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The Ohio Economy: A Time Series Analysis

by James G. Hoehn
and James J. Balazsy, Jr.

What do regional economic statistics, such as those for Ohio, convey about the present and future state of the regional economy? What do they say about the sources of regional fluctuations? To what extent do they reflect national conditions versus regional factors? Which regional and national series are most useful to watch? What degree of accuracy can a regional forecaster hope for?

These questions are addressed by regional economic models of both the time series and structural variety. The latter, in a setting in which the nature of economic relationships is already reasonably well known and data sets are adequate, may best embody answers to these and related questions. But given the incomplete theory and data actually available, time series methods can be very helpful in interpreting and forecasting regional economic statistics. Here we summarize both some suggested time series methods and the answers they provided to the above questions for the Ohio economy. (The working paper by Hoehn and Balazsy [1985] provides greater detail on some of these methods and answers.)

The analysis here can augment or precede efforts to make more elaborate structural interpretations. The analysis also uncovers and measures important phenomena—for example, the decline in Ohio's growth after 1977 that cannot be attributed to overall national conditions—that would probably not be as transparent in a structural model and might be distorted by its assumptions. Time series methods provide measures of relationships and events without elaborate interpretations imposed on them; that is at once their advantage and their drawback, vis-à-vis structural models.

An important impediment facing the regional economist is the lack of reliable and timely measures of aggregate activity. Direct comprehensive measures of output are unavailable. In practice, regional economists have come to place greatest emphasis on the establishment-survey, or payroll, employment series. They are available on a timely basis, disaggregated by major industrial categories. The survey

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directly covers a substantial minority of employment. The sample is relatively fixed from one month's survey to the next, so that movements do not significantly reflect changes in the sample. This is both a virtue and a vice: the sample fixity prevents movements from reflecting changes in the sample, as can occur in the household-survey employment series, but shifts of employment away from the mostly large-firm employment that dominates the survey can bias measured growth. The payroll series is revised early each year to largely eliminate accumulation of such bias, but it can still build up within the year.

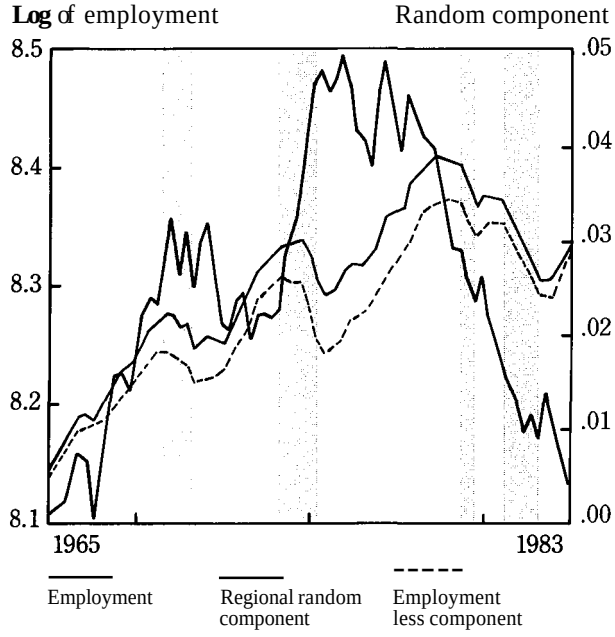
By contrast, the household-survey series, because it is based on a small sample in terms of individuals directly covered, reflects a substantial sampling error. Standard sampling errors, even for quarterly growth rates, suggested by the collecting agency are quite high relative to the observed fluctuations in the series. The accuracy of payroll figures is most likely less affected than the household-survey series by changes in the labor force, because the household survey series necessarily require assumptions about population growth that are confirmed only at the time of population censuses. Of course, any employment series cannot exactly reflect output, because of changes in technology or productivity and in nonlabor inputs.

Empirical findings to be presented here conform to expectations about the relative usefulness and accuracy of the employment series. Payroll employment, as measured, displays a closer coherence with the cyclical variation in other series, both national and regional? Movements in the payroll series also tend to persist from one quarter to the next, unlike the household-survey series. Also, the former tends to foreshadow the latter, although not vice versa.

These properties of the payroll series suggest that they are relatively more accurate indicators of employment and are more useful in understanding and predicting regional trends. But lacking a comprehensive output series, we have looked to personal income in particular and to the other regional series in general for confirmation of conclusions drawn from the payroll series. These series include household-survey employment and the labor force, (nominal) personal income, retail sales, housing starts, the factory workweek, and consumer prices. The properties of these series are of independent, if secondary, interest.

Figure **1** shows, as the solid dark blue line, the quarterly averages of seasonally adjusted Ohio payroll employment from **1965** to **1983**.[2] The most obvious characteristics of that series are long-term growth and variability in growth. The variability appears somewhat cyclical. Factors determining fluctuations in regional growth tend to persist in the same direction for a short time (but typically less than a year, as we shall see). Forecasts should therefore reflect not merely the long-run growth of the

Fig. 1 Payroll Employment and Components



NOTE: Shaded areas indicate recessions.

1. For example, payroll employment was more closely related to personal income than was household-survey employment. The correlation coefficients of quarterly growth rates were 0.87 and 0.55, respectively. The correlations with the U.S. index of approximately coincident indicators were 0.87 and 0.58.

2. The data shown are those actually used in the study, and are given in Hoehn and Balazsy (1985).

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3. The most critical assumption is that the parameters are stable over the sample period. However, this assumption is less of a problem in the out-of-sample simulations we use as a check on our within sample period results.

series, but also give special consideration to growth in the most recent quarters. These characteristics pertain to the properties of the series in isolation and require no theoretical knowledge to acquire. For deeper understanding, and possibly more accurate forecasts, the series must be related to other series, regional and national.

As a vivid illustration, consider the effects of national recessions, as identified by the National Bureau of Economic Research. They are shown in figure 1 as the shaded areas. We shall show how the national composite indexes of leading and coincident indicators are particularly useful proxies for the national business cycle. We formally express their relationship with Ohio employment by a trickle-down model.

A number of time series models for 10 seasonally adjusted quarterly Ohio series will be sequentially considered to establish the forecasting signals available from a variable's (a) own past, (b) other regional variables' pasts, (c) national variables' pasts and, in some cases, (d) contemporaneous relationships with other variables. Analysis also helps us understand the characteristics, quality, and usefulness of various available regional indicators. Comparisons of the models' performance in a 1965–1983 sample period and a 1979–1983 out-of-sample forecast simulation are designed to assess these potential sources of information. Finally, the particularly successful trickle-down model is further studied to yield insight into the sources of regional growth fluctuations in Ohio from 1965 to 1983.

I. A Time Series Methodology

Before presenting results, some explanation of methods is helpful. One major advantage of the time series methods we use is that they are quite transparent. They can be replicated in this and other contexts. These methods are appropriate in many contexts in which a priori information about relationships is scarce or inadequate. We regard the economic process at the regional and national levels to be an example of such contexts. Our methods are informative, although less informative than methods that use stronger correct prior information. A reader in possession of such information may rightfully regard a time-series approach as neglecting it, resulting in inefficiency in extracting knowledge. We do not ask the reader to accept an elaborate structural hypothesis of our own at the outset of the analysis, nor do we impose such a hypothesis on the data. We shall make some structural speculations and interpretations of our results after the data have spoken through a set of more neutral statistical hypotheses, in the form of simple linear time series models. Of course, even these models involve some ad hoc assumptions, although they are minimal.[3]

Our objective is to model, consequently predict and, in some sense, explain, the movements of Ohio series. Each quarter is treated as a separate event. Each variable is analyzed in terms of a quarterly growth rate, measured as the change in the natural logarithm. (When multiplied by 100, this rate is essentially a percentage.) The various models to be considered condition expected growth rates on various potential sources of information. By comparing the performance of alternative models, which differ by including or excluding some variable or variables, we can assess the information value associated with the addition of a source or sources of information. We shall always allow models to reflect information about its parameters from historical data. The comparisons will involve the effect on model performance from the addition of some past growth rates of the series itself (own-lags), or that of some other series or group of series. (Contemporaneous relationships are largely irrelevant for forecasting, although important for structural analysis.)

For example, the ***random walk*** (with drift) model simply predicts that the historical average growth will occur in any quarter in the future; it uses no past growth rates except, of course, in the calculation of the average—the key parameter in the random walk model.

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The autoregressive model we consider uses the past two quarterly own-lags to forecast a quarter's growth rate. The information gain from using the series' own past growth can be measured by comparing the size of a typical forecasting error of the autoregressive model with that of the random walk model. If a variable is characterized by cyclicity, or persistence, then the autoregressive model will have typically smaller errors.

Additional information from other variables, both regional and national, was assessed by measuring the reduction in typical forecast error after including the first two lags of those variables. We have tried a list of 27 possible variables—the other nine regional and 18 national variables—each individually as possibly useful. Each of these trials created a bivariate model, in which a series' growth was conditioned on its own recent growth rates and those of one other variable. Finally, two multivariate models, a trickle-down and a stepwise model were tried. The trickle-down model predicts a series' growth rate using the two most recent own-lags plus one lag each of payroll employment, the U.S. composite index of leading indicators, and the U.S. composite index of approximately coincident indicators.

As it turned out, the (total) payroll variable in each equation for the other nine regional series generally had very little explanatory power once the national variables (and own-lags) were included, justifying the characterization "trickle-down." In order to use the trickle-down model to forecast more than one quarter ahead, we augmented it with equations for the two national variables. They included, as regressors, two own-lags and one lag of the other national variable. The equation for Ohio payroll employment and for the two national variables are shown in the box in section III. Their implications will be analyzed extensively there.

The stepwise model used a variant of the familiar stepwise regression procedure. It searched opportunistically among regressors suggested by their significance in the bivariate tests, in order to find a well-fitting equation. A similar, but less mechanistic, method of model construction proved successful for Texas in an earlier study (Hoehn 1984). The stepwise model helps us assess the total information available without regard to source, and is less dependent on ad hoc, prior assumptions than the trickle-down model. In forecasting more than one quarter ahead, the stepwise model used two-lag autoregressive equations to provide the prerequisite forecasts of the national variables.

In implementing this methodology of assessing information gain, we have necessarily imposed certain ad hoc, although reasonable, and commonly made, assumptions. First, the lag structures described were assumed to be sufficiently long to capture all the information. The series were seasonally adjusted, so longer lags would not be necessary to capture seasonal influences. We openly acknowledge that the X-11 seasonal adjustment procedure may not be entirely adequate, however. The models implemented were linear in the growth rates and were estimated using ordinary least squares.

The information value of a series for predicting another series was measured in two different ways to provide confirmation. First, the models (except the stepwise) were constructed from a long sample from 1965 to 1983. The standard error of the equation for a given model was used as the measure of a typical forecasting error. Then the information gain is measured by comparing the standard errors of the equations. For example, the gain from using two own-lags is measured by the reduction in the standard error of the autoregressive model relative to that of the random walk model (whose standard error is identical to the standard deviation of the growth rate). The reduction is stated as a percent of the standard error of the benchmark, or simpler, model. The calculation of standard errors automatically controls for the tendency of least squares regression to "overfit" a prespecified relationship, so that addition of actually uninforma-

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tive variables does not tend to reduce standard errors or to produce spurious measured information gains. However, the stepwise procedure searched a long list of possible variables for information, so that the overfitting tendency cannot be adequately controlled by this method. Its performance can only be assessed by a second method.

The second method measures information by the reduction in the root mean square error (RMSE) of alternative models' forecasts during a simulation period from 1979 to 1983. To simulate real-time forecasting, each model's forecast was based on parameter estimates constructed using data for periods prior to the period forecast. The stepwise model was specified (its information variables and their lags chosen) using only data through 1978; it was not respecified in the simulation, giving it a handicap it would not suffer in real-time forecasting. (Of course, its parameter estimates were updated during the simulation period.) For all models, we give emphasis to and report RMSEs for the one-quarter-ahead and four-quarter-ahead forecasts. Our results for longer forecast horizons are less interesting, other than to confirm the frequently bemoaned lack of useful information about growth rates beyond a year.[4] Models of longer-term growth would involve demographic and other factors not included in our cyclical analysis.

II. Time Series Properties of Ohio Economic Statistics

This battery of time series tests and confirmations yielded results that probably conform to, yet may strengthen, refine, and extend, the knowledge that economists studying regions such as Ohio already possess. Some results, such as the relative importance of the national business cycle in accounting for regional fluctuations, may vary across regions; other results may be more general.

First, there is a degree of cyclicity, persistence, or autocorrelation in the regional economy, according to comparisons of the autoregressive and random walk models. The first column of numbers in table 1 shows significant information gains for payroll employment, personal income, and consumer prices, confirmed by the reductions in RMSEs shown in the next two columns. We speculate that the lack of autocorrelation in household-survey employment and retail sales may, in large part, reflect measurement error. As a simple illustration, if the latter tended to reverse itself each quarter in terms of the level of the series, as would be the case for sampling errors, then the observed first-order autocorrelation (correlation between adjacent periods) in growth rates would tend to be pulled away from its true value toward minus one-half. Of course, the nature of measurement errors is far more complex (see Green [1969], Korns [1979] and U.S. Department of Labor [1985]). Depending on the exact nature of the measurement error, the true cyclical properties of the underlying series, and the relative influence on the observed series of each, they might roughly cancel out in the sense of producing no persistence in the observed series. Measurement and sampling errors are likely to be particularly large for household-survey employment and retail sales because the samples are small. This interpretation of the household-survey employment series is reinforced by the slight negative autocorrelation in the labor force series obtained by the same samples.[5]

The degree of persistence in payroll employment is not large; it accounts for less than 18 percent of the standard deviation of total payroll growth rates, and about one-tenth of its manufacturing and nonmanufacturing categories taken separately. Although this persistence may be slightly understated due to measurement problems, the conventional X-11 seasonal adjustment procedure may tend to overstate it somewhat. Examination of the autocorrelation of adjacent growth rates suggests that cyclical factors influencing total payrolls tend to persist in the same direction

4. This reveals itself as a lack of further reduction in root means of square error measured in (log) levels of series, beyond the one-year horizon.

5. We confess that time aggregation—the averaging of data from more than one point in time—can create spurious positive autocorrelation. See Tiao and Wei (1976). The use of monthly data would eliminate this problem for the employment surveys, but would make lag structures more complex, the resulting models less transparent, and seasonal adjustment issues more serious.

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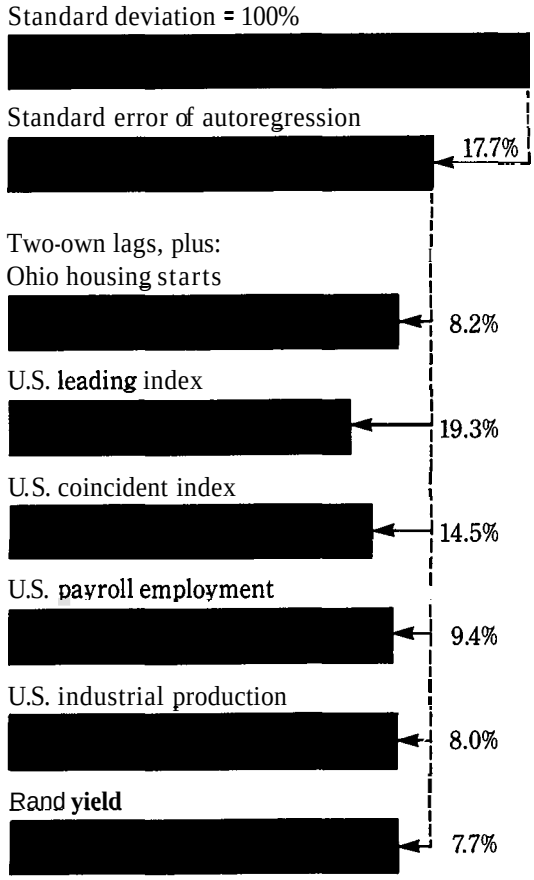
6. The potential of the interest rate and inflation to provide leading information is consistent with new interpretations of the business cycle that stress changes in productivity. A study by Litterman and Weiss (1983) suggests that innovations in real interest rates precede innovations in output.

for only a few quarters. Autocorrelations are 0.57, 0.32, and 0.22 for lags one through three, respectively, 0.23 being equal to the approximate .05 two-tailed critical value.

The lack of substantial autocorrelation beyond a few quarters is consistent with the notion that cyclical factors tend to persist in the same direction for only a short period. A short duration and relatively small amplitude of the business cycle is suggested in studies of national and international data by Nelson and Plosser (1982) and Stulz and Wasserfallen (1985).

Most persistence in Ohio payroll employment beyond a single quarter is attributed to the nonmanufacturing category, whose autocorrelations are significant at up to five lags. By contrast, the manufacturing sector's growth rate is significantly autocorrelated only at the first lag, although the second lag's autocorrelation is nearly significant. Beyond the second lag, manufacturing employment autocorrelation declines rapidly. A higher magnitude of persistence in total payroll employment in comparison to its components seems paradoxical, but is due to independent fluctuations in and intersectoral shifts between the two. (Interestingly, once their relation with the U.S. coincident index is controlled for, they display a slightly negative relationship.) Hence, cyclical movements of the total are somewhat obscured in the components.

Fig. 2 Information Sources for Payroll Employment



The bivariate tests suggested that the two national composite series contain particularly valuable information about the future course of Ohio payroll employment, confirming prior notions upon which the trickle-down model was built. Indeed, these two series proved more informative than any others, as shown in figure 2, which depicts gains from the six most informative series. Significant at the .01 level, in descending order, were the two composite indexes, U.S. payroll employment (one of four components in the coincident index), Ohio housing starts, U.S. industrial production (also a coincident index t) a term interest ra the U.S. consumer ice index, U.S. manufacturing payroll employment, and the gross national product deflator.

The composite indexes seem to summarize reasonably well the information available from national data. Perhaps the long-term interest rate, classified as a "lagging indicator" but showing leading information here, is the maior element omitted from those two composites.[6] Among the regional i , only Ohio housing s gives significant leading information about future payroll employment at the .01 level in the bivariate tests. However, we discovered later that the series did not add

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7. We tried adding one lag of starts to the payroll equation of the trickle-down model. The standard error of the equation rose as a result.

any incremental information after the leading and coincident series were included? The payroll measure gives leading information about the future household-survey employment and labor-force series, but not vice versa. In fact, of all the intraregional bivariate leading relationships found, the strongest was from payroll to household-survey employment, whose standard error was reduced by over 13 percent. The manufacturing workweek was included in our study in the hope it would provide advance information about manufacturing payrolls. Instead, the workweek was foreshadowed by manufacturing payrolls. This result is inconsistent with the prevailing characterization of the workweek as leading. (Its national counterpart is included in the composite index of leading indicators.) The result is nevertheless consistent with the results of Beveridge and Nelson (1981), who find that its national counterpart is a lagging indicator of the business cycle.

Based on the bivariate results, we regard cyclicity in payroll employment as largely linked to the national cycle, an interpretation to be reinforced in the next section. Results for personal income were quite similar in that the same series that were informative about payrolls were generally also informative about income. The two composite indexes were again most valuable, followed by U.S. payrolls, the manufacturing component of U.S. payrolls, and Ohio housing starts. However, the inflation and interest-rate variables were insignificant, while real gross national product was significant, at the 1 percent level.

The leading or lagging character of the series can be tentatively judged in view of

Table 1 Information Gains and Forecast Simulation Results

	Cyclicity			General interdependence					
	Autoregressive (univariate)			Trickle-down			Stepwise		
	Information gain[1]	Reduction in RMSE[2]		Information gain[3]	Reduction in RMSE[5]		Information gain[4]	Reduction in RMSE[5]	
Ohio Series		1-step	4-step		1-step	4-step		1-step	4-step
Payroll employment (establishment survey)	17.7[b]	26.4	12.7	19.5[b]	20.2	6.8	34.2	14.6	6.3
Manufacturing	10.1[b]	14.7	1.1	25.3[b]	24.7	14.8	36.1	18.1	3.9
Nonmanufacturing	9.6[b]	28.2	15.6	7.5[a]	0.0	-2.7	21.7	-9.8	-1.7
Household-survey employment	-0.8	-1.9	-2.0	16.1[b]	11.0	4.9	24.9	20.7	6.0
Labor force	2.4	-3.9	-4.2	7.6[a]	7.5	21.5	16.7	4.7	34.9
Personal income	7.6[b]	10.3	2.4	18.4[b]	23.7	5.1	26.3	-4.3	5.1
Retail sales	2.0	1.4	-0.5	1.2	11.0	1.9	4.9	5.7	-1.2
Housing starts	-1.0	-2.8	-2.5	9.0[b]	5.6	8.6	15.6	17.6	25.2
Factory workweek	-0.5	0.8	1.2	25.5[b]	17.6	17.6	37.5	5.6	7.8
Consumer prices	19.1[b]	7.7	9.1	0.7	0.0	3.3	7.7	-3.8	-5.9

a. Significant at the .05 level.
b. Significant at the .01 level.
NOTE: All series were seasonally adjusted. (Data sets and sources described in Hoehn and Balazsy [1985].)
1. The percent reduction in standard error of equation relative to the random walk model, for the 1965:IVQ to 1983:IVQ sample period.
2. The percent reduction in root mean square error relative to the random walk model, for the 1979:IQ to 1983:IVQ simulation period.
3. The percent reduction in standard error of equation relative to the univariate autoregressive model, for the 1965:IVQ to 1983:IVQ sample period.
4. The percent reduction in standard error of equation relative to the univariate autoregressive model, for the 1965:IVQ to 1978:IVQ sample period. Warning: The calculated information gain does not control for the "overfitting" arising from opportunistic selection of regressors.
5. The percent reduction in root mean square error relative to the univariate autoregressive model, for the 1979:IQ to 1983:IVQ simulation period.

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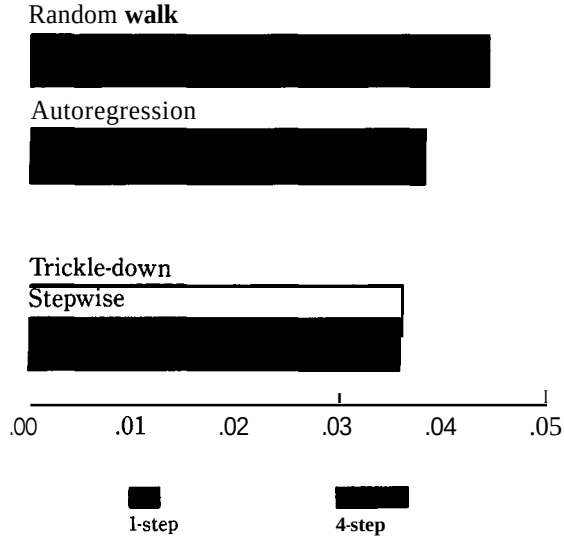
the above results and interpretations of quarterly data. We regard housing starts as leading, hours as lagging, and most other series as approximately coincident. The household-survey series for employment and labor force would probably be coincident, aside from the measurement errors they contain. The labor force series may be a noncyclical series, since it is contemporaneously uncorrelated with any series other than household-survey employment. Measurement errors in both household-survey series may give them a lagging appearance; the other series, particularly the payroll series, are needed to help locate their true, underlying level. The Ohio consumer price series was virtually unrelated to any other, except national price series, and so could be called an irrelevant or non-indicator.

The trickle-down and stepwise models of payroll employment and its components, and of personal income, fit better, in the sense of standard errors of equations, than either the autoregressive or any of the bivariate models. Employment according to the household survey was slightly more closely related to two past values of the coincident index than to the regressors of the trickle-down model (of which the first lag of the coincident index was the most powerful). The trickle-down model's standard errors for retail sales and consumer prices were no smaller than for their autoregressive equations, a result that conforms to the bivariate evidence that these variables cannot be forecast by using other information. Although retail sales were related to other series within a given quarter (the correlation with payroll employment was 0.28), no leading information about it from other series was uncovered.

The out-of-sample forecasts of the trickle-down and stepwise models provide evidence that simple multivariate forecasting models can perform successfully, having lower RMSEs than simple autoregressive models. As shown in table 1, the improvements are reasonably consistent across the 10 regional variables. The trickle-down model had a RMSE at least as small as the autoregressive model in one-quarter-ahead forecasts for all variables and provided statistically significant information gains in eight cases, at the .05 level. For payroll employment, the gain and the reduction in RMSE was about one-fifth (figure 3). Much of that improvement appears to come from information about manufacturing employment.

This evidence of the forecasting ability of simple multivariate models roughly replicates a previous result by Hoehn (1984) for Texas. While the improvement over the univariate autoregressions should not be exaggerated, it is meaningful, consistent, and to our knowledge has not been documented for structural models (such as the "Bayesian vector autoregressive" models) commonly employed.

Fig. 3 RMSEs of the Payroll Forecasts for Models



Regional Fluctuations

The trickle-down model can help address the linkage between national and regional fluctuations. It suggests that variations in payroll employment over periods of several quarters

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can be mostly attributed to national developments, as summarized, apparently rather well, by the two composite indexes.

The trickle-down model describes the determination of payroll employment according to the three equations shown in the accompanying box. Movements in payroll employment are attributed to the disturbances or shocks to each of the three equations. These shocks feed through the equations to generate the observed changes in the three variables. (While not observed directly, these disturbances can be estimated as residuals in the fitted equations.) The shocks to the national indexes' equations clearly reflect national events. But so, to some extent, do those to the payroll equation, creating some ambiguity. However, this ambiguity is eliminated by attributing any portion of payroll shocks that are statistically related to the national equation shocks to national events. The part of the payroll shock (linearly) unrelated to national events can be found by regressing the residual from the trickle-down equation for payrolls on those for the national indexes. The residuals from this regression represent both distinctly regional events and idiosyncratic elements of the region's response to national events. In the vector autoregression ("VAR") literature, these are called ***orthogonalized*** shocks because they are "washed" of correlation. These residuals have a variance only 41 percent as great as that of the payroll equation's disturbance term, because correlation with national equation errors accounts for 59 percent (R^2). The interpretation is that even short-run movements in Ohio employment are largely accounted for by national events. Over longer time horizons, the importance of national events looms larger, as national shocks create persistent

The Trickle-Down Model of Payroll Employment

Sample: 1965:IVQ to 1983:IVQ

(1)
$$\Delta\ln PAYROLL_t = \underset{(.0008)}{-.0004} - \underset{(.20)}{.06}\Delta\ln PAYROLL_{t-1} + \underset{(.12)}{.36}\Delta\ln PAYROLL_{t-2} + \underset{(.06)}{.18}\Delta\ln LEAD_{t-1} + \underset{(.13)}{.16}\Delta\ln COIN_{t-1} + e_{1t}$$

standard error of equation = .0065

(2)
$$\Delta\ln LEAD_t = \underset{(.0024)}{.0057} + \underset{(.12)}{.84}\Delta\ln LEAD_{t-1} + \underset{(.13)}{.22}\Delta\ln LEAD_{t-2} - \underset{(.19)}{.89}\Delta\ln COIN_{t-1} + e_{2t}$$

standard error of equation = .0192

(3)
$$\Delta\ln COIN_t = \underset{(.0016)}{.0015} + \underset{(.16)}{.02}\Delta\ln COIN_{t-1} + \underset{(.12)}{.22}\Delta\ln COIN_{t-2} + \underset{(.09)}{.51}\Delta\ln LEAD_{t-1} + e_{3t}$$

standard error of equation = .0128

PAYROLL = Ohio payroll (establishment-survey) employment, seasonally adjusted.
LEAD = Index of leading indicators.
COIN = Index of approximately coincident indicators.

NOTE: Figures in parentheses are the standard errors of estimates of the parameters.

Random Regional Component

Let the national component of e_{1t} be:

$$\hat{e}_{1t} = E[e_{1t}|e_{2t}, e_{3t}] = k_1 e_{2t} + k_2 e_{3t}.$$

Then the orthogonalized error is:

$$e^*_{1t} = e_{1t} - \hat{e}_{1t}, \text{ and,}$$

the random regional component of $\ln PAYROLL_t$ is:

$$(1 - L)^{-1}(1 + .06L - .36L^2)^{-1} e^*_{1t},$$

where L is the lag operator.

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fluctuations in the composite indexes that trickle down and feed through the payroll equation. As shown in table 2, a 1 percent positive shock to the leading index is followed by a progressive increase in Ohio employment, peaking at 0.81 percent in five quarters. The typical movement of Ohio payrolls in the wake of orthogonalized shocks to the coincident index—washed of their correlation with the shocks to the leading index—is more immediate, but fades, meaning that increases in the coincident index that are not validated by the leading index tend to be followed by unsustainable increases in Ohio payrolls. Given the relative magnitudes of the orthogonalized errors, and the response patterns just described, forecasting errors at long-term horizons owe about 85 percent of their variance to national events, as shown in table 3.

Table 2 Response of Ohio Payroll Employment to Orthogonalized Shocks

Quarters ahead	National shocks: Index of leading indicators, Unit[a]	National shocks: Index of leading indicators, Standard[b]	National shocks: Index of coincident indicators, Unit[a]	National shocks: Index of coincident indicators, Standard[b]	Regional shocks: Payroll employment, Unit[a]	Regional shocks: Payroll employment, Standard[b]
1	.13	.25	.46	.44	1.00	.42
2	.37	.71	.59	.56	.94	.39
3	.57	1.09	.59	.56	1.30	.54
4	.73	1.40	.46	.44	1.26	.53
5	.81	1.55	.29	.27	1.39	.58
6	.82	1.57	.13	.12	1.37	.57
7	.79	1.52	.01	.01	1.42	.59
8	.75	1.44	-.04	-.04	1.41	.59
9	.71	1.36	-.05	-.05	1.43	.60
10	.68	1.30	-.03	-.03	1.42	.59

a. Percent response of payroll employment to a 1 percent shock.
b. Percent response of payroll employment to a shock of typical size, i.e., one standard deviation.

Table 3 Decomposition of Variance of Ohio Payroll Employment Forecast Errors

Quarters ahead	Standard deviation[a]	Percentage of variance attributable to: Leading index	Coincident index	Payroll employment
1	.65	14	45	41
2	1.18	40	36	23
3	1.79	55	26	19
4	2.37	66	18	16
5	2.91	72	13	15
6	3.35	76	10	14
7	3.73	78	8	14
8	4.04	79	7	14
9	4.31	80	6	14
10	4.54	80	5	14

a. Percent.

Although the national series, particularly the leading index, have considerable leading information about regional employment growth, this does not necessarily imply that Ohio lags behind the economy over business cycles. Other evidence suggests the relation between national and Ohio payroll employment may be essentially contemporaneous. The timing relation can be summarized by the cross-correlation function—the correlation of growth rates, after the latter are washed of autocorrelation, at various leads and lags. (Spurious results can arise without such a washing.) We implemented the washing by using residuals in regressions with two own-lags for the two employment series. The contemporaneous correlation of those residuals was 0.83. No other correlations were significant, although the correlation between the Ohio payroll residual and the national payroll residual lagged once was 0.21, not far from the 0.23 critical value for the .05 significance level. The lagged correlation, however, might easily be a result of larger measurement error in the Ohio series, time aggregation (Tiao 1972), or seasonal adjustment problems. Hence, the evidence provides weak support for anything other than a contemporaneous relation between Ohio payrolls and its national counterpart.

The trickle-down model also permits a decomposition of the historical values of the payroll series into a long-run growth component and random components attributable to national and regional shocks? Figure 1 shows the overall payroll series, with the random regional component (right-hand scale, blown up) and the payroll series minus its random regional

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8. Our time series model cannot break down the long-run growth of the series into components attributable to national and regionalfactors; to do so would require additional structural information.

9. Our colleague, Philip Israilevich, speculates that smaller increases in (regulated) electricity prices in Ohio, compared with the nation, during the mid-1970s oil price increases may be responsible for the uncharacteristically moderate decline of Ohio employment in that recession period. An alternative or complementary explanation would stress the increased demand for new, less energy-intensive capital goods as energy prices rose. (Ohio is a major capital goods producing state.) We are unable to provide convincing tests of these hypotheses without an extensive, more structural analysis, which is beyond the scope of our study.

component superimposed. The random or cyclical regional component reflects the impact on the level of the payroll series arising from the orthogonalized shocks to its equation. It is essential to bear in mind that, because the long-run growth has been removed, the random regional component, which starts at zero, necessarily also ends the sample at nearly zero. It is the movements of the component during particular periods, compared with other periods in the sample, that is informative.

The random regional component rises during the economic expansion of the late 1960s. During the 1973–1975 recession, the component again rose sharply, greatly cushioning the impact of the national recession? Indeed, the decline of 115,000 jobs during the six-quarter recession would have been 90,000 larger without the aid of the component. But from the late 1970s to the end of 1983, the regional component declined, accounting for a loss of 189,000 jobs from 1977:IIIQ to 1983:IVQ. In contrast to the 1973–1975 recession, distinctly regional factors appear to have aggravated Ohio's economic weakness in the early 1980s. Furthermore, the rise and subsequent fall of the component might reflect a kind of structural change in the region; perhaps the underlying long-run growth rate declined in a permanent way after the mid-1970s.

Conclusion

Time series methods can be used to exploit limited prior information and data sets to acquire insight into economic systems. In this study, we designed and applied time series methods to Ohio and (a) assessed the quality and quantity of information in various indicators of economic activity in Ohio, (b) developed relatively efficient forecasting schemes, (c) provided insight into the sources of variation in sectors of the Ohio economy, and (d) uncovered and measured phenomena for further analysis. The methods employed were simple and transparent and could be applied in other contexts, such as in other regional economies.

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