GLOBAL EDITION

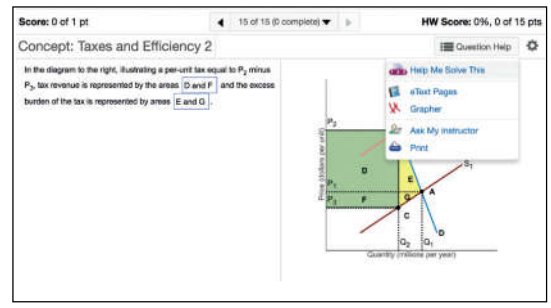
Introduction to Econometrics

FOURTH EDITION

James H. Stock • Mark W. Watson

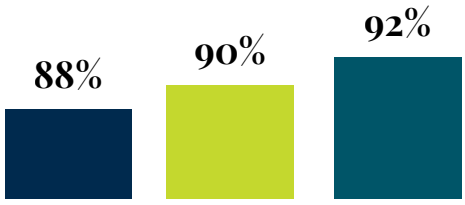
Question Help

MyLab Economics homework and practice questions are correlated to the textbook, and many generate algorithmically to give students unlimited opportunity for mastery of concepts. If students get stuck, Learning Aids including Help Me Solve This and eText Pages walk them through the problem and identify helpful information in the text, giving them assistance when they need it most.



"[MyLab Economics] provides ample practice and explanation of the concepts at hand."

— Heather Burkett, University of Nebraska at Omaha



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Pearson eText enhances student learning—both in and outside the classroom. Worked examples, videos, and interactive tutorials bring learning to life, while algorithmic practice and self-assessment opportunities test students' understanding of the material. Accessible anytime, anywhere via MyLab or the app.

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of students would tell their instructor to keep using MyLab Economics

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James H. Stock
Harvard University

Mark W. Watson
Princeton University

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Brief Contents

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Contents

Key Concepts

PART ONE Introduction and Review

PART TWO Fundamentals of Regression Analysis

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General Interest Boxes

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Preface

Econometrics can be a fun course for both teacher and student. The real world of economics, business, and government is a complicated and messy place, full of competing ideas and questions that demand answers. Does healthcare spending actually improve health outcomes? Can you make money in the stock market by buying when prices are historically low, relative to earnings, or should you just sit tight, as the random walk theory of stock prices suggests? Does heavy intake of coffee lower the risk of disease or death? Econometrics helps us sort out sound ideas from crazy ones and find quantitative answers to important quantitative questions. Econometrics opens a window on our complicated world that lets us see the relationships on which people, businesses, and governments base their decisions.

Introduction to Econometrics is designed for a first course in undergraduate econometrics. It is our experience that to make econometrics relevant in an introductory course, interesting applications must motivate the theory and the theory must match the applications. This simple principle represents a significant departure from the older generation of econometrics books, in which theoretical models and assumptions do not match the applications. It is no wonder that some students question the relevance of econometrics after they spend much of their time learning assumptions that they subsequently realize are unrealistic so that they must then learn "solutions" to "problems" that arise when the applications do not match the assumptions. We believe that it is far better to motivate the need for tools with a concrete application and then to provide a few simple assumptions that match the application. Because the methods are immediately relevant to the applications, this approach can make econometrics come alive.

To improve student results, we recommend pairing the text content with MyLab Economics, which is the teaching and learning platform that empowers you to reach every student. By combining trusted author content with digital tools and a flexible platform, MyLab personalizes the learning experience and will help your students learn and retain key course concepts while developing skills that future employers are seeking in their candidates. MyLab Economics helps you teach your course, your way. Learn more at www.pearson.com/mylab/economics.

New To This Edition

- New chapter on "Big Data" and machine learning
- Forecasting in time series data with large data sets

- Dynamic factor models
- Parallel treatment of prediction and causal inference using regression
- Coverage of realized volatility as well as autoregressive conditional heteroskedasticity
- Updated discussion of weak instruments

Very large data sets are increasingly being used in economics and related fields. Applications include predicting consumer choices, measuring the quality of hospitals or schools, analyzing nonstandard data such as text data, and macroeconomic forecasting with many variables. The three main additions in this edition incorporate the fundamentals of this growing and exciting area of application.

First, we have a new chapter (Chapter 14) that focuses on big data and machine learning methods. Within economics, many of the applications to date have focused on the so called many-predictor problem, where the number of predictors is large relative to the sample size—perhaps even exceeding the sample size. With many predictors, ordinary least squares (OLS) provides poor predictions, and other methods, such as the LASSO, can have much lower out-of-sample prediction errors. This chapter goes over the concepts of out-of-sample prediction, why OLS performs poorly, and how shrinkage can improve upon OLS. The chapter introduces shrinkage methods and prediction using principal components, shows how to choose tuning parameters by cross-validation, and explains how these methods can be used to analyze nonstandard data such as text data. As usual, this chapter has a running empirical example, in this case, prediction of school-level test scores given school-level characteristics, for California elementary schools.

Second, in Chapter 17 (newly renumbered), we extend the many-predictor focus of Chapter 14 to time series data. Specifically, we show how the dynamic factor model can handle a very large number of time series, and show how to implement the dynamic factor model using principal components analysis. We illustrate the dynamic factor model and its use for forecasting with a 131-variable dataset of U.S. quarterly macroeconomic time series.

Third, we now lay out these two uses of regression—causal inference and prediction—up front, when regression is first introduced in Chapter 4. Regression is a statistical tool that can be used to make causal inferences or to make predictions; the two applications place different demands on how the data are collected. When the data are from a randomized controlled experiment, OLS estimates the causal effect. In observational data, if we are interested in estimating the causal effect, then the econometrician needs to use control variables and/or instruments to produce as-if randomization of the variable of interest. In contrast, for prediction, one is not interested in the causal effect so one does not need as-if random variation; however, the estimation ("training") data set must be drawn from the same population as the observations for which one wishes to make the prediction.

This edition has several smaller changes. For example, we now introduce realized volatility as a complement to the GARCH model when analyzing time series data with volatility clustering. In addition, we now extend the discussion (in a new general interest box) of the historical origins of instrumental variables regression in Chapter 12. This treatment now includes a first-ever reproduction of the original derivation of the IV estimator, which was in a letter from Philip Wright to his son Sewall in the spring of 1926, and a discussion of the first IV regression, an estimate of the elasticity of supply of flaxseed.

Solving Teaching and Learning Challenges

Introduction to Econometrics differs from other texts in three main ways. First, we integrate real-world questions and data into the development of the theory, and we take seriously the substantive findings of the resulting empirical analysis. Second, our choice of topics reflects modern theory and practice. Third, we provide theory and assumptions that match the applications. Our aim is to teach students to become sophisticated consumers of econometrics and to do so at a level of mathematics appropriate for an introductory course.

Real-World Questions and Data

We organize each methodological topic around an important real-world question that demands a specific numerical answer. For example, we teach single-variable regression, multiple regression, and functional form analysis in the context of estimating the effect of school inputs on school outputs. (Do smaller elementary school class sizes produce higher test scores?) We teach panel data methods in the context of analyzing the effect of drunk driving laws on traffic fatalities. We use possible racial discrimination in the market for home loans as the empirical application for teaching regression with a binary dependent variable (logit and probit). We teach instrumental variable estimation in the context of estimating the demand elasticity for cigarettes. Although these examples involve economic reasoning, all can be understood with only a single introductory course in economics, and many can be understood without any previous economics coursework. Thus the instructor can focus on teaching econometrics, not microeconomics or macroeconomics.

We treat all our empirical applications seriously and in a way that shows students how they can learn from data but at the same time be self-critical and aware of the limitations of empirical analyses. Through each application, we teach students to explore alternative specifications and thereby to assess whether their substantive findings are robust. The questions asked in the empirical applications are important, and we provide serious and, we think, credible answers. We encourage students and instructors to disagree, however, and invite them to reanalyze the

data, which are provided on the text's Companion Website (**www.pearsonglobaleditions.com**) and in MyLab Economics.

Throughout the text, we have focused on helping students understand, retain, and apply the essential ideas. *Chapter introductions* provide real-world grounding and motivation, as well as brief road maps highlighting the sequence of the discussion. *Key terms* are boldfaced and defined in context throughout each chapter, and *Key Concept boxes* at regular intervals recap the central ideas. *General interest boxes* provide interesting excursions into related topics and highlight real-world studies that use the methods or concepts being discussed in the text. A *Summary* concluding each chapter serves as a helpful framework for reviewing the main points of coverage.

Available for student practice or instructor assignment in MyLab Economics are *Review the Concepts questions, Exercises,* and *Empirical Exercises* from the text. These questions and exercises are auto-graded, giving students practical hands-on experience with solving problems using the data sets used in the text.

- 100 percent of Review the Concepts questions are available in MyLab.
- Select Exercises and Empirical Exercises are available in MyLab. Many of the Empirical Exercises are algorithmic and based on the data sets used in the text. These exercises require students to use Excel or an econometrics software package to analyze the data and derive results.
- New to the 4th edition are concept exercises that focus on core concepts and economic interpretations. Many are algorithmic and include the Help Me Solve This learning aid.

Contemporary Choice of Topics

The topics we cover reflect the best of contemporary applied econometrics. One can only do so much in an introductory course, so we focus on procedures and tests that are commonly (or increasingly) used in practice. For example:

- ***Instrumental variables regression.*** We present instrumental variables regression as a general method for handling correlation between the error term and a regressor, which can arise for many reasons, including omitted variables and simultaneous causality. The two assumptions for a valid instrument—exogeneity and relevance—are given equal billing. We follow that presentation with an extended discussion of where instruments come from and with tests of overidentifying restrictions and diagnostics for weak instruments, and we explain what to do if these diagnostics suggest problems.
- ***Program evaluation.*** Many modern econometric studies analyze either randomized controlled experiments or quasi-experiments, also known as natural experiments. We address these topics, often collectively referred to as program