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THE RESEARCH INTERESTS OF PAUL NEWBOLD

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1. INTRODUCTION

Paul Newbold was born in Sileby, a village in rural Leicestershire, England, in 1945. He was accepted for a place at the London School of Economics at the age of just sixteen, and in 1966 he obtained a B.Sc. degree in economics, with first class honors. He then studied for a Ph.D. in statistics at the University of Wisconsin, under the supervision of George Box. Paul was awarded his Ph.D. in 1970 and began a lengthy and distinguished career in time series econometrics that was to prove highly influential for the discipline, particularly in the area of forecasting and in the analysis of nonstationary time series.

His research career can be divided into three main periods: 1970–1979 in the Departments of Economics and Mathematics, University of Nottingham; 1979–1994 in the Department of Economics, University of Illinois at Urbana-Champaign; and 1994–2006 in the School of Economics, University of Nottingham. In addition, there were several visiting positions held during these times. Paul retired in 2006 and now holds the title of Emeritus Professor of Econometrics at Nottingham.

Counting just papers published in refereed journals, he produced 23 articles in the first period, 56 in the second, and over 60 in the third period. He also singly and jointly authored a number of student textbooks and research-level books over this time.

In this survey of Paul's work, the papers in the early Nottingham period are discussed by Clive Granger and those in the later one by Stephen Leybourne. We both discuss some of the papers from the Illinois period.

*Regrettably, Clive Granger died on 27 May 2009. An obituary appears in *Econometric Theory* 25(5), 1139–1142 [Editor].

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2. THE FIRST NOTTINGHAM PERIOD (1970–1979)

In 1969 I applied for funds to appoint a postdoctoral fellow in economics at Nottingham to study forecasting. To my surprise I obtained the money (for three years), and at the time it was almost a unique fellowship outside of Oxford and Cambridge. I wrote to every major department of statistics, economics, and econometrics but had only one applicant. However, because this turned out to be a young Paul Newbold, matters worked out rather well! Our research interests fitted together as though planned; we were both trained in time series and both knew the Box–Jenkins methodology, but Paul was also trained as a Bayesian and was adept at computer programming.

One of our first tasks was to try to persuade econometricians to use time series formulizations in their models. We were just leaving a period where their models had not been dynamic at all; it was now a question of how dynamic they should be. An example is the paper "The Time Series Approach to Econometric Model Building" in *New Methods in Business Cycle Research*, edited by C. Sims and C. Granger (Minneapolis: Federal Reserve Bank, 1977).

We concentrated on the major differences in approaches between traditional econometrics model builders and those who take a time series approach. The two sets of modelers differ greatly in the handling of lagged dependent variables and of the error terms. We pointed out that the time series approach is more flexible, allowing for autoregressive lags and moving average error terms, for example. Using two sets of quarterly data, quite complicated bivariate models were fitted using up to four lags and with care taken about *spurious regression* possibilities. The models look quite different from the typical macroeconomic model of the era.

On discussing the interactions between time series considerations within standard econometric techniques, we produced the paper "Spurious Regressions in Econometrics," which appeared in the *Journal of Econometrics* in 1974. We realized that if the "dependent variable" was $I(1)$ but the explanatory variables were either $I(0)$ or just unrelated to it, the equation would be unbalanced and the equation could have strange properties. Considering the "theory" we were uncertain what we would find, and so Paul performed simulations using time series of length 50 and 100 observations (which was all that the Nottingham computer could handle at that time). We first regressed a random walk onto an independent random walk and found "significant" t-statistics 76% of the time with an average R^2 of 0.26 and an average Durbin–Watson statistic of 0.32. Back in 1974 it was not unusual to find published macroeconomic models having statistics like these, although not all papers published a Durbin–Watson statistic. Our paper considered further simulations involving more unrelated explanatory variables or random walks with moving average terms, but all obtained similar results.

This paper had a stimulating effect on the profession. Before its publication I gave a lecture at the London School of Economics based on it, and the audience

was convinced that Paul's simulations had been programmed incorrectly; the results just could not be correct. One of the better known attendees slipped away and repeated the basic simulation. He returned to report that he had obtained the same results as Paul! Apparently editors of major journals were sifting through their files of accepted papers to see if any of the articles included spurious regressions. The result of all this was a discussion about what to do to avoid the problem. We suggested always looking at the Durbin–Watson statistic and adding one or more lagged variables if it looked suspicious. Several years later Peter Phillips produced some excellent asymptotic theory to explain our small-sample results.

Although a lot of our research and much of Paul's personal research considered time series topics, our project tried to concentrate on forecasting questions usually based on forecast theory and the procedures suggested by Box and Jenkins. However, we realized that very little attention was being paid to one important and practical question, which produced the paper "Some Comments on the Evaluation of Economic Forecasts" in *Applied Economics* in 1973. A variety of new results were obtained, and it was shown that some of the methods previously suggested were either suboptimal or even incorrect. In recent years this has become a very active area of research.

Of course it is all very well to consider theory, but it is what works in practice that is most important. In our paper "Experience with Forecasting Univariate Time Series and the Combination of Forecasts" in the *Journal of the Royal Statistical Society, Series A*, in 1974, time series were used of which 106 were monthly and 26 were quarterly. For each series a Box–Jenkins model was fitted together with a Holt–Winters model and a stepwise autoregressive model, forecasts formed from each, and then an optimal combination formed. There was an enormous amount of work involved. It was shown that the Box–Jenkins approach was usually the best individual forecasting method but that combining forecasts would often produce a superior forecast.

It is worth noting that these papers in the first Nottingham period were all produced before the advent of modern computers with word processors. All were written by hand with pens on paper and then later typed by professional typists. In contrast to my own efforts, Paul showed an extraordinary ability to produce a whole page of clear handwritten text without any corrections, deletions, or additions. I always thought that Paul must have a very clear and orderly mind, thinking ahead, instead of my own "spur of the moment" mentality.

The linear theory of forecasting was well developed by the early 1970s, but little consideration had been given to nonlinear methods. In an attempt to develop some results Paul and I published "Forecasting Transformed Series" in the *Journal of the Royal Statistical Society, Series B*, in 1978. If X_t is a Gaussian series suppose that one is interested in forecasting $Y_t = T(X_t)$ where $T(\cdot)$ is some well-behaved function. Three approximate forecasts are considered but are found to be inferior to the optimal forecast, according to the mathematical results when $T(\cdot)$

could be well approximated in terms of Hermite polynomials. The results were well received at the time.

The Hermite polynomial results were used also in our short paper "The Use of R^2 to Determine the Appropriate Transformation of Regression Variables" in the *Journal of Econometrics* in 1976. It is shown that in the nonlinear regression $h(y) = g(x) + error$, the functions $h(\cdot)$ and $g(\cdot)$ can be chosen using the maximum R^2 value, contrary to standard belief at the time.

In 1974–1975 Paul visited the University of California, San Diego, where I had just taken a position. We were finishing the first edition of the book *Forecasting Economic Time Series* (Academic Press, 1977). The book covered the practical aspects of Box–Jenkins time series modeling and the theory and practice of time series forecasting. Much of the material was appearing for the first time in book form, and it was widely used in graduate schools in the United States and elsewhere.

At the same time, Paul had also developed keen interests in evaluating exact likelihood functions for time series models and also studying the behavior of tests of model adequacy based on residual autocorrelations. This led him to produce a series of papers that were subsequently published in *Biometrika* in the late 1970s and early 1980s. Even today most of these are still widely cited and are regarded as seminal contributions to the time series literature.

3. THE ILLINOIS PERIOD (1979–1994)

After visiting positions at the University of Chicago, the University of Wisconsin, and the Institute for Advanced Studies in Vienna, in 1979 Paul took up a chair at the University of Illinois at Urbana-Champaign. While continuing with his previous research into standard and relevant time series topics, Paul began a series of survey papers, "Some Developments in Time Series Analysis," appearing in the *International Statistical Review* between 1981 and 1988. Each of these is a serious technical discussion of new ideas and techniques that had been receiving attention in the area of time series research. They cover many topics and are well worth reading by any student of the area wanting to appreciate how new ideas are developed and then interact.

Although many of the Illinois papers demonstrate Paul's continuing contributions to the theory of time series analysis, such as those jointly written with Craig Ansley in the *Journal of Econometrics* and *Journal of the American Statistical Association*, others show a clear intention by Paul to extend his list of interests (particularly the application of time series techniques and forecasting) into areas such as accounting, stock market risks and prices, bankruptcy, banking, electric utilities, bonds, futures, and various macroeconomic series, both current and historical. His papers that appeared in journals such as the *Journal of Business*, *Journal of Monetary Economics*, and *Journal of Futures Markets* bear testament to this.

This period of widening experience may explain Paul's production of several very successful textbooks: *Statistics for Business and Economics* (Prentice Hall, 1984), *Principles of Management Science* (Prentice Hall, 1986), and *Introductory Business and Economic Forecasting* (South-Western Publishing, 1990). Each of these has been updated, and reprinted several times, and they remain widely considered as core texts at both the undergraduate and postgraduate levels.

The paper "Estimating Trend and Growth Rates in Seasonal Time Series" in the *Journal of the American Statistical Association* in 1987 is archetypical of Paul's growing interest in deterministic trend function analysis during this period. At the same time, he was also developing interests in fractional integration, persistence, and nonstationary time series, leading to publications in journals including the *Journal of Time Series Analysis, Biometrika*, and the *Journal of Business & Economic Statistics*. These lines of investigation would come to characterize much of his subsequent research output.

4. THE SECOND NOTTINGHAM PERIOD (1994–2006)

On returning to Nottingham in 1994, now as Professor of Econometrics, Paul very quickly established an excellent research rapport with members of the econometrics group within the School of Economics, immediately bringing to bear his accumulated wealth of experience and by now trademark insightfulness. By this stage he had become deeply interested in the performance of unit root tests under different assumptions regarding the deterministic components in the data generating model, particularly the role played by unattended structural change. This led to a number of collaborative theoretical papers on the topic, appearing in journals such as *Econometric Theory*, *Economics Letters*, the *Journal of Econometrics*, and the *Journal of Time Series Analysis*. Applications of this research to the behavior of interest rates and exchange rates appeared in the *Journal of Money, Credit and Banking*.

At the same time Paul continued to make very valuable contributions to the forecasting literature, most notably in testing for forecast equality and forecast encompassing. The output was published in the *Journal of Forecasting*, *International Journal of Forecasting*, *Journal of Applied Econometrics*, and *Journal of Business & Economic Statistics*. A number of these testing techniques have subsequently been adopted widely and developed further by other researchers.

Paul also had long-standing links with the agricultural economists within the school going back to his first period in Nottingham and in collaboration with this group published a number of applied papers in journals such as the *Journal of Agricultural Economics* and the *Journal of Futures Markets*.

A large proportion of Paul's research output over this period was coauthored either with Ph.D. students or relatively junior members staff from Nottingham. It was clear to see that his unselfish attitude toward conducting and promoting research both engaged and inspired the minds of these young researchers (many

of whom have gone on to establish successful careers in academia and commerce). His approach to research remains an object lesson to all in how to formulate interesting and practically relevant problems and then seek pragmatic means to solving them.

There can be no doubt that Paul Newbold's career as a researcher, which has spanned over 35 years, including well over 100 refereed journal articles, numerous books, and contributions to edited works, has had a substantial and enduring influence on the theory and practice of time series econometrics. Even after his retirement, one can only believe that this will continue to be the case.[1]

NOTE

1. A full version of Paul Newbold's curriculum vitae can be found at www.nottingham.ac.uk/economics/staff/details/Pn.htm.