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Macroeconomic Implications of the Information Revolution

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Surely not all time-series data have been improved nor have all data concepts been clarified progressively in economics. Indeed, any proliferation in the underground economy, a withdrawal of resources from data-gathering agencies, and growing obsolescence of past classification and measurement conventions could have diminished the reliability of macroeconomic aggregates for some purposes. On the whole, however, we take it that data have become so much more substantiated, detailed, timely, and accurate as to support an ongoing information revolution. At the same time, the costs of data access and dissemination, storage, and processing have declined to the point of making vastly more information effectively available and public. Before showing how macroeconomic relations are affected by some of this, a brief illustration is offered of how information can be defined by its consequences for the probabilities assigned at first to an exhaustive list of n mutually exclusive events. This is done with the concept of simple entropy (EN) which is frequently used as an inverse measure of information.

If it had been known beforehand which of the n events was bound to happen—perhaps because Bayesian learning from the accumulation of uniformly relevant data already had identified the one with sole claim to the “truth”—no further information would be gained from its occurrence. There would be zero entropy (uncertainty) in this limiting case, very far from the maximum entropy of $\ln(n)$ that would be displayed by a rectangular distribution of n elements, each with probability, $p_i > 0$ of $1/n$. Normally, however, the degree of simple entropy stays be-

tween these extremes for the measure,

$$(1) \quad EN(p) = \sum_{i=1}^n p_i \ln(1/p_i),$$
$$\sum_{i=1}^n p_i = 1.$$

Then the release of economic data brings news that triggers a learning process about salient elements in the open set of contingent events and about their probability weights and determinants.

If only the probability weights change, so that the probabilities p_i become q_i in a given set of prospective events, the information gain (–) or loss (+) is measured by the change in entropy as $EN(q) - EN(p)$. The fact that this difference can be either positive or negative shows that the release of data need not reduce uncertainty or reinforce an agent's previously held beliefs. Rather, a learning process may be initiated that has the capacity of not only changing probability weights but also precision and content of prior beliefs. In other words, the size of the weights p_i , the inverse of the variance attributed to them, and the descriptors of any of the events i as well as their total number n may all be affected by news releases. Any change in the frequency, coverage, or quality of these releases will change the way learning and revalidation may proceed.

I. Implications of Data Improvements

Because of the use of benchmarks and other conventions that provide time averaging and shared reference for several time series, measurement errors in economic variables may rarely follow a stationary, serially independent random process. Nor are such errors likely to be contemporaneously uncorrelated across the series. Nevertheless, it is useful to start with this simple specification

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to show how data improvements could affect the structures estimated over time even when the underlying economic behavior, that is, the behavior conditional upon the "true" variables, does not change at all. Assuming only two observable data series in a linear model with errors in variables, the pair of data observed at time t (Y_t, X_t), is distinguished from the associated latent variables, y_t and x_t . The lowercase variables are the ones on which economic behavior is based subject to the disturbances e_t . With measurement errors u_t and v_t , the elementary system to consider is

$$(2) \quad Y_t = y_t + u_t; \quad X_t = x_t + v_t$$

$$\text{and} \quad y_t = a + bx_t + e_t.$$

Substituting observable variables and ignoring the intercept yields the familiar single-equation model (see Dennis Aigner et al., 1984, pp. 1324-25),

$$(3) \quad Y_t = bX_t + u_t + e_t - bv_t.$$

Its variance-covariance structure (S) is

$$(4) \quad S_{YY} = bS_{YX} + S_{uu} + S_{ee},$$

$$\text{where} \quad S_{YX} = bS_{XX} - bS_{uv},$$

$$\text{and} \quad S_{XX} = S_{xx} + S_{vv}.$$

Without more information than the data (Y_t, X_t) can provide, system (4) cannot be solved for the structural parameter,

$$(5) \quad b = S_{yx}/S_{xx} = S_{YX}/(S_{XX} - S_{vv}),$$

because it contains 3 equations with 5 unknowns (b and 4 latent variances). This may lead to bias being accepted in estimating the system by OLS as

$$(6) \quad Y_t = BX_t + W_t, \quad B = S_{YX}/S_{XX}.$$

With one additional bit of information, one may now be able to tell a great deal from changes (d) in the variances of the observed

variables. For instance, if there is reason to believe that S_{XX} has declined over time solely on account of improvements in data quality, it follows that dB will have the same sign as S_{YX} and hence B :

$$(7) \quad dS_{XX} = dS_{vv} < 0; \quad dS_{YX} = 0;$$

$$dS_{YY} = dS_{uu} + dS_{ee};$$

$$db = 0; \quad dB = -S_{YX}dS_{vv}/(S_{XX})^2.$$

The second implication in (7), covariance stationarity, can be used to test whether the first assumption is appropriate so that b does not change. Its biased estimate, B , increases asymptotically in absolute value from 0 toward b as the noise in X declines toward 0. In this sense, updated regression estimates of form (6) may be becoming more reliable over time. This is not usually discussed as a reason for continuous updating or "sequential" estimation, for rolling regressions, or for letting estimated regression coefficients vary with the quality of information.

If this quality has in fact improved over time, changes in B do not necessarily signify changes in b . Furthermore, changes in the variance of Y —where Y could stand for GNP or the unemployment rate before and after World War I or before and after the Great Depression in recently revived debates—would not necessarily be indicative of stabilization policies or of other factors that have reduced remaining disturbances ($dS_{ee} < 0$) and hence the variance of y . Rather, a decline in S_{YY} could indicate a reduction in measurement error ($dS_{uu} < 0$) equally well. Thus improvements in data quality can add uncertainty about the interpretation of trends in variation if it is not known at what rate the measures are becoming better.

Adding a law of motion for the latent variable x to system (2) allows focusing on another consequence of data improvements. Changes in data quality produce time variation of the coefficients in the optimal forecast. Hence, if improvements in data quality are perceived correctly by agents, the coefficients estimated for the dynamic process they follow will change. This will happen even

when there would be no change in the dynamic forecasting equation if the true series, x and y , were known. Assuming the latent variable x follows the random walk,

$$(8) \quad x_t = x_{t-1} + z_t, \quad z_t = N(0, \sigma^2),$$

John Muth (1960) has shown that the optimal forecast involves weights on the lagged values of X that decline exponentially. Hence equation (6) is replaced by the forecasting equation,

$$(6') \quad Y_t = B(1 - c) \times (X_{t-1} + cX_{t-2} + c^2X_{t-3} \dots) + W_t,$$

where c is chosen to minimize the squared prediction error on past data. The coefficient c is lower, and hence the rate of decline of the lag weights faster, the lower the noise, due to S_{ee} , S_{uu} , and S_{vv} , relative to the strength of the signal measured by the variance (σ^2) of z . Hence if the measurement errors for x and y decline so that S_{uu} and S_{vv} fall, the response speed to lagged data would appear to rise. The reduction in the mean lag would be due not to a change in the underlying behavior, but to changes in the clarity of signals shifting the optimal balance between the risk of missing out on news and the risk of being misled by noise in recent data.

Such possible consequences of technical changes in the informational environment generally have been ignored, for instance, by those who have analyzed and interpreted the reduction in inflation of earlier this decade. In the judgment of Robert J. Gordon (1985), the rapidity of this decline surprised many who then began to look for autonomous changes in behavior rather than changes in the state of information.

II. Temporal Compression

In addition to the possible reduction in measurement error, another important achievement in the information revolution is to make ever more data available on a timelier basis ever more frequently. Furthermore, the cost of immediate access to data increases very little with the distance from their point of release. As a result, data are now almost equally available around the

world and cheap to communicate. Under these changed circumstances, many of the signal extraction problems designed to deduce from high-frequency series available with short collection and reporting lags what may be happening to low-frequency series, or series with longer lags, now appear needlessly contrived. The survey by von Furstenberg and Jin-Ho Jeong (1988) provides numerous examples.

Signal extraction problems have been used to explain temporary disequilibria and slow adjustment to unexpected and unannounced developments. The intended lesson was that correct adjustment can be expected only if the current constellation of the data, some of which are treated as not yet observable, turns out to conform exactly to the model and the variance-covariance pattern of the residuals of past data. One would expect such a theory to imply that if more data are being reported faster and more frequently, there would be less scope for real effects to arise from errors in inferences about current data. However, any precise accounting for how changes in the actual state of information may have affected the behavior of economic time series and their model is rarely found in the signal extraction literature.

While more information can obviously solve those problems of temporary disequilibrium and slow adjustment thought to arise solely on account of deficiencies in information, it need not solve others. It can even create problems, some of which may turn out to be genuine. The reduced need for time averaging and the narrowing of time and coverage gaps in information have the effect of allowing developments to be screened almost as they happen, with less information gained longer after the fact. Indeed, certain optimization programs requiring continuous monitoring and vast computational effort are now automated and self-reprogramming, perhaps through the application of artificial intelligence. Hence distinctions between short- and long-run outcomes of impulses and disturbances that are based on the premise that "only in the long run will it all have come out" are collapsing. Furthermore, the more frequent, and therefore less averaged, the reporting of potential news and the updating of outcome distributions

like those represented by equation (1) or by more comprehensive measures of information (Maasoumi, 1988), the more fluctuating and "volatile" the level of uncertainty can be. As episodes of high news are interspersed with periods of low news intensity, the movement of high-frequency price series frequently takes on characteristics of a random walk with step-ahead distributions that are leptokurtic and inscrutable from the viewpoint of economic fundamentals.

More timely, frequent, and accurate public information that can travel at the speed of light reduces one of the objective reasons for temporary differences in subjective beliefs, that of being unavoidably differently informed at a point in time. Specialists whose definition of efficiency tends to be based on the completeness of arbitrage and the "consistency" of spot and future price series thus can undoubtedly claim that efficiency has grown in the small. On the other hand, reduced confidence in prior beliefs based on "fundamentals" can raise the volatility of outcomes. Formulas such as those derived by John Taylor (1975, p. 1017) could yield this result if there is a decline in the precision of previously held beliefs but some "cycling" or eventual reversion to the mean, as opposed to a strict random walk, in news content. Correspondingly, Sanford Grossman and Joseph Stiglitz (1976, p. 251) have suggested that added information, by increasing price variability, could raise uncertainty about, and thereby diminish, the value of one's endowments. Faster information may also lower insurability and the ability to arrive at efficient risk sharing arrangements on account of temporal compression (Jacques Drèze, 1979).

Altogether this suggests that orientation and efficiency may not be helped in all respects by the ongoing information revolution. Rather, this development can reveal as it obscures, and stabilize as it unsettles. For instance, statistical models and coefficients are likely to be made time-varying by cumulative improvements in data and the state of information, but this is rarely attended to in monitoring estimates of macroeconomic relations. Estimated relations can change and drift without any change in policy for rea-

sons quite different from those originally emphasized by Robert Lucas (1976). Losing yet one more of the things that have traditionally been taken as pre-given to economic analysis can be disorienting but necessary. For it is, by now, almost a contradiction in terms to treat information technology and its yield as remaining fixed long enough for macroeconomists to finish a portrait from time series under that condition.

REFERENCES

- Aigner, Dennis J. et al., "Latent Variable Models in Econometrics," in Zvi Griliches and Michael D. Intriligator, eds., *Handbook of Econometrics*, Vol. II, Amsterdam: North-Holland, 1984, ch. 23.
- Drèze, Jacques H., "Human Capital and Risk-Bearing," *The Geneva Papers on Risk and Insurance*, June 1979, 4, 5-22.
- Gordon, Robert J., "Understanding Inflation in the 1980s," *Brookings Papers on Economic Activity*, 1:1985, 263-99.
- Grossman, Sanford J. and Stiglitz, Joseph E., "Information and Competitive Price Systems," *American Economic Review Proceedings*, May 1976, 66, 246-53.
- Lucas, Robert E., Jr., "Econometric Policy Evaluation: A Critique," in Karl Brunner and Alan Meltzer, eds., *The Phillips Curve and Labor Markets*, Vol. 1, Carnegie-Rochester Conference Series on Public Policy, *Journal of Monetary Economics Suppl.* 1976, 1, 19-46.
- Maasoumi, Esfandiar, "Information Theory," in John Eatwell et al., eds., *The New Palgrave: A Dictionary of Economics*, Vol. 2, New York: Stockton Press, 1988.
- Muth, John F., "Optimal Properties of Exponentially Weighted Forecasts," *Journal of the American Statistical Association*, June 1960, 55, 299-306.
- Taylor, John B., "Monetary Policy During a Transition to Rational Expectations," *Journal of Political Economy*, October 1975, 83, 1009-21.
- von Furstenberg, George M. and Jeong, Jin-Ho, "Owning Up to Uncertainty in Macroeconomics," in *The Geneva Papers on Risk and Insurance*, January 1988, 13, 12-90.