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An Analysis of Labor Productivity Effects on Regional Growth

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Introduction

This paper focuses on the implications from changes in labor productivity for a state's economy. A large scale simulation model for Minnesota is utilized to determine whether the economic structure of the state has any influence on the degree to which changes in labor productivity affect growth. Further, we intend to discuss the strengths of using such a mathematically deterministic simulation approach for analyzing the implications from the Kaldorian model for regional economies demonstrating differing industrial structures.

Although regional economic growth in general and regional growth disparities in particular have been topics of considerable interest to economists, there is no general agreement about the underlying causes of growth. Two broad, competing models have been developed to explain the determinants of regional economic growth--neoclassical and export base.

The neoclassical model emphasizes the role of supply. In this model, growth of output is deemed to be a function of the growth of labor supply, growth of capital stock, and technical progress. Under standard neoclassical assumptions that capital and labor move toward regions offering the highest rates of return, regional growth rates are predicted to converge over time.

One weakness of the neoclassical model is its failure to explicitly recognize the role of demand factors in explaining regional economic growth. The export base approach as developed by Kaldor [3] and formalized by Dixon and Thirwall [2] remedies this situation by making regional rates of growth explicit functions of both the external demand for the reference region's output and the region's industrial structure relative to that external demand. An additional feature of the export base model is that it contains a mechanism which allows for regions to grow at different rates indefinitely.

The focal point of the export base model is the growth in labor productivity. An increase in labor productivity in an exporting region is

seen to lead to a decrease in wages relative to other producing regions. This decrease in wages results in a decrease in the relative price of regional exports which in turn stimulates the growth of regional exports. The growth of exports is modified by the external price elasticity of demand, the cross elasticity of demand, and the income elasticity of demand for industrial exports.

An increase in exports increases profits in the exporting region making possible an increase in investment, output, and thus, employment. The extent to which these profits and resulting investments and employments are affected depends on which industries realize the productivity changes. Finally, the model contains a feedback mechanism whereby an increase in regional economic growth results in the growth of labor productivity.[1]

Economic Development and the IPASS Model

The model used in this study is an input-output based computerized system developed at the University of Minnesota, St. Paul, called IPASS [6, 7]. IPASS is a large-scale simulation laboratory model representing significant extensions of traditional input-output techniques. IPASS uses secondary data from a variety of sources, including Census data as well as data from the Departments of Labor and Commerce. The input-output tables are based on the original U.S. input-output table from the Department of Commerce.

More importantly, IPASS is an empirical model based on Kaldorian assumptions. The model is composed of several interactive modules: investment, market, final demands, production, output, employment, labor force, population, and primary inputs.

The investment module calculates, on an industry by industry basis, needed investment to replace depreciated capital plus investment needed to accommodate regional industrial expansion. Required investment is a function of the region's output. If demand for the region's output exceeds current capital capacities, investment is triggered subject to available funds.

The market module is the export base component of the model. This component is slightly different from Kaldor's notion, however. As mentioned in the introduction to this paper, Kaldor's model relates export activity to changing relative prices for the reference region's output vis a vis the rest of the world. In IPASS, exports are a function of the

reference region's relative market share of U.S. output, changes in the region's market share, and projected growth in output for the nation. All of these measures are on the basis of seventy-five industrial sectors out of the input-output system.

The Kaldor and IPASS models are similar in their analysis of the results of changing export levels. They both assert that a region's performance is in large measure a function of those factors influencing regional export activity. The significance of the handling of prices within the two models will be apparent in the simulation results to follow.

The final demands module adjusts the investment levels out of the investment module to gross capital formation measures. This module also utilizes the projections out of the market module to estimate export activity. Household consumption and government spending projections are also included in this module. Since these latter measures are not directly involved in the analysis presented in this paper, they will not be described beyond pointing to their inclusion in the model.

The production module is the Leontief inverse out of an input-output system.

The output module combines the forecasted levels of final demands with the production module to calculate demand consistent industrial output levels for the region.

In the employment module, industrial demand for labor is a function of the gross output (computed in the output module) and labor productivity. Labor productivity is stated in terms of output per worker along with rates of change in output per worker. The rate of change in output per worker by industry is a parameter in the system capable of being changed by the system's user. This parameter will be modified for the purposes of this analysis in order to simulate a portion of the Kaldorian assertion that changes in labor productivity result in regional economic growth in both investment and subsequent employment.

The labor force module combines labor force participation rates, population levels, and the occupational distribution of the participating population to calculate labor supply.

The population module combines the population base for the region with births, deaths, and calculated rates of migration. The rates of migration are a function of the demand for labor out of the employment

module and the supply of labor out of the labor force module on an occupation basis. If labor demand exceeds labor supply, inmigration occurs, and vice versa.

The primary inputs module calculates incomes resulting from the production and employment processes described above. Earnings are essentially the same as wages. Business income is calculated as total value added less earnings to labor and indirect business taxes. Imports, also a part of this particular module, are defined as imports required to fulfill output requirements as determined in the output module.

IPASS is capable of interactive analysis; i.e., analysis where the user is allowed to change parameters and to simulate impacts from these parameter modifications on regional economic and demographic variables. The recursive-modular approach described above forces consistency in forecasting; that is, consistency in projection between the various modules and calculated levels of final demand.

Output cannot expand beyond employment and capital availabilities in the region. Constraints to unlimited change are built into the system. This forces the user to explain simulated changes in one module in terms of indirect changes triggered in the remaining modules.

As mentioned earlier, a key component explaining economic growth in the Kaldorian framework is the rate of change in labor productivity. The IPASS model allows this parameter to be changed. In this way, the IPASS model for Minnesota is utilized to determine whether the economic structure of the state has any influence on the degree to which changes in labor productivity affects growth.

The Simulation

In this simulation, the rate of change in output per worker was increased for three industries: health services, retail trade, and pulp and paper. Several sectors were used in this analysis to investigate the implications of industrial structure for economic performance. The three sectors were chosen because of their significant contributions to Minnesota's economy. Retail trade is a relatively large employer in the state, health services exhibits a relatively large level of gross output, and pulp and paper is a major exporting industry.

Specifically, the rate of change in output per worker was increased by 5% per year throughout the simulation for each of the three industries. All other parameters in the system were held constant.

One advantage of such an input-output based approach over others is that the input-output model allows for an examination of the implications of regional structure over several industries as opposed to looking at only one industry at a time. Such a systems approach is of particular importance within the Kaldorian framework. According to Kaldor, the gains from productivity differ by sector with the manufacturing sector reaping greater benefits from productivity growth than land based activities, such as mining or agriculture.

Further, the systems approach used here assumed "all other things constant" in a specific manner. Rather than all other absolute values being held constant, the assumption in this type analysis is that all other trends or rates of change are constant. The modified run is then compared to a baseline run where all trends are identified in the original data base.

The simulation was run between the years 1987 and 1990. The results reported here are for the years 1988, 1989, and 1990. The year 1987 is not reported as it is the base year and no changes occur.

The results from the simulated changes for the pulp and paper, retail trade, and health services industries are summarized in Tables 1, 2, and 3 respectively. These tables report the changes in gross output, the changes in employment, employment for individual sectors, value added for the state, value added, and earnings per worker for the state between a baseline and modified simulation.

In all cases, it is interesting to note that increases in labor productivity lead to reductions in employment, value added from earnings, and earnings per worker both for the state as a whole and for the individual sector in which the productivity change occurs. Gross output exhibited either a zero change or a slight increase for the years in question. In addition, the decreases in value added from earnings are in every case offset by corresponding increases in other value added categories. These other value added categories include profits, income from capital and land resources, and proprietors' income.

The results for each sector were consistent in the direction of changes from the baseline to the modified scenario. The only major

difference that could be attached to the three industrial sectors was in the magnitude of change. For example, the changes in the two service based sectors, retail trade and health services, were consistently larger than for the manufacturing based pulp and paper industry. Such a result is consistent with the Kaldorian assertion that regional industrial structure does make a difference and that the manufacturing sector reaps greater benefits from productivity changes, or based on our results, smaller losses. In the value added category, by far the largest change in other value added occurred in the health services industry.[2]

What are some of the implication from these results? The most interesting of the results is that employment actually falls in both the affected sector and in the state as a whole when labor productivity increases. Such a result might demonstrate the continued dependence on neoclassical theory by the Dixon-Thirwall extension of Kaldor. Input-output is generally a price constant approach to economic simulation. There is an assumption in the Dixon-Thirwall theory of growth that increased productivity leads to cost reductions within a regional economy. If competitive conditions are assumed to exist, these cost reductions result in a reduction in regional product prices relative to other regions. As a result, the region becomes more competitive vis a vis other regions leading to increases in export activity. This increase in export activity leads to increases in regional employment, income, etc. In fact, Dixon and Thirwall's theory would lead us to believe that increases in labor productivity alone would lead to increased regional export activity.

It is absolutely essential that increases in productivity result in lower export prices for the general Dixon-Thirwall model to hold. Input-output, on the other hand, assumes that output and resulting employment are consistent with levels of final demand [5]. If productivity increases without increases in final demand, the output consistent with final demand can be produced with less labor. In fact, what would happen in the absence of price changes is that worker earnings would decrease relative to property based earnings as the relative advantage of increased productivities is realized by the owners of nonlabor inputs. The results presented here are more consistent with the view that prices are administered as opposed to "market dominated" or, at the very least, inflexible downward [4].

It must be emphasized that this is not an attempt to prove or disprove the Kaldor-Dixon-Thirwall hypothesis. However, there are strong indications that the export growth hypothesis is presented as an alternative to conclusions of traditional neoclassical price theory. Our

preliminary analysis might indicate that, in fact, the export base theory of productivity effects on regional growth are also quite dependent on price changes stemming from the operation of a competitive market.

There does seem to be some evidence from our simulation that the extent of the effects from such a change depends on the industrial mix in which the changes take place. To this extent the simulation does support Kaldor. Such analyses will certainly be the focus of further simulation attempts along these lines.

Directions for Future Simulations

The State of Minnesota can be identified in terms of three distinct economies: agricultural, resource, and manufacturing based. It would be interesting to simulate the extent to which the export base of a region influences the impacts from productivity changes.

Finally, changes in regional market share can be analyzed through additional simulations relating changes in productivity to changes in the competitiveness of the state's economy. Such a simulation would require either heroic assumptions about the relationship between productivity and regional export activities or a separate analysis of such a relationship the results of which may be entered into the simulation as changes in regional market share.

All such simulations would look at the implications of the various theoretical models for regional economic performance, both within and outside of traditional neoclassical theory with its assumption of competitive markets.

Endnotes

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1. For a detailed discussion of the Kaldor-Dixon-Thirwall model see Harvey Armstrong and Jim Taylor [1].

2. The magnitude of change in this particular category might be explained as resulting from one of two causes. The first is that medical doctors are included in the employment and value added base of the simulation system. Much of the income to these individuals appears in other value added as proprietors' income. Changes in productivity might result in significant returns to these individuals as proprietors at the expenses of wage earnings of other health services personnel.

A second cause might stem from the way in which the input-output component of the simulation system was put together. Earnings were taken from secondary data sources directly. The input-output system was balanced through adjustments in the import/export structure of the region. Other value added then became a residually adjusted figure from the interaction between earnings and imports. Since the two components of value added were determined from separate sources or procedures, there may exist a glitch in these results due to internal inconsistencies. While this is a possibility, the simulated results for the other two sectors and for additional runs of the system for other purposes seem reasonable.

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Table 1
Employment/Value Added Impacts from a Simulated 5% Increase in Labor Productivity: Pulp & Paper*

	1988		1989		1990	
	Level	% Change	Level	% Change	Level	% Change
State Gross Output	117924 (117924)	0.00	121002 (120996)	0.004	123899 (123899)	0.017
State Employment	2088.2 (2088.8)	-0.03	2118.8 (2119.8)	-0.05	2145.5 (2146.8)	-0.06
Sector Employment	26616 (27235)	-2.27	25992 (27217)	-4.50	25269 (27075)	-6.67
Value-Added State Earnings	32969770 (32973947)	-0.01	34573747 (34581257)	-0.02	35888733 (35895981	-0.02
Other	22223918 (22219732)	0.02	22171888 (22161064)	0.05	22314269 (22295439)	0.08

Table 1 (continued)
Employment/Value Added Impacts from a Simulated 5% Increase in Labor Productivity: Pulp & Paper*

	1988		1989		1990	
	Level	% Change	Level	% Change	Level	% Change
Value Added-Sector Earnings	210185 (215071)	-2.27	213645 (223707)	-4.50	213666 (228937)	-6.67
Other	575394 (570507)	0.86	591668 (581596)	1.73	608143 (592824)	2.58
State Earnings Per Person	7447 (7448)	-0.01	7737 (7738)	-0.01	7959 (7960)	-0.01

*Baseline levels are in parentheses. The % change refers to the change in the simulated level relative to the baseline value.

Table 2
Employment/Value Added Impacts from a Simulated 5% Increase in Labor Productivity: Retail Trade*

	1988		1989		1990	
	Level	% Change	Level	% Change	Level	% Change
State Gross Output	117924 (117924)	0.00	121059 (120996)	0.052	124131 (123877)	0.21
State Employment	2081.1 (2088.2)	-0.37	2105.6 (2119.8)	-0.67	2128.5 (2146.8)	-0.85
Sector Employment	262953 (27062)	-2.83	261781 (276647)	-5.37	226796 (282238)	-19.64
Value Added-State Earnings	32866219 (3297394)	-0.27	34418287 (34581257)	-0.47	33569331 (35895981)	-0.06
Other	22307469 (22219732)	0.39	22360522 (22161064)	0.90	22628124 (22295439)	1.49

Table 2 (continued)
Employment/Value Added Impacts from a Simulated 5% Increase in Labor Productivity: Retail Trade*

	1988		1989		1990	
	Level	% Change	Level	% Change	Level	% Change
Value Added-Sector Earnings	3023487 (3111700)	-2.83	3113793 (3290669)	-5.38	3183722 (3452399)	-7.78
Other	1260168 (1171977)	7.52	1328985 (1141727)	16.40	1418124 (1124637)	26.10
State Earnings Per Person	7428 (7448)	-0.27	7002 (7738)	-9.51	7917 (7960)	-0.54

*Baseline levels are in parentheses. The % change refers to the change in the simulated level relative to the baseline value.

Table 3
Employment/Value Added Impacts from a Simulated 5% Increase in Labor Productivity: Health Services*

	1988		1989		1990	
	Level	% Change	Level	% Change	Level	% Change
State Gross Output	117924 (117924)	0.00	121014 (120996)	0.014	124230 (123877)	0.285
State Employment	2082.9 (2088.8)	-0.28	2108.5 (2119.8)	-0.53	2138.4 (2146.8)	-0.39
Sector Employment	146923 (152807)	-3.85	143166 (154868)	-7.56	139691 (155437)	-10.13
Value-Added State						
Earnings	32861345 (32973947)	-0.34	34349415 (34581257)	-0.67	35653666 (35895981)	-0.68
Other	22332343 (22219732)	0.51	22403605 (22161064)	1.09	22718066 (22295439)	1.8

Table 3 (continued)
Employment/Value Added Impacts from a Simulated 5% Increase in Labor Productivity: Health Services*

	1988		1989		1990	
	Level	% Change	Level	% Change	Level	% Change
State Gross Value Added-Sector						
Earnings	2827328 (2940616)	-3.85	2919250 (3157930)	-7.56	2975715 (3311213)	-10.13
Other	306212 (192924)	58.72	265340 (26669)	894.94	265097 (-106039)	**
State Earnings Per Person	7422 (7448)	-0.35	7687 (7738)	-0.66	7908 (7960	-0.65

*Baseline levels are in parentheses. The % change refers to the change in the simulated level relative to the baseline value.

**Extremely large value.