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## Productivity Convergence in Eight Sectors in Eight U.S. Midwestern States

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## **Productivity Convergence in Eight Sectors in Eight Midwestern States**

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### Abstract

This paper investigates whether there is convergence in the productivity of eight sectors in eight midwestern states over the period 1963-89. Both cross-section and time-series techniques are used. Using cross-section techniques, it is found that convergence did occur for total, state productivity but not for each of the sectors. In particular, convergence did not occur in the productivity of service-related sectors while it did occur in manufacturing and transportation and public utilities. Using time-series techniques, no convergence is found. However, common trends were present for both the total, state productivity and most of the individual sectors.

## I. Introduction

The neoclassical growth model suggests that productivity, or per capita income, in different regions will converge over time with lower productivity regions catching up to higher productivity regions. This would suggest that regions with low initial levels of productivity would exhibit higher rates of growth in productivity than regions with high initial levels.

This convergence hypothesis has received much empirical attention over the past decade. For example, Baumol (1986), using 1890-1979 data and cross-section techniques, finds convergence in output per labor-hour among developed countries but not for less developed countries. He argues that the convergence arises from trade and imitation necessary for competitiveness. Alam and Naseer (1992) test for two competing theories noted by Baumol (1986): convergence among developed countries but none among lesser developed countries. They argue one would expect to find a quadratic or "inverted-U" relation between growth in income per capita and initial levels of income per capita. Looking at a large sample of countries, they find that the quadratic specification produced significant results. Button and Pentecost (1995), in testing for convergence of the European Union regional economies, find that regressions of growth in per capita GDP on initial levels of per capita GDP support the convergence hypothesis. Although Niemi (1983) does not explicitly investigate the convergence hypothesis, he notes that productivity growth (measured in terms of GSP per employee) in southeastern states exceeded that of the United States as a whole. This implies convergence in productivity.

Using time-series techniques, Carlino and Mills (1993) test for convergence in per capita incomes in U.S. regions over the 1929-90 period. They find evidence in support of convergence. Bernard and Durlauf (1995) also use time-series techniques. Using cointegration tests and per capita GDP for 15 OECD countries, they find no convergence but do find common trends. Bernard and Jones (1996) examine the convergence of total factor productivity both at the aggregate, national level as well as at the sectoral level for 14 OECD countries for the period 1970-87. They argue that finding convergence at the aggregate level may be masking differences in sectoral convergence. Using both cross-sectional and time-series techniques, they find convergence occurring at the aggregate level. However, at the sectoral level they find that convergence is occurring in the non-manufacturing sectors but, surprisingly, little evidence for convergence in manufacturing.

The purpose of this paper is to investigate the convergence hypothesis for productivity both at the aggregate and sectoral level for a sample of eight midwestern states in the U.S. over the 1963-89 period. Using cross-sectional techniques, it is found that convergence exists at the aggregate level. At the sectoral level, convergence is found in the manufacturing sector but not in the non-manufacturing, service-related sectors, contrary to the findings of Bernard and Jones (1996). With time-series techniques only common trends but not convergence were found both for total, state productivity and for the majority of individual sectors. This is consistent with the Bernard and Durlauf (1995) findings for the 15 OECD countries.

The paper proceeds in the usual fashion. The next section discusses the empirical techniques to be used and the data. The following section describes the results and a concluding section summarizes the paper and presents some suggestions for future research.

## II. Methodology and Data

To investigate the convergence hypothesis both cross-sectional and time-series techniques were used. With respect to the cross-sectional techniques, if there is convergence in productivity across states or sectors, states or sectors with low initial levels of productivity should exhibit a growth rate in productivity which is greater than states or sectors with high initial levels of productivity. Thus, one would expect an inverse relation between initial levels of productivity and growth rates in productivity.

With respect to the time-series techniques, the well-known cointegration tests proposed by Johansen (1991) are used. These tests are based on the rank of the  $\mathbf{P}$  matrix of coefficients in the following model:

$$\mathbf{D}Y = \mathbf{G}(L) \mathbf{D}Y_t + \mathbf{P}Y_{t-1} + \mathbf{m} + \mathbf{e}_t \quad (1)$$

where  $Y_t$  represents, in our case, the log of productivity,  $L$  is the backshift or lag operator,  $\mathbf{G}(L)$  and  $\mathbf{P}$  are parameter estimates based on maximum likelihood estimates (MLE),  $\mathbf{m}$  is a vector of constants and  $\mathbf{e}_t$  is the error vector having the usual properties. Following Bernard and Durlauf (1995),  $\mathbf{P}$  gives the long-run relationship among the productivity series while  $\mathbf{G}(L)$  gives the short-run effects of shocks to the system. Since we are interested in the long-run relationships among the variables, tests for the cointegrating vectors come from the matrix  $\mathbf{P}$ . These tests are based on the maximum

eigenvalues and the trace statistics to determine the rank of the cointegrating matrix derived from  $\mathbf{P}$ . If there are  $p$  variables, the rank,  $r$ , of  $\mathbf{P}$  indicates the number of cointegrating vectors and  $p - r$ , the number of common shocks or trends. Thus, if the rank of  $\mathbf{P}$  is  $p$ ,  $p - r = 0$ , there are no common trends and the productivity series,  $Y_t$ , are a stationary process. If the rank is  $0 < r < p$ , there are  $p - r$  common trends. Finally, if  $r = 0$ , the number of trends is  $p$ ; there are no common trends since each state productivity series is driven by its own stochastic shocks. If the productivity series converged, then there must be  $p - 1 = r$  cointegrating vectors or one common trend, i.e.,  $p - (p - 1) = 1$ . Thus, convergence would imply that productivity for states or sectors would move to one, common trend.

The sample used here consisted of total, state productivity for eight midwestern states and productivity for eight major sectors in each of those states. The states were arbitrarily chosen based on their proximity to Ohio. The eight states were Illinois (IL), Indiana (IN), Kentucky (KY), Michigan (MI), Ohio (OH), Pennsylvania (PA), Tennessee (TN) and West Virginia (WV). The eight sectors were the major sectors in each state: Mining (MIN), Construction (CON), Manufacturing (MFG), Transportation and Public Utilities (TPU), Wholesale Trade (WT), Retail Trade (RT), Finance, Insurance and Real Estate (FIRE) and Services (SER).

Productivity was calculated as real output per employee. A preferable measure would have been real output per labor-hours, but hours were not available for every sector nor for the states as a whole. The fact that productivity is measured as output per unit of labor rather than per labor-hour is a minor shortcoming. From hours data that were available for some sectors average hours worked were similar across sectors in the eight-state sample used here. Real output, both for the aggregate, state level and for the various sectors within each state, were obtained from data diskettes distributed by the Bureau of Economic Research. The diskettes contained Gross State Product (GSP) from 1963 through 1989. Also on the diskettes were industry and sector output estimates; the broad, two-digit, sectoral output figures were used here to maximize coverage. Employment data were obtained from the Bureau of Labor Statistics (BLS) web page (<http://www.bls.gov>). Hours data were also obtained from the same source but were not used because of incomplete coverage.

The average growth in real output per employee, in decimal terms, for the 1963-89 period are presented in Table I. For some sectors available data did not extend over the whole period for some states. For example, retail and wholesale trade for Ohio only extended from 1972 to 1989.

These figures were obtained by regressing the log of real output per unit of labor on a constant and trend; the coefficients on the trend term represent the growth rate. From Table I productivity in the construction and services sectors declined over the period for every state in the sample. Mining productivity declined in Illinois and Indiana but increased in the other states. Similarly, productivity declined in the retail trade and finance, insurance and real estate sectors for some states while increasing for others. For these two sectors productivity growth was virtually zero. The largest increases in productivity occurred for the manufacturing and transportation and public utilities sectors.

Table I  
Productivity Growth Rates by State and Sector 1963-89

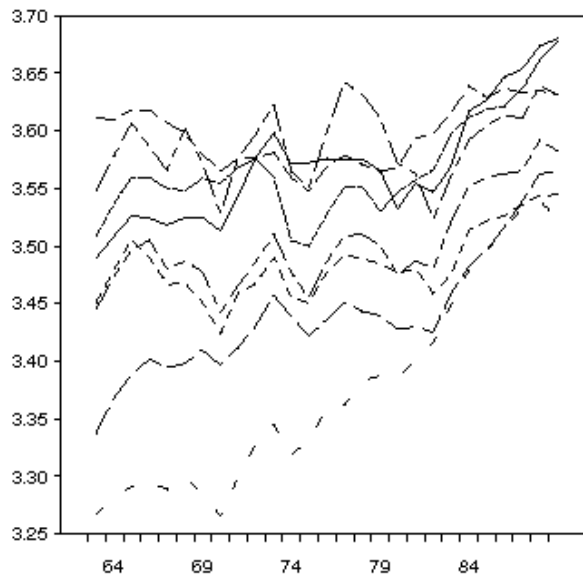
State	MIN	CON	MFG	TPU	WT	RT	FIRE	SER	TOTAL
IL	-.0217	-.0244	.0262	.0255	.0104	.0025	-.0049	-.0016	.0056
IN	-.0017	-.0284	.0183	.0185	.0073	-.0007	-.0038	-.0105	.0025
KY	.0120	-.0163	.0132	.0219	.0083	-.0085	.0060	-.0098	.0012
MI	.0476	-.0330	.0163	.0212	.0023	-.0048	-.0024	-.0104	.0014
OH	.0016	-.0352	.0243	.0193	.0085	.0003	-.0016	-.0063	.0040
PA	.0078	-.0288	.0238	.0286	.0064	-.0043	.0003	-.0020	.0063
TN	.0183	-.0193	.0331	.0208	.0077	.0083	.0071	-.0010	.0108
WV	.0172	-.0097	.0115	.0292	.0036	-.0044	.0158	-.0073	.0040

Figures I and II present the basic, log of productivity data. Figure I shows the total, log of productivity levels for the eight states. From looking at the graph it appears that productivity has converged from 1963 to 1989 as the productivity levels of Tennessee and Pennsylvania approached the levels of Michigan and Illinois.

Figure II shows the log of productivity levels for the eight sectors in the eight states. The graphs indicate a variety of patterns. Productivity in manufacturing and transportation and public utilities increased while that for construction and services declined. Productivity in the other four sectors exhibits no general pattern, although mining productivity has a slight trend upward. Productivity for retail and finance, insurance and real estate is generally flat with variations by state. Wholesale trade exhibits a dramatic decline in 1976-77 followed by an equally dramatic increase thereafter. The only sector for which there a distinct convergence is manufacturing and, to a lesser

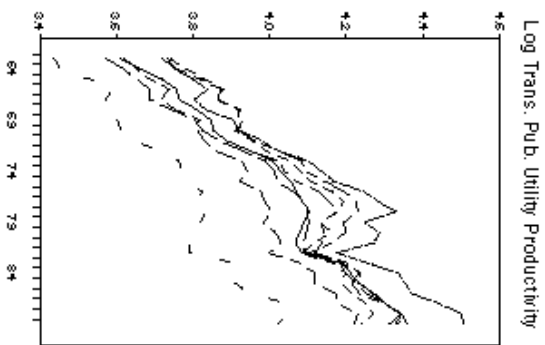
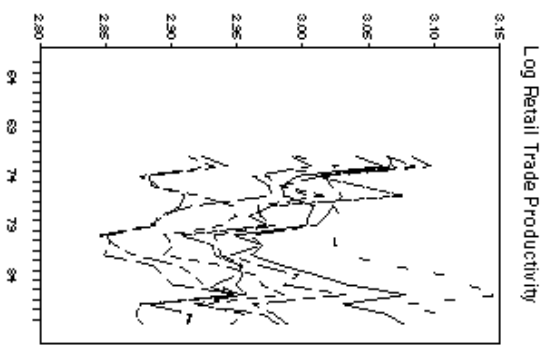
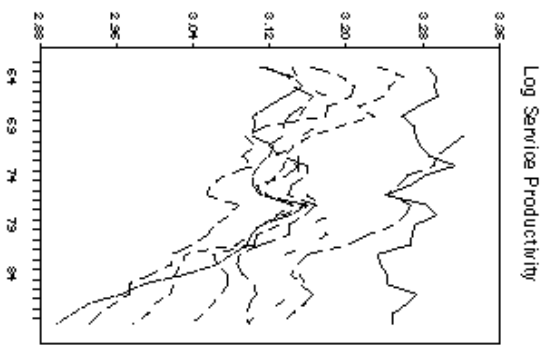
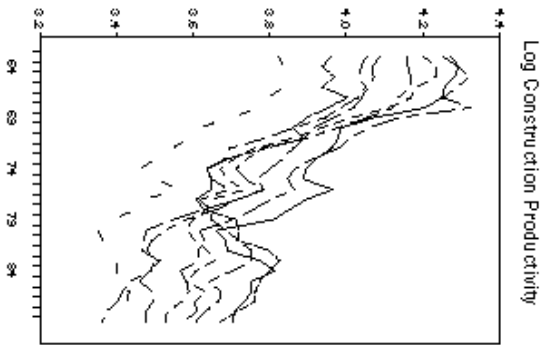
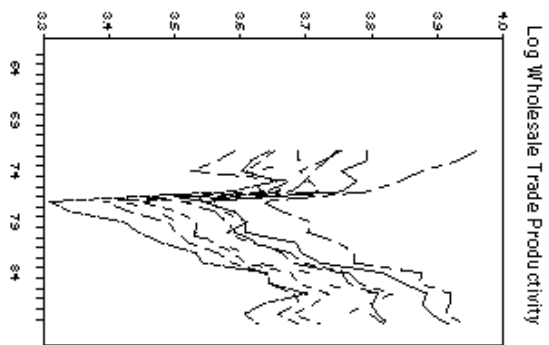
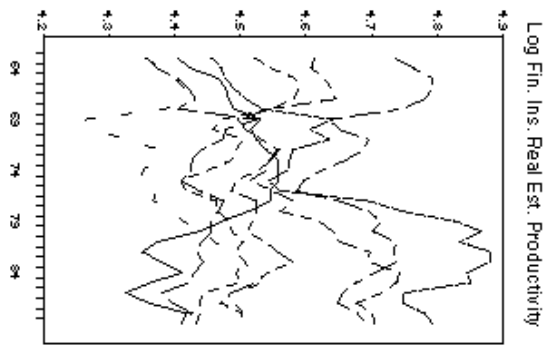
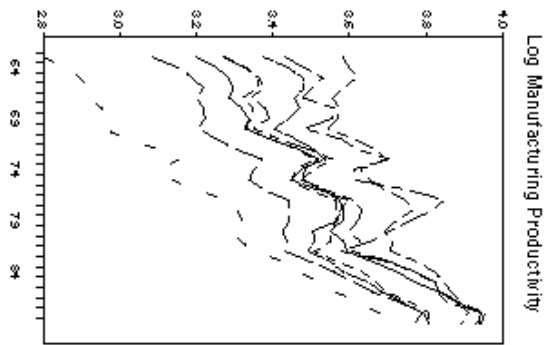
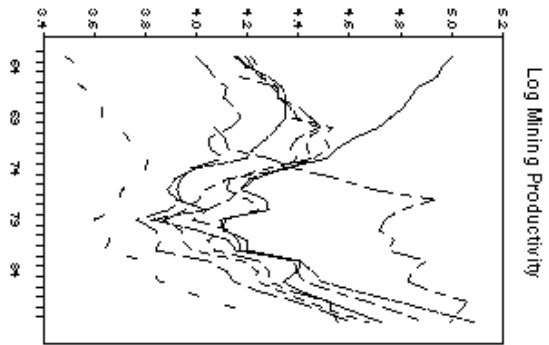
extent, mining. Although productivity for transportation and public utilities is increasing, it appears to be diverging. Similarly, while productivity for services is declining, it is diverging.

**Log Total State Productivity**









### III. Results

The cross-sectional techniques involved regressing the growth rates for individual sectors in the eight states on the initial levels of the log of productivity. With productivity growth over time convergence would imply an inverse relation between growth and initial productivity as low productivity states grew faster than high, initial productivity states. With declining productivity—as was the case in the service and construction sectors—the relation would be either positive or negative. This would depend on whether the high, initial productivity states declined faster or slower than low, initial productivity states. The case of declining productivity, however, is not very interesting from the point of view of the convergence hypothesis.

Regression results for some selected sectors are presented in Table II. Not all sectors are presented in Table II because data were not available for the whole period for all sectors.

Table II

Cross-Section Regression Results:  
Selected Sectors

	Coeff.	<i>t</i> -value
Total	-0.025	-4.80
MFG	-0.028	-4.86
CON	-0.037	-2.06
MIN	-0.020	-1.01
TPU	-0.025	-2.61
FIRE	0.003	0.21
SER	0.012	0.42

From Table II the negative coefficient for total, state productivity indicates there is convergence; the *t*-value indicates the negative coefficient is statistically significant. Looking at the individual sectors, manufacturing and transportation and public utilities, both of whose productivity increased, also exhibit convergence with the negative coefficient being statistically significant. Mining too exhibits a negative relation which would indicate convergence; however, it is not statistically significant. The finance, insurance and real estate sector also has an insignificant coefficient. Construction exhibits significant convergence, but this is a perverse convergence in that productivity was declining in this sector. Finally, services, whose productivity was also declining, exhibits no convergence. Overall,

we can conclude that there is convergence in total, state productivity. However, at that sectoral level only manufacturing and transportation and public utilities exhibited convergence while the other sectors were mixed.

Turning to the time-series results, the model in (1) was estimated with an arbitrary lag length of two to preserve degrees of freedom. Table III presents the results of the Johansen maximum eigenvalue test and Table IV, that of the trace test. Significance at the 5% level are indicated by an "\*" and based on the tables presented in Ostewald-Lenum (1992).

Table III  
Maximum Eigenvalue Test

(p-r)	MFG	CON	MIN	TPU	FIRE	SER	WT	RT	TOTAL
1	0.00	4.37	0.08	0.77	0.02	4.02	0.52	2.95	0.06
2	10.55	14.80	12.41	7.20	15.29	5.56	7.91	5.74	10.03
3	19.46	20.32	22.86*	8.99	15.55	14.83	11.61	8.09	13.02
4	28.22*	20.55	34.43	25.91	27.62*	20.37	19.62	20.84	19.41
5	38.93	38.21*	38.85	33.76*	35.26	32.51	—	—	25.42
6	53.34	45.39	56.34	37.54	44.92	49.73*	—	—	56.16*
7	69.21	97.14	65.14	71.56	54.91	—	—	—	87.96
8	223.68	245.32	—	—	—	—	—	—	173.06

\* indicates significance at the 5% level

Looking at Table III the maximum eigenvalue test indicates that no series exhibit convergence (recall that for convergence  $p - r = 1$ ). However, except for WT and RT, all the series have common trends. For example, MFG has four or more common trends affecting the series; CON has five and so forth. The WT and RT series have no common trends and appear to be stationary processes. The trace test presented in Table IV gives similar results. Again, WT and RT appear to be stationary processes. CON, with one or more common trends, appears to exhibit convergence contrary to the maximum eigenvalue test which suggests five. According to the trace test, MFG has three common trends; based on this result and that of the maximum eigenvalue test, we can conclude that MFG has three or four common trends. Similarly, FIRE has three or four common trends based on the two tests. The trace test indicates SER has five common trends while the maximum eigenvalue test indicates six. Both tests indicate three common trends for MIN and five for TPU.

Except for the CON series, there is substantial agreement between the maximum eigenvalue test and the trace test on the number of common trends in the productivity series.

Table IV

## Trace Test

(p-r)	MFG	CON	MIN	TPU	FIRE	SER	WT	RT	TOTAL
1	0.01	4.37*	0.08	0.77	0.02	4.02	0.52	2.95	0.06
2	10.55	19.17	12.49	7.97	15.30	9.58	8.43	8.70	10.10
3	30.02*	39.49	35.35*	16.96	30.86*	24.41	20.04	16.78	23.12
4	58.24	60.03	69.78	42.87	58.48	44.79	39.66	37.63	42.53
5	97.16	98.24	108.63	76.62*	93.74	77.30*	—	—	67.95
6	150.50	143.64	164.97	114.16	138.67	127.02	—	—	124.11*
7	219.71	240.78	230.11	185.72	193.58	—	—	—	212.07
8	443.39	486.10	—	—	—	—	—	—	385.12

\* indicates significance at the 5% level

Based on the time-series results, one can conclude that no convergence exists for the productivity series. However, most of the series exhibit common trends. The cross-section results, however, indicate convergence in total, state productivity and the sectors of manufacturing and transportation and public utilities; the other sectors, most notably the service-related sectors, exhibited no convergence.

## IV. Conclusions

This paper has investigated whether there is convergence in the productivity of eight sectors in eight midwestern states. The findings indicate that there is convergence in the overall productivity in the eight states using cross-section techniques. However, there is no uniform convergence for the individual eight sectors within the states. Manufacturing and transportation and public utilities exhibited convergence while the other sectors exhibited no evidence of convergence. In particular the service-related sectors did not show convergence. This is contrary to the findings of Bernard and Jones (1996) who observed convergence in the service-related areas and none in manufacturing in their 14 OECD countries. The time-series evidence, on the other hand, indicates only common trends. These results are consistent with the findings of Bernard and Durlauf (1995).

More work needs to be done in this area. It is obvious that the sample needs to be expanded to include more states. However, the data limitations preclude the inclusion of all 50 states for the time-series analysis. These early results are encouraging and suggest that expanding the sample may prove worthwhile.

## References

- Alam, M.S. and A. Naseer, 1992, "Convergence and Polarization: Testing for the Inverted-U Relation Between Growth Rates and GDP Per Capita," *Applied Economics*, 24: 363-66.
- Baumol, William J., 1986, "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show," *American Economic Review*, 76: 1072-85.
- Barro, Robert J. and Sala-i-Martin, Xavier, 1992, "Convergence," *Journal of Political Economy*, 100: 223-51.
- Bernard, Andrew B. and Steven N. Durlauf, 1995, "Convergence in International Output," *Journal of Applied Econometrics*, 10: 97-108.
- Bernard, Andrew B. and Charles I. Jones, 1996, "Productivity Across Industries and Countries: Time Series Theory and Evidence," *Review of Economics and Statistics*, 78: 135-46.
- Button, Kenneth J. and Eric J. Pentecost, 1995, "Testing for Convergence of the EU Regional Economies," *Economic Inquiry*, 33: 664-71.
- Carlino, Gerald A. and Leonard O. Mills, 1993, "Are U.S. Regional Incomes Converging?," *Journal of Monetary Economics*, 32: 335-46.
- Johansen, S. 1991, "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," *Econometrica*, 59: 1551-80.
- Niemi, Albert W., 1983, "Gross State Product and Productivity in the Southeast, 1950-80," *Growth and Change*, 14: 3-8.
- Ostwald-Lenum, M., 1992, "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics," *Oxford Bulletin of Economics and Statistics*, 54: 461-72.