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Teaching basic econometric concepts using Monte Carlo simulations in Excel

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ABSTRACT

Monte Carlo experiments can be a valuable pedagogical tool for undergraduate econometrics courses. Today this tool can be used in the classroom without the need to acquire any specialized econometrics software. This paper argues that Microsoft Excel, which is already available at many office and home computer stations, offers the opportunity to run meaningful Monte Carlo simulations and to successfully teach students basic econometric concepts. The reader is guided, step-by-step, through two different exercises. The first one is a repeated sampling exercise showing that least squares estimators are unbiased. The second one expands on the first to explain the true meaning of confidence interval estimates of least squares estimators.

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1. Introduction

Monte Carlo experiments rely on repeated random sampling to simulate and compute results of interest to researchers, instructors or students. Undergraduate econometrics textbooks make use of Monte Carlo simulations to help teach basic econometric concepts. In [Gujarati and Porter \(2009\)](#), the authors state that the reader will be asked to conduct Monte Carlo experiments using different statistical packages (p.12). [Hill et al. \(2011\)](#) illustrate the sampling properties of the least squares and interval estimators in the beginning chapters of their textbook (pp. 88–93 and pp. 127–129). In later chapters, they make use of Monte Carlo simulations to explore the properties of the least

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squares estimator in the case of random independent variables (pp. 273–4, 280) and limited dependent variables (pp. 442–4). Murray (1999) points out that “Monte Carlo techniques offer a rich device for discovery learning” (p. 308–9). He further states that “as I explored the potential of Monte Carlo techniques for learning econometrics, I realized how much Monte Carlo methods highlight the central role of sampling properties in econometrics” (p. 309). In his preface for teachers, Murray (2006) explains that his textbook “starts out with the Monte Carlo approach to estimators” and “returns to Monte Carlo analyses to facilitate learning about heteroskedasticity, errors in variables, and consistency” (p. xxvii and p. xxx). Kennedy (2008, 1998a, 1998b) is a strong advocate of Monte Carlo experiments as a pedagogical tool for undergraduate econometrics courses. He suggests the use of “explain how to do a Monte Carlo study” problems to teach student the sampling-distribution concept which, he argues, is the “statistical lens” allowing students to make sense of the statistics world (1998a, 1998b). He proposes an array of such problems in Appendix D of his textbook (2008).

Kennedy recommends that instructors do not ask students to actually do a Monte Carlo study (1998a). He cautions of the high opportunity cost of having them learn how to program (1998b). Although Murray (1999) “eagerly champions” using computers to teach econometrics and allow “a hands-on, discovery mode of learning”, he also warns that a computer classroom can be very costly in faculty time and institutional dollars (p. 308).

We, on the other hand, following Judge (1999) and Craft (2003), argue that Microsoft Excel offers the means to run meaningful Monte Carlo simulations and to successfully teach students basic econometric concepts, at a relatively low opportunity cost. Cahill and Kosicki (2000 p. 771) offer this perfect summary of arguments for using Microsoft Excel:

From a practical perspective, spreadsheet software such as Excel is a natural choice to use in exploring economic models because it is widely available on most campuses. This availability eliminates the task of seeking funding for the purchase and support of specialized software packages. In addition, spreadsheet software is relatively easy to use, and its flexibility makes it useful in many different courses at all levels of the traditional economics curriculum. Most economics students almost certainly will use it after graduation in both career and personal settings. Most important, it minimizes black-box features that characterize much computer-assisted learning software.

Our paper differs from Judge (1999) and Craft’s (2003) in that we restrict ourselves to presenting how Monte Carlo simulations can be run in Excel. Instructors will decide for themselves how to incorporate them in their econometrics courses. Our exposition includes many screen shots and provides step-by-step instructions for using Excel to run the Monte Carlo simulation exercises.

The first Monte Carlo simulation exercise we go through is a repeated sampling exercise showing that least squares estimators are unbiased. The second one expands on the first to explain the true meaning of confidence interval estimates of least squares estimators.

2. Repeated sampling and unbiasedness

Following Hill et al. (2011) and Briand and Hill (2012), the examples that follow are developed around the idea of studying the relationship between household weekly income and their corresponding weekly expenditure on food. We consider the experiment of randomly selecting households from a population, and subsequently estimating the simple linear regression model: $y = \beta_1 + \beta_2 x + e$, where y represents weekly food expenditure and x represents weekly income. In a Monte Carlo experiment the repeated sampling properties of estimators and tests are observed directly, by creating many samples of data, applying an estimator or test to each sample, recording the outcomes, and then summarizing the outcomes. Samples are created using a specific data generating process (DGP) by which we create a sample of N values. The ingredients of the DGP include (i) choosing the sample size N , (ii) choosing x values (which may be fixed in repeated samples, or not) (iii) selecting parameter values, and (iv) randomly selecting values of the regression error terms e from a probability distribution with a given mean and variance. Given these elements we can “create” an outcome y via a process that resembles a controlled experimental outcome.

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