COMPUTERS AND OUR UNDERSTANDING OF THE ECONOMY

A Talk by Clopper Almon of the University of Maryland to the Conference of the Free European Academy of Sciences on The Relevance of Data Processing to Understanding in the Sciences Erasmus University, Rotterdam, April 1986

Allow me to begin with a personal note, for on a subject such as this it is important to know from what sort of background a man speaks. I am not a distant onlooker to the question of computers and our understanding of the economy. I cannot claim to speak with unbiased, scientific objectivity on the subject. For thirty years, I have been engaged in trying to use the computer to improve our understanding of how the economy works. As an undergraduate student of economics, I was impressed by how barren and inadequate were the theoretical explanations. I continually asked, "Can you put numbers into those theoretical explanations you have given and get a system that describes the way the economy actually works?" For me, if the answer was no, the theory was idle speculation. For most theorists, my question was unwelcome. The pursuit of a system that could be quantified led me to Wassily Leontief and his "input-output" analysis and, of course, to econometrics.

To get answers to my questions, I learned the necessary trades. Besides the academically respectable ones, I learned the "dirty" ones as well. I have programmed in half a dozen languages, managed a minicomputer installation, and nowadays plug in chips, boards, and drives like a clumsy little bear putting his paws in the honeycomb.

After coming to the University of Maryland in 1966, I was able to establish an economic forecasting service based on interindustry economics and econometrics. Presently, we operate three models of the US economy. One distinguishes 78 industries and shows all of the sales from each of these to each of the others. It shows also exports, imports, investment, employment, wages, profits, prices, and other variables for each industry. It shows the income distribution of the population and how it is affected by taxes. The model accounts for the impact of income distribution, prices, age and regional distribution of the population on consumption expenditures. The second model distinguishes some 425 industries in the economy but borrows consumer behavior and income generation from the first. The third is a small model without industry detail but running with quarterly rather than annual periodicity. I wrote the software used in building this model in the C language on personal computers. I use both the software and the model in teaching undergraduates about business cycles and forecasting. This work is, I should mention, supported by private users, not by government grants.

In recent years, I have worked with groups in some twenty countries to develop similar multi-industry models for their own countries. We now have an interlinked system of these models. I am happy to say that our Dutch partner is here at Erasmus University.

With this background, you may be sure that you would wait in vain for me to say that I did not think that the use of computers had enhanced our understanding of the economy. I think it has. But my reasons for thinking so may be different from what you suppose. We shall need to distinguish three quite separate ways in which the computer is used to study of the economy. Briefly, they may be called data collection, data analysis, and economic modeling.

Data Collection

The first of these areas is in collection of economic data. I must emphasize at the outset that the study of economics differs essentially from, say, botany in its dependence on data processing. A botanist can walk out into his garden and observe dandelions. He can, if he be of an experimental turn of mind, spray the dandelions with this or that and watch what happens, confidant that his dandelions represent all dandelions. Or if he be of a more observational bent, he may look for dandelions in the wild, note the conditions in which they grow, see, remember, and picture to himself how they unfold, and compare them with other plants. All this can be done without any formal, numerical data processing. If he turns to gathering data and feeding it into a computer for analysis, it is not for want of an alternative.

How different it is with economics! Take the simple statement, "Real gross domestic product grew 3.2 percent last year." That statement involves the work of every salesperson who operates a cash register, every bookkeeper who makes a payroll tax report, every importer or exporter who files out a customs declaration, and, ultimately, very individual who files an income tax return, not to mention the thousands of people who process these reports and few dozen who put together the final national accounts which report the gross domestic product. Thus, behind even the basic "observations" of macroeconomics loom mountains of data processing. When I want to take my students into the "garden" and show them a real, live economy, the best that I can do is to show them plots of series after series of highly processed data. The behavior of these series and their mutual connections do indeed become the phenomena which macroeconomics studies. Even if we had a firm in our "garden" which we could examine in detail, there would be no grounds for supposing that it, like the botanist's dandelions, would be representative or typical of most firms.

I must digress, however, to say that economists are pretty well aware that these data are but the "shadows on the wall of the cave," and that there are real phenomena generating them. In fact, economists are rather fond of speculating about those real phenomena. These speculations go under the name of "economic theory" or "microeconomics" or "micro foundations of macro economics." They are all based upon a further difference between economics and the natural sciences. Few botanists, I believe, admit to asking themselves, "How would I behave if I were a dandelion." Economists, however, continually ask themselves, "How would I behave if I were an entrepreneur, a banker, a union leader, a consumer, a laborer, an investor, a politician, a this or a that." A good bit can be learned from careful answers to those questions, though personally I have grown rather weary of the abstraction with which "my" motivations, information, and possible actions are described in this theoretical introspection. I return to the "shadows on the wall" and delight in the concrete richness and vitality reflected in them. An unemployment rate may be just a number to computer, but to me -- and probably to you -- it is packed with human meaning.

Given this almost total dependence of economic information on data processing, it is surprising how little has changed in available macroeconomic information over the last thirty years. By contrast, between 1940 and 1950, there was a revolution in economic statistics in the United States. Only a small fraction of the economic time series now in common use can be known prior to 1947. But most can be approximated back to 1947 or at least back to the 1950's. Whether one is looking at national accounts or employment data or prices or manufacturing statistics, 1947 is the watershed year. Since 1956, the year of introduction of the first commercial computer, there has been gradual growth and improvement in economic data collection, but no revolution.

The revolution of 1940-1950 was due mainly to the revolution in perceived needs for information brought by the great depression and World War II. There were important new ideas about how to use information, ideas connected with Keynesian economics or with input-output analysis, for example. There was also a revolution in data processing in these years. This was the age of the punched card accounting machine and the electrical desk calculator. Today it is pretty hard to get anybody excited about a punched card accounting machine. But the difference in human labor between summing a million 8 digit numbers mentally and summing them with a 1950 vintage accounting machine is enormous. The difference between doing it with those machines and with those of today is much smaller, for in each case most of the work is in putting the raw data into machine-readable form. Once in that form, of course, there is a difference I do not mean to deny between feeding fifty boxes of cards through a cantankerous accounting machine and mounting a tape and typing a few lines on a terminal. But from the point of view total labor required, the punched card revolution was the most important one.

The computer has, however, made an important difference in the accessibility or ease of use of economic data. It is far easier to ship a reel of tape than to ship fifty boxes of cards. It is even easier to mail a few floppy diskettes that may be adequate. The ease of use has led to greater use, and the greater use has led to demands for more detailed data. These demands, coupled with the reduced cost of meeting them, has brought an evolutionary increase in the volume of data available. As a rough estimate, I would say that in the United States, there are today two to three times as many regularly prepared governmental statistical series as in 1956.

Since 1956, data processing has been revolutionized several times over. Macroeconomic data has evolved slowly and gradually. The computer has been a help, but not a driving force. In contrast to the revolution of 1940 to 1950, we have been living in peaceful times.

Analysis of Economic Data

The situation is quite different in the second area in which data processing touches our understanding of the economy. A quick survey of the journals of the economics profession shows two broad types of articles reporting original research, theoretical studies and empirical investigations of the economy. The first elaborates an economic theory, usually with the aid of mathematics, but without any notion of ever quantifying the functions or empirically testing the conclusions. This has always been a popular gendre among economists. From Smith to Keynes, the arguments were mostly verbal. Graphical presentation gained ground in the 1930's and 1940's, and then mathematical formulas became increasingly in vogue. But I think it safe to say that advances in data processing <u>per se</u> have had nothing directly to do with this trend, for there are no data to be processed. (The effect of data processing on the way people think is another question.)

The second sort of article describes some aspect of the economy. Here the influence of data processing is enormous. A standard paradigm has emerged for these articles. It begins with a brief statement of the issue of interest and cites other work on the subject. Then comes the section entitled "The Model" where a mathematical description is given of the behavior to be studied. Then follows the section entitled "The Data" where a summary description of the data sources is given and one is told how to get the data should one want it. The chance of publication is enhanced if this data is some survey that hasn't been used before, but wringing new meaning out of old data is also acceptable. It is also explained that various observable variables, such as last year's inflation rate, will be used as "proxies" to stand for the really relevant but unobservable factors, like expected inflation. Next comes the "Results" section which invariably reports on a large regression analysis that would have required several lifetimes of computing with a desk calculator in 1950 or a huge computing budget in the 1960's or a few minutes on today's personal computer. Finally, the "Conclusions" section underlines the significant contributions of the article but notes that further research is needed to answer the really hard questions.

How much have we learned about how the economy works from this sort of research? Quite a lot, I believe. Some results have been positive. Keynesian theory emphasized, for example, the importance of the growth in output in determining investment. This effect shows up so strongly in a properly formulated investment equation that I think no one denies its importance. The estimation of that properly formulated equation, however, would be unthinkable without modern equipment. There are, of course, thousands of such positive results, some more memorable than others.

It is, however, striking that some results have been negative. These negative results may be even more important than the positive ones, for they show up problems in accepted theories of how the economy works. It is also noteworthy that these negative results are far more dependent on data processing than the positive ones. Let us take the example of the influence of interest rates on investment and saving. Classical economic theory taught -- and goes on teaching -- that high interest rates deter investment and stimulate saving. It stresses that these are important, powerful relations that equilibrate the economy. Regression equation after regression equation has failed to find significant relations between interest rates and investment outside residential construction. Evidence for the "proper" influence on saving is almost as scarce. Note that the amount of computing necessary to establish such a negative result is far greater than that required to establish a positive result. If I report one equation which says that interest rates have no effect on investment, it is easy for any economist to dismiss it. "Oh, you were using nominal rates and you should have been using real rates," he may say, or, if I were using real rates, he would say, "Oh, you were using real rates and you should have been using nominal," or "Probably you didn't specify the lags correctly," or "You don't have the right production function," or "There are perhaps other factors that you have failed to account for that are obscuring the dependence on the interest rate," and so on with a long list of perfectly valid objections. Every macroeconomist worth his salt has his own interior picture of how the economy works. He is sure it is complete and accurate. If some silly number cruncher tells him that a key relation is invalid, it will only confirm his suspicion that that number cruncher (like most) doesn't know what he is doing. What is one, ridiculous, hopelessly misspecified equation against the beautiful conceptual edifice in his mind? One is reminded of the disdain of Galean physicians for empiricists like Paracelsus. One negative result truly means nothing. But if a researcher tries many formulations -- each requiring what would have been a lifetime and a half of computation without a computer -- and they all consistently fail to find the sought-for relation, he may begin to suspect that like the logically necessary Northwest Passage, it isn't there. His friends, of course, won't believe him until they too have tried and failed. All the more data processing.

A negative conclusion both requires more computing than a positive one and is more thought provoking. If interest rates do not have important effects on savings and investment, then what equilibrates them? What determines interest rates? These and other questions would be taken to have been answered long ago in works on economic theory were it not for the highly unpleasant fact that a large quantity of empirical work with massive data processing has shown that those theoretical solutions are based on relations that cannot be detected. It takes a long time to convince theoreticians that their emperors have no clothes on. Gradually, however, we may hope that theory will take some note of what observation finds.

The third way in which the use of computers has affected our understanding of the is economy is through an activity that was impossible without them. It is the construction of complete models of the economy. Such a model is a set of mathematical equations, usually difference equations, whose solution purports to describe how the economy will behave over time, given certain assumptions. The possibility of building such models fascinated me for years before it became a reality for me. It was perfectly obvious to me that no one knew whether the theories advanced to explain business cycles or economic equilibrium would explain them or not. There were vague references to "short- run" equilibrium and "long-run" equilibrium, but nobody could say beans about the dynamics of transition. If written down mathematically, the equations were too complicated to solve even if linearized -- and the essence of the system was probably in its nonlinearities. For me, this state of affairs was pure frustration. Did I understand how the economy worked or did I not? The only way to know would be to build a model of the economy, put into it all the relations that were thought to hold, and see what happened when this model was used to try to reproduce the past or forecast the future.

By the late 1950's, the computer began to offer the possibility of making such models and testing our understanding. It was a wonderful new <u>plaything</u>. Now you must understand that that word is used here by the husband of a Waldorf kindergarten teacher for whom nothing is more valued than a good toy, especially a doll, into which the child can project feeling, thoughts, and drives, and then play out all manner of situations that may later arise in real life. By play, the child learns to deal with life.

And so it was with we economists who first had access to computers for building models of the economy. We began to learn about the economy by making "economic dolls" composed of economic data, regression equations, and computer programs. The computer was splendid doll material because it had no "face" or "character" of its own, but could assume any which we inscribed on it. From its responses to the "situations" in which we put it, we gradually began to learn about the real economy. Not everything could be learned, of course, and not all at once. But we were making progress where we had been at a dead end without our plaything.

Of course, the "character" that we could ascribe to our "doll" had to be one that could be expressed in numbers, but that limitation was not so serious, because -- for reasons already indicated -- most of our picture of macroeconomics reaches us in numerical form anyway. This is a point, however, to which I shall return.

"What, precisely," you may ask, "has been learned from these models?" That question is, if I may say so, something like one child asking another, "What have you learned from your doll today?" No child asks that question because he knows he has to play with the doll himself to find out. Much of my present work is aimed at making it possible for any semi-serious student of economics to play with such a model, and, in fact, to build his own model. About 300 undergraduate students each year at the University of Maryland now have the opportunity to "play" with one of the models, and a number of graduate students get practice in model building. The first thing learned, then, is that one learns through play, that there is no real substitute for the experience of playing with a model.

I will, however, be slightly more specific. One learns that there are no easy solutions or that every economic policy cuts two ways. The easy money that lowers interest rates today will turn into inflation and raise interest rates within a few years. Low interest rates that stimulate residential construction also reduce personal interest income and reduce consumption expenditure, perhaps by more that the increase in construction. Yes, that is right; high interest rates can stimulate an economy and low ones depress it. This perhaps surprising fact is a direct consequence of simply doing the accounting correctly. Models force us to do this accounting; theoretical discussions often leave it unattended. Higher taxes do mean more revenue, but by less than might be hoped, since they reduce spending and this reduction is "multiplied" by the mechanisms of the economy. On the other hand, even the disappointingly small initial reduction in the deficit gradually becomes significant, for it also reduces interest payments on the debt, and certain long-run stabilizing forces begin to counteract the initial reductions in income.

If the students learn that there are no easy answers, that what has good long-run effects is usually bitter medicine, and that what is sweet in thy mouth is bitter in thy belly, that is already a great deal. Such a realization should make them as voters less inclined to buy simple-solution nostrums such as have wreaked disaster with the US budget in the last five years.

If you would like to know the specific answer to the question I set out with -- Do the theories explain the behavior of the economy? -- the answer would have to be mixed. They certainly provided some useful insights. But other important elements, such as the influence of the unemployment rate on the savings rate or the stimulating effect of the decline in profits during recessions were missing, as far as I am aware, from the old business cycle literature. None of the theories I studied in the 1950's were adequate to explain what happens during business cycles. Today's models do better, but if I were satisfied with them, I wouldn't go on tinkering with mine and trying to improve them.

Such, then are some of the positive influences of the revolution in computing on our understanding of the economy. The first was by helping with the vast labor of collection of the data on which macroeconomics rests. The second was by making possible empirical investigation using extensive regression analysis and other computation-intensive methods. The third, and to me personally the most exciting, was offering us the opportunity to test and develop our understanding by "playing" with economic models.

There have been costs. The most obvious are the direct ones. A fellow who is getting a bug out of some computer program -- an activity that has consumed more of my own life than I care to admit -- is not engaged in some other, presumably useful, activity like promoting rational use of the state's oyster beds.

The more hidden, more insidious costs are in the ways of thinking. The dominance of the research article based on regression analysis is driving out other forms of empirical investigation. What doesn't fit into the computer doesn't get studied. Let me give an example. People who work in an economy should enjoy their work, should feel it is important, valuable to others, exciting, and stimulating. They should work for the joy of it, not for money. How well an economy achieves this goal is at least as important as its material standard of living, perhaps more important. Yet in all the thousands of series known to me, not one is worth much as a measure of "joy of work." One can, of course, think of surrogate measures, such as absenteeism; or one can conduct a sample survey and count answers to some questions that probably didn't mean much to the respondent, who was doubtless irritated by questionaire in the first place. Or, on the other hand, one can study the "joy of work" in a country by simply talking to people. One can train oneself to listen. One can become quite sensitive to how people feel about their work and what makes them feel that way. In that way, one can learn which economics have high "joy in work" and which, low. But if, as a scientist, I put forward such results, my evidence will be dismissed as anecdotal, suitable material for a novelist, perhaps, but certainly not for a true scientist. For my results to be considered "science," I had best report some measure, something that could, well, be fed to a computer. That would be evidence. That would fit into the paradigm of the typical article described before. But a hundred heart-to-heart talks in ten countries do not provide any "evidence" in the academic world, unless, of course, I tabulate the results and run a regression on them.

In this way, the very success of the computer in analyzing some types of evidence is making us prone to overlook the relevance of other types. These other types may well be the most important. We desperately need ideas today to lead us beyond private capitalism and state socialism to a society as lively and efficient as capitalism yet better than any socialism in assuring that every willing worker can earn his livelihood. We cannot be sure that when such ideas are found, that they will come buttressed with tables and graphs and equations with statistically significant coefficients. In fact, I rather suspect that they will come, if at all, without any of this armament. Rather, they will come in imaginations, in insights.

There is, in fact, no shortage of imaginations about the economy. Most of them are worthless; some, dangerous; and some have a grain of truth in them. They need careful thought before adoption. Part of an imagination will deal with quantifiable relations and can be studied with the aid of computer "dolls" just as are the relations of the present economy. But part of any vision of the economy must concern such matters as the "joy of work" that do not lend themselves to quantification. We must not let ourselves get to the point that, if we find cannot formulate a problem quantitatively, we then suppose that we cannot think about it. The present situation, unfortunately, is that while we have a <u>discipline</u> for dealing with the quantitative, we have not developed a similar discipline for handling the non-quantitative. The development of that discipline is perhaps the most important task facing science today. Sometimes it seems that Socrates was further along in it than we are.

The tendency to accept only quantifiable evidence did not originate with the computer. We were already far down that path long before we had computers. They have accelerated the trend by helping in dealing with one sort of evidence but not with others. This bias has helped to make one sort of research the norm, not to say the fashion. And who wants to be caught out of fashion?

The fundamental antidote to this trend in our thinking is an understanding of Man as much more than the body with its quantifiable masses and laws. We need to recognize ideas and feelings as no less real for not being measurable. If that realization can be reached, we can use the computer for dealing perfectly mechanically with what is perfectly easily and naturally quantifiable without the danger that it makes us think that only the quantifiable is real or important.