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Some Milestones in Econometric Computing

Introduction

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The short articles in this section are, for the most part, memoir descriptions of econometric computing in its various phases during the early days from about 1953 to the period of sustained expansion during the 1970s. The year 2003 essentially marks the 50th anniversary of the first development of econometric software, including the publication, that year, by Brown, Houthakker, and Prais of a still informative article on electronic computation in economic statistics in the *Journal of the American Statistical Association*, as well as early computational work towards the development of the first regression package by Lucy Slater, working with M.J. Farrell, all at the Department of Applied Economics at the University of Cambridge, and the use of the computer by Klein, Goldberger, and colleagues at the University of Michigan to calculate moments in preparation for parameter estimation. However, whereas this collective milestone marks the first step, in actuality it took another 10 years before the use of the computer began to become at all general. Throughout the 1950s, and even into the 1960s, the standard computing device remained for economists the electromechanical desk calculator. The 1960s were the period of transition, the point in time that the computer became a common applied research tool, and economists moved beyond applying it to calculations that were in principle possible using hand methods to those that fundamentally either required a computer or else a literal lifetime to perform a single (albeit complex) task.

The first milestone article is by Arthur Goldberger, who describes aspects of the pre-computer era and recalls some of the trials and tribulations associated with the desk calculator. These devices could occasionally be seen on desks in economic departments as late as the 1970s, but not much later. Consequently, anyone much younger than 50 is unlikely to have seen such a device in operation, with the possible exception of someone who has visited a museum. However, a point of interest of the Goldberger memoir is not just the glimpse of a bygone era it affords, but also a sense of the continuity of applied economic research. The calculations still performed today, in their operative characteristics, are the same as those performed then. The differences are the speed with which they are performed (not to mention the associated human ease of the modern laptop computer) and certain algorithmic differences that reflect the need to deal with roundoff and other numeric errors in a somewhat different way in each context. Of course, because of the speed with which calculations can now be performed, much can be done today that simply could not even be attempted then.

Lucy Slater's memoir begins the description of the use of the computer, but as you turn to her contribution do not expect to be brought face to face with a machine anything like what you may be used to, for this is $t = 0$. The machines then, the EDSAC at the University of Cambridge, the ENIAC and the EDVAC at the University of Pennsylvania, or the Whirlwind at the Massachusetts Institute of Technology, all predate both the Cathode Ray Tube (CRT) terminal, and the line printer, each of which of course themselves much predate the flatscreen monitor or the modern inkjet or laser printer. The particular machine that is here described is one that until about 1951–52 was both input- and output-challenged, and cobbled together from scavenged parts. This machine also marks the dawn of programming, which itself then needed to be defined in its characteristics as an activity: this was the pre-Formula Translation (FORTRAN) and pre-transistor era, not to mention the real Johnny-come-latelies, such as C or C+. Tape drives, disk drives, printers, and other computer peripherals (with the notable exception of punch card devices) were then at best only twinkles in the eyes of their creators. Moreover, even at the end of that decade, IBMfls then latest and greatest machine, its first transistor-based computer, was oil-cooled.

The year 1960 roughly defines the point at which computers, as collections of transistor circuits and what today would be easily recognized assemblages of peripheral devices, began to be manufactured and installed for widespread use. These second generation machines were the first to offer their users software tools, such as ALGOL, COBOL, FORTRAN and other compilers, as well as object libraries, that enabled young economists at various universities around the world to begin to develop econometric software. The memoir by Charles Holt describes one of the results of having available one of the later first generation computers, the IBM 650, which permitted the first computer implementation of the then rather computer-challenging Holt-Winters forecasting technique by Winters in 1959–60. Fortunately, the technique was not particularly demanding in terms of memory requirements, inasmuch as the IBM 650 offered only 2K of 10 digit word storage. Interestingly, Although the Holt-Winters technique has had widespread practical application during the past more than 40 years, the theoretical basis of this technique has not yet actually been published in the literature. Today, Holt's original article can be obtained as a research memorandum from the University of Texas Engineering Library, but stimulated by Holt's memoir, it will now be published in 2004.

Rex Bergstrom, as a graduate student, was present in Cambridge during the period described by Slater's memoir and used EDSAC. In antipodal New Zealand, in the early 1960s, his graduate students began to use the IBM 1620 to program linear and non-linear, single and simultaneous equation parameter estimation algorithms. The memoir by Peter Phillips and Viv Hall describes computing at the University of Auckland during the 1960s, not only the development of models of the New Zealand economy, but also the characteristics of two of the IBM computers of that time and some interesting and even amusing aspects of their hands-on operation. These authors also provide additional retrospective on the use of EDSAC at Cambridge by Bergstrom.

At more or less the same time, but in the United States, development of progressively larger scale models at, principally, the University of Pennsylvania and the contemporaneous development of the Brookings Quarterly Econometric Model of the United States by scholars at a number of institutions, not all in the United States, lead to the need to develop efficient computer algorithms to solve these large scale models. Even as late as 1968, and in possibly one or two cases even later, models estimated using the computer were still being solved on desk calculators. The article by George Schink published here addresses this quest for efficient solution and in fact incorporates verbatim a never-before-published paper, he originally presented at an Association for Computing Machinery meeting in June of 1970. The present day introduction by Schink describes the context of this paper, but the paper itself conveys a good sense of the process of the discovery of an appropriate model solution algorithm during those years.

In contrast to the early stages of the use of the computer, which generally involved the development of specific algorithms, as described in the foregoing memoirs, in the middle 1960s, with the development of increasingly large scale econometric models, it became important to create software systems that not only performed the necessary computations, but also managed the process of econometric model construction and use. The next memoir, by Charles Renfro, traces the development of econometric modeling languages, during the period beginning in the mid-1960s through the middle 1980s. A characteristic of the advent of this type of software system was the progressive development of a quasi-algebraic, more or less natural command syntax and at the same time an increasing degree of process integration. This description is buttressed by the next memoir, by Michael McCracken and Keith May, which focuses more specifically on a particular example of an econometric modeling language, one that today is known as MOSAIC. This software system began its development in the early to mid 1960s as a data base management system, known as DATABANK, and has progressively developed into an integrated econometric modeling language designed to support the construction and use of large to very large econometric models.

Following the take off phase in the 1960s, the 1970s were in general a time of noticeable expansion in the use of the computer, in terms of both wider use and for progressively more intensive applications. The memoir by Terry Barker, Wagner Dada and William Peterson focuses on the Cambridge Growth Model, and the software system MREG/IDIOM that was developed over a 20 year period to support it. A notable aspect of this model was its sheer size, ultimately numbering in excess of 2500 equations. Such size requires the maintenance of a substantial database, as well as overcoming a number of computational hurdles. Significantly, the Growth Model began to be developed during the time that even a 300 equation model taxed the capabilities of existing mainframes. The effectively available RAM in those days was normally less than 512 K, and contiguous disk storage was limited to – at best – 10–30 megabytes and often much less. The disk storage capacity of the present day Apple IPOD easily competes with, if not dominates, that of the 1970s era computers, and even a digital camera may offer 512 megabytes of storage. The challenge of mounting the entire Cambridge Growth Model on a Pocket PC PDA is possibly less now than the challenge then of mounting and maintaining it on an IBM mainframe.

The final Milestone memoir, by Houston Stokes, addresses in contrast the issue of the interplay between the computer and the first development of econometric techniques. Often, perhaps usually, econometric theory has been perceived as being developed with pencil in hand, and not with the computer. However, even in the past, this perception has not always been accurate. The development of the Theil BLUS technique is a specific example of a two-way relationship between econometric theory and software design. In particular, the fact that the sum of squares of the N-K BLUS residuals is equal to the sum of squares of the N OLS residuals was first observed experimentally and subsequently proved in theory. Increasingly, such a symbiosis may become common, perhaps in ways that cannot yet even be imagined.