance (such as mortgage rates), development economics, public policy, and more. Moreover, I strive for geographical coverage by incorporating data from different countries, including the US, UK, China, and developing nations. This cross-country perspective allows students to understand the application of econometric methods in diverse economic contexts.

Promoting diversity issues must be an integral part of the curriculum. Examples of topics in econometrics can be racial discrimination in hiring practices, disparities in mortgage rates based on ethnicity (as exemplified by studies using resumes with Black names), gender biases in teaching evaluations, gender pay gaps, and post-maternity employment challenges. Great resources include the American Economic Association's Diversity, Equity, and Inclusion in Economics (Div.E.Q) initiative, led by Bayer (2021). These materials provide teaching aid for suggestions on how to and incorporate inclusive and innovative approaches supported by empirical evidence.

As for the teaching practice, the key lesson is to approach all issues and evidence with a critical lens, distinguishing between causal and correlational relationships. By adopting this approach, I encourage students to critically analyze research findings, evaluate causal claims, and understand the limitations and assumptions inherent in econometric analysis. This helps students develop a deeper understanding of the complexities and challenges involved in applying econometric methods to real-world scenarios. By this, I believe students will learn with confidence.

Set Students' Expectations Clearly

Third, like the general practices set in undergraduate education, effective and inclusive classroom techniques are to be carefully established to *set students' expectations clearly in terms of classroom environment, course assessment, and educator-student interactions*. Besides discussing the use of digital forums and programs to aid classroom management, I discuss the imbalance between the technique-oriented approach and problem-oriented approach in econometrics teaching that often does not well prepare students for real-world econometric work, and in my experience, their expectations about assessments against the marking rubrics.

As for econometrics teaching, I prioritize creating a conducive classroom environment where students feel comfortable and engaged. Educators play a crucial role in establishing this environment by being transparent about expectations. I ensure that students have a clear understanding of the assessment criteria, exam formats, coursework requirements, and grading standards. By providing this transparency, I avoid making assumptions about students' prior knowledge or familiarity with the educational system. Setting the right expectation of econometrics being "precise" is key to making the econometrics learning process more inclusive in the broader sense for prospective social sciences and business students considering studying introductory econometrics (Colander, 2019; Swann, 2019).

Another important aspect is addressing the expectations gap that may exist, particularly among first-generation students. (Collier & Morgan (2008) highlight that first-generation students often face challenges in navigating and understanding the academic expectations of higher education. Educators can strive to bridge this gap by providing explicit guidance and support to these students, ensuring they have the necessary resources to succeed in econometrics courses.

One popular topic in my teaching is to acknowledge the existence of the "hidden curriculum," which refers to the implicit messages and norms embedded within educational institutions. Apple (1971) and Bergenhenegouwen (1987) emphasize that the ability to uncover and navigate this hidden curriculum can be influenced by students' family backgrounds. Recognizing this, I actively work towards minimizing any barriers that students may face in deciphering the unwritten rules and expectations of the educational system. By being aware of these potential disparities, I aim to create an inclusive learning environment that supports

students from diverse backgrounds. Employing diverse modes of communication and reinforcing information dissemination aids in enhancing accessibility to information and fostering discussions. Platforms like Piazza or Moodle/Blackboard online forums can be utilized as alternatives to relying solely on personal email channels.

In summary, I prioritize transparency, clarity, and inclusivity in my econometrics teaching. Educators should ensure that students are aware of the classroom expectations, assessment criteria, and grading standards. I strive to bridge the expectations gap, especially among first-generation students, by providing explicit guidance and support. Additionally, I acknowledge the existence of the hidden curriculum and work to minimize any barriers that students may encounter based on their family backgrounds. Through these practices, I aim to create an inclusive and equitable learning environment for all students in my econometrics courses. And these activities require a consistent level of discipline.

Promote Relevance, Sense of Belonging and Growth Mindset

The fourth principle is to promote the relevance of econometrics to students' lives and their future careers. Instructors should show how econometric methods can be applied to real-world economic problems, such as poverty, inequality, and climate change. They should also encourage a growth mindset among students, promoting the idea that econometrics is a valuable and relevant skill that can be developed through practice and hard work. Instructors should also strive to create a sense of belonging among students, making them feel valued and supported in their learning journey.

In my teaching, I employ a range of activities to foster a sense of belonging. One approach is to increase exposure to diverse mentors and peers, providing students with role models who come from various backgrounds. Utilizing resources like CORE and MRU videos, such as "Economists in Action," "Women in Economics," and "Economists in the Wild," can showcase the real-world applications of economics and the diverse perspectives within the field. Another approach is to highlight the work of Nobel Prize winners in economics, incorporating their lectures and discussing their contributions during class or organizing special events during the Nobel Prize Week. Econometrics lectures and exercises should not shy away from providing examples and readings from a wide range of authors and different topics and econometric settings. Additionally, incorporating examples of pop culture econometrics, such as those found in "Freakonomics" or music videos that relate to economic concepts (e.g., Marginal Revolution University), can help students connect with the subject matter based on their personal interests. Between or before classes, instructors can introduce an "Econometrician of the Day" before class, presenting information about a featured econometrician or statistician and their primary research question related to recent related events. This practice allows students to be exposed to diverse economists and the varied topics they study, thereby broadening students' understanding of the profession and increasing the subject's relevance.

Incorporating interactive elements in lectures, such as in-lecture polling through platforms like Zoom Poll, Teams, Poll Everywhere, or Turningpoint, helps engage students and reinforce key concepts. Utilizing tools like Padlet can offer a smaller and more personalized platform for class discussions. Visualizations, including animations and gadgets, can be employed to demonstrate complex econometric concepts such as regression, bad control, instrumental variables (IV), and the central limit theorem (CLT).

Providing clear feedback and opportunities for improvement after coursework and exams, including grade distribution, enables students to understand their performance and areas for

growth. Following exams, sending congratulatory emails, and encouraging students' continued interest in economics and further study can further enhance their sense of belonging. In a related paper, Dang and Radu (mimeo) introduce a system of Peer Support Tutor in which students in their senior years act as academic mentors for junior students taking courses in statistics and introductory econometrics. The Peer Support scheme has been a well-received initiative for both the mentors and mentees.

Instructors can also utilize welcome emails to increase students' sense of belonging. Bayer, Bhanot, and Lozano (2019) show that sending emails to incoming first-year women and underrepresented minority (URM) students, explicitly discussing diversity in the field of economics, can increase their completion of economics courses during the fall semester. This highlights the importance of raising student awareness of diversity in the field to enhance their interest and engagement.

By implementing these best practices, econometrics teaching can become more inclusive, diverse, and engaging, providing students with a supportive environment that fosters their sense of belonging, encouraging them to further study and apply econometrics.

Being Welcoming and Supportive

We emphasize the vital role of *being welcoming and supportive* in facilitating a sense of belonging at the undergraduate level, not just simply for econometrics teaching but for economics education in general. Instructors should create a positive and supportive learning environment that encourages student participation, questions, and feedback. They should also be approachable and available to students outside of class, providing support and guidance when needed. Particularly, I discuss two initiatives adopted in my econometrics courses: establishing incentivization of course participation and introducing a Peer Support program for students in a junior year. I also discuss used practices, perhaps already popularized and adopted by other colleagues, to help students' transition from mathematics and statistics training in high school to the university econometrics level.

Creating a welcoming environment through emails and messages, with clear and transparent communication, enthusiastic tone, and consideration for students' well-being, can significantly impact students' engagement and sense of belonging. Sharing study tips, acknowledging preferred pronouns, expressing passion for the course, and demonstrating care for students' progress contribute to a positive learning experience. Rather than solely offering office hours, dedicating specific hours for student feedback and support encourages attendance, especially among first-generation or international students. Incorporating continual and informal feedback from students, such as through "Stop-Start-Continue" exercises or short surveys, enables instructors to make improvements based on student input. This practice is particularly valuable for less experienced teachers and can have a lasting effect on students' learning experience. Regular meetings with class teachers can help establish a connection and provide ongoing support, particularly fostering the passion for teaching and identifying early issues and feedback on the course.

To create a supportive and engaging environment for econometrics students, several practices can be implemented. Incentives to promote student participation in the course can encourage active engagement. This can be achieved through responsive communication on platforms like Piazza, where instructors strive to maintain a quick average response time (in my courses, the average has been 1 hour and 23 minutes). By providing timely feedback and addressing students' inquiries, instructors demonstrate their commitment to supporting students'

learning journey. Encouraging discussions rather than providing immediate answers can foster a collaborative learning environment. Instructors can create opportunities for students to share their thoughts, ask questions, and engage in peer-to-peer interactions. This approach promotes critical thinking and allows students to develop a deeper understanding of econometric concepts through active participation.

Recognizing and celebrating student engagement, the "Excellence in Econometrics Participation Award" can be awarded to students who consistently demonstrate active involvement in the course. This award not only acknowledges students' efforts but also motivates others to actively participate in class discussions and activities. Another initiative is to involve students as part of the education journal. Implementing a peer support program, where junior year students are paired with senior year students, can provide additional guidance and mentorship. This program allows students to connect with their peers who have more experience in econometrics, fostering a sense of camaraderie and creating a support system within the student community.

Research has shown that repeated math quizzes can improve student learning (Leggett et al., 2022). Incorporating regular math and statistics quizzes throughout the course helps reinforce foundational knowledge and allows students to practice their skills. These quizzes serve as formative assessments, providing students with opportunities to identify areas for improvement and enhance their understanding of mathematical concepts. Encouraging students to pursue research and empirical analysis using available data can deepen their understanding of econometrics. Instructors can provide guidance and resources for students to explore real-world datasets and conduct their own analysis. This hands-on approach empowers students to apply their knowledge to practical scenarios and develop critical research skills. One institution-wide approach is to invite students to be change-makers and contribute to the improvement of the courses and the educational experience. Instructors can encourage students to provide feedback on what aspects of the course can be enhanced or suggest innovative ideas for implementation, with resources for them to conduct necessary research and surveys to provide evidence-based recommendations. This inclusive approach not only values students' opinions but also empowers them to take ownership of their learning.

Promoting reproducibility and replication practices among students highlights the importance of transparency and rigor in econometrics. Instructors can introduce students to the principles of replicable research, emphasizing the significance of documenting methodologies and sharing code and data. By fostering good research practices, students develop a deeper appreciation for the integrity of econometric analysis and contribute to the overall advancement of the field.

Finally, enthusiasm plays a crucial role in creating an engaging and supportive learning environment. Instructors should approach each class session with enthusiasm and passion, conveying their love for econometrics. Enthusiastic teaching motivates students, sparks their curiosity, and instils a sense of excitement about the subject matter. This positive energy can inspire students to actively participate, ask questions, and explore econometrics beyond the classroom. By implementing these best practices, econometrics instructors can create an inclusive and supportive learning environment that encourages student involvement, fosters collaboration, and promotes academic growth. It demonstrates a strong sense of compassion.

Some Proven Practices

In addition to the overarching principles and approaches, there are five specific practices that I have found to be effective in making econometrics intuitive and interesting for students.

i Using Visual Aids: Using visual aids, such as graphs and diagrams, can help students understand complex econometric concepts more easily.

ii Incorporating Active Learning: Incorporating active learning strategies, such as group work and problem-solving activities, can help students engage with econometrics content more actively and effectively.

iii Providing Regular Feedback: Providing regular feedback to students on their progress and performance can help them identify areas for improvement and adjust their learning strategies accordingly.

iv Encouraging Peer Learning: Encouraging peer learning, through activities such as peer review and group discussions, can help students learn from each other and develop a sense of community in the classroom.

v Making Use of Technology: Making use of technology, such as different econometric software and online resources, can help students apply taught concepts to practice and further encourage their own learning outside of the classroom.

Conclusion

The paper argues that econometrics educators must be intentional in creating an inclusive and engaging learning environment for diverse cohorts of undergraduate students. I have proposed five major principles and best practice frameworks for economics education: creating accessible and applicable content, choosing diverse and relevant examples, setting clear expectations for students, promoting a sense of relevance, belonging, and growth mindset, and being welcoming and supportive of students. Based on the data from a comprehensive archive of syllabi around the world, I identify several interesting trends in econometrics teaching in business and economics departments to guide the principles and future practices. I have also provided some qualitative results from two undergraduate/introductory econometrics courses at two large economics and business programs. By implementing these principles and practices, I hope that econometrics education can become more intuitive, interesting, and inclusive for undergraduate students.

The paper shies away from the technical and methodological debates around radical changes in the undergraduate econometrics' curriculum. The aim is more modest: sharing practices and key principles to make students feel welcomed, supported, and belong to one of the most exciting and rewarding courses in economics and business education.

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