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ABSTRACT

Several explanations can be offered for the unbalanced growth of U.S. regional manufacturing industries in the decades after World War II. The convergence hypothesis suggests that the success of the South in catching up to the Northeast and Midwest should be understood by analogy with the economic success of Japan and the rest of the G-7 in closing the gap relative to the U.S. as a whole. Endogenous growth theory, on the other hand, assigns a central role to capital formation, broadly defined. A variant of endogenous growth theory focuses on investments in public infrastructure as a key determinant of regional growth. Finally, traditional location theory stresses the evolution of regional supply and demand and the role of economies of scale and agglomeration.

This paper compares these alternative explanations of U.S. regional growth by testing their predictions about the productive efficiency of regional manufacturing industries. We find little evidence that technological convergence explains the regional evolution of U.S. manufacturing industry, or that endogenous growth was an important factor. We also find little evidence that public capital externalities played a significant role in explaining the relative success of industries in the South and West. The main engine of differential regional manufacturing growth over the period 1970-86 seems to be inter-regional flows of capital and labor. The growth of multifactor productivity is essentially uniform across regions, although there is some variation in the initial levels of efficiency.

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I. Introduction

The American South started the post World War II era as the poorest region of the country. Per capita disposable income was less than 70 percent of the national level and the South produced less•than 13 percent of national manufacturing output at that time. However, during the ensuing 40 years, the South grew much faster than the most of the rest of the nation. As a result, incomes in the South are now 90 percent of the national average and the South now produces 22 percent of all manufacturing output.

Several explanations have been offered for this pattern of unbalanced regional growth. The convergence hypothesis postulates an inverse relationship between the rate of economic growth and the initial level of economic activity (Barro and Sala-i-Martin 1991, Holtz-Eakin 1991).[1] In this view of growth, backwardness per se implies a potential advantage that can allow lagging regions to catch up to the leaders. Applied to the U.S., the convergence hypothesis suggests that the success of the U.S. South in catching up to the Northeast and Midwest should be understood by analogy with the economic success of Japan and the rest of the G-7 in closing the gap relative to the U.S. as a whole.

Endogenous growth theory, on the other hand, assigns a central role to capital formation, which is broadly defined to include physical, human, infrastructure, and knowledge capital.[2] The rate of growth of any region depends on the rate of time preference relative to the marginal productivity of capital, which is assumed to exhibit constant returns to scale instead of diminishing returns as in previous neoclassical models. The larger the wedge between the time rate of discount and the return to investment, the more rapid the rate of growth. When applied to U.S. regional growth, this framework suggests that the lagging economic performance of the South was due to inadequate capital formation, and the subsequent boom to an increase in the rate of investment. The work of Garcia-Mila and McGuire (1987), Aschauer (1989), Munnell (1990), and Morrison and Schwartz (1992) focuses particular attention on the role of public investment as a determinant of U.S. regional growth performance.

In contrast to these two explanations, traditional location theory stresses the evolution of regional supply and demand and the role of economies of scale and agglomeration, combined with nation-wide factors like technological change, aggregate savings, and population growth, as the determinant of regional location and growth. The recent paper by Krugman (1991) shows that the location of manufacturing activity can be concentrated or dispersed among regions depending on the relative strengths of scale economies, regional demand, and transport costs.

This paper compares these alternative explanations of U.S. regional growth by testing their predictions about the productive efficiency of regional manufacturing industries.[3] Using 1970-1986 data from the Census and Annual Survey of Manufactures for the nine Census divisions of the U.S. and national data from the Bureau of Labor Statistics and Bureau of Economic Analysis, we estimate the level of multifactor productivity (MFP) in each region. We then test for technological convergence and endogenous growth effects associated with infrastructure externalities and increasing returns to reproducible inputs, against the prediction of conventional regional theory that the growth rates of technical efficiency are the same across regions (i.e., that any differences in efficiency levels are region-specific and constant over time). This test has the collateral effect of addressing the actively debated question of whether or not public capital has a strong impact on manufacturing productivity.

II. Testing the Alternative Models

Our tests of the competing theories are derived from the assumption that there is a Hicks-neutral production function for manufacturing industry within each region. We assume that manufactured goods in region i in year t, Q_{it}, are produced using privately owned capital K_{it}, labor L_{it}, intermediate inputs M_{it}, and public capital B_{it}:

$$(1) \qquad Q_{it} = A_{i0} B_{it}^{\gamma_i} e^{\lambda_i t} \cdot F^i[K_{it}, L_{it}, M_{it}, B_{it}].$$

Our specification of the public capital variable follows Meade (1952) and Berndt and Hansson (1991) in identifying two ways that public capital influences output. First, it yields direct productive services and thus appears as an argument of $F^i[\cdot]$ (as, for example, when trucks and drivers are combined with public highways to produce transportation services). Second, public capital acts as an "environmental" factor or "systems spillover" which enhances the productivity of some or all of the private inputs. Thus B_{it} appears as an argument of the technical efficiency term in constant elasticity form, where the parameter γ_i measures the strength of the within region spillover effect. This formulation of (1) also assumes that the spillover effect is separable from the pure technical effect, as represented by the parameter λ_i. A_{i0} is the index of the level of regional productive efficiency in the base year 0.[4]

A. Technological Convergence

One variant of the convergence model stresses the importance of technological diffusion. The model of Dowrick and Nguyen (1989) assumes that nations with low levels of technical efficiency can, at some point in their history, become open to outside technological possibilities and can thus appropriate the existing technologies of advanced countries at a faster rate than the advanced nations can develop new technology. This mechanism is found by Dowrick and Nguyen to be an important source of cross-national growth differentials. Applied to regional growth within the U.S., this variant of the convergence model assumes that technological backwardness is an important source of lagging economic performance, and focuses on diffusion of technology as a process through which regional disparities are reduced or eliminated.

The technological convergence formulation assumes that regional technologies exhibit initial differences in the level of technical efficiency in some base year, A_{i0}, and that the gap between the level of efficiency in any region i and the level of technical efficiency in the most advanced region, A_{0t}, closes with a speed of convergence θ:

(2) $$\ln A_{it} - \ln A_{i0} = (1-(1-\theta_i)^t)(\ln A_{0t} - \ln A_{i0}).$$

In (2), the growth rate of A_{it} exceeds that of the leader, but the two converge over time. This provides the lagging region with an extra impetus to output growth.

If the pattern of regional growth is influenced by (2), we should observe that regional rates of technical change, λ_i, estimated from (1) should vary inversely across regions according to the initial level of efficiency, A_{i0}. On the other hand, if the λ_i do not vary across regions there is no possibility of convergence and either the θ_i must be zero or the initial levels A_{i0} must be equal. In either case, technological convergence cannot be adduced as an explanation of regional growth differentials in U.S. manufacturing industry.[5]

B. Endogenous Growth Models

The endogenous growth literature has two principal branches: the "AK" model developed by Rebelo (1991) and the externality-increasing returns model of Romer (1986) and Lucas (1988). Both emphasize the importance of increasing returns to scale generated by reproducible capital inputs and both predict nonconvergent rates of growth. In the "AK" model, constant returns to capital input is imposed directly and growth differentials depend on the wedge between the marginal product of capital A_i and the rate of time discount ρ_i. To explain regional growth patterns, each region must be treated as a separate economy with its own A_i and ρ_i. Regional differences in marginal products may occur because of locational advantages, differences in region specific capital, or region specific externalities generated by capital. Regional differences in the propensity to invest that are driven by differences in the propensity to save (ρ_i) are more difficult to rationalize in an economy which is open to capital flows, but this is a problem common to many growth models, including Solow-type convergence models.

The Rebelo-Romer-Lucas mechanism of endogenous growth theory is based on constant marginal returns to capital generated by capital related spillovers. This may occur because of "within-region" externalities or, following Barro (1990) and Barro and Sala i Martin (1992), because public capital is fixed by policy at a constant fraction of the private capital stock, i.e., $B_{it} = \tau_i K_{it}$. In this last case, the Romer-Lucas production function might be written as

$$(3) \qquad Q_{it} = A_{i0}[B_{it}^{\gamma_i}] K_{it}^{\alpha_i} L_{it}^{\beta_i} = A_{i0} \tau_i K_{it}^{\alpha_i+\gamma_i} L_{it}^{\beta_i}$$

If $\alpha_i + \beta_i$ equals one, private producers perceive that production takes place under constant returns to scale and a competitive equilibrium may be established. However, because public capital enhances production and because it is proportional to private capital, the true elasticity of output with respect to capital is $\alpha_i + \gamma_i$, and there are increasing returns to scale (the further restriction $\alpha_i + \gamma_i = 1$ yields the "AK" model).

The endogenous growth formulation of technology (3) is clearly a special case of the production function (1), in which $F^i(\cdot)$ has the Cobb-Douglas form, disembodied technical change λ_i is zero, and the direct and indirect effects of public capital are collapsed into the parameter γ_i. Public capital enters the production function of manufacturing industries mainly as a service purchased from other sectors (e.g., transportation services are reflected in M_{it}), and thus the direct contribution of B_{it} is of minor importance.[6] In this case, tests of the parameter γ_i are equivalent to tests of the endogenous growth model, in conjunction with tests of increasing returns to scale.

C. Location Theory

Location theory does not have the kind of analytical unity that characterizes the two convergence and endogenous growth hypotheses (see, for example, Krugman 1993). It is hard to formalize a parametric test of "the theory," so we will only observe that location models typically put more emphasis on regional or spatial factors, increasing returns to scale (i.e., agglomeration economies), etc. There is no reliance on regional differences in technology as an explanation of growth differentials except, perhaps, those introduced by differences in industry mix across regions. This leads to the expectation that the manufacturing production function for each region should have the same degree of technical efficiency, or $A_{0t} = A_{1t} = \dots = A_{Nt}$ in each year t. We can test this hypothesis using the parameters of (1), since a common technology implies $A_{00} = A_{10} = \dots = A_{N0}$ and the equality of the technical change parameters, λ_i. And, as shown below, we can also test for increasing returns to scale.

III. The Sources of Growth Framework

Since our tests of the competing models primarily involve the efficiency term in the production function, it is unnecessary to estimate all of the parameters of the structure of production. Instead, the relevant tests can be based on a two stage procedure that makes use of nonparametric index number techniques. The first step involves the computation of the Solow residual under the assumption that public capital has no effect on private output growth.[7] The continuous time version of the Solow residual has the form:

$$\hat{A}^S_{it} = \hat{Q}_{it} - \pi^K_{it}\hat{K}_{it} - \pi^L_{it}\hat{L}_{it} - \pi^M_{it}\hat{M}_{it} , \tag{4}$$

where hats over variables denote rates of growth and the π_{it} are income shares.

In practice, the rate of productivity growth is estimated by replacing logarithmic differentials with differences in successive logarithms and using average shares:

$$\begin{aligned} \ln A^S_{it} - \ln A^S_{it-1} = {} & \ln Q_{it} - \ln Q_{it-1} \\ & - 1/2\ (\pi^K_{it} + \pi^K_{it-1})\ (\ln K_{it} - \ln K_{it-1}) \\ & - 1/2\ (\pi^L_{it} + \pi^L_{it-1})\ (\ln L_{it} - \ln L_{it-1}) \\ & - 1/2\ (\pi^M_{it} + \pi^M_{it-1})\ (\ln M_{it} - \ln M_{it-1}). \end{aligned} \tag{5}$$

This approximation places only weak restrictions on the functional form of the underlying production function (Diewert 1976) and, in particular, is not restricted to the Cobb-Douglas form. However, Hicks-neutral technical change is assumed (Hulten 1973). Each term in (5), except the growth rate of the Solow residual, can in principle be measured directly, and the growth rate of the technology index can thus be estimated as a residual.

Jorgenson and Nishimizu (1978), Denny, Fuss, and May (1981), and Christensen, Cummings, and Jorgenson (1981) have shown that this sources of growth model can be extended to estimate differences in the level of productivity across regions or countries. In their framework, the difference between the level of technology in region i at time t and region j at time s equals the logarithmic differences in output minus the share weighted logarithmic differences in inputs, where the shares are the simple averages of the shares in the two regions. Thus the level index analog to (5) is

$$(6) \qquad \ln A^S_{it} - \ln A^S_{js} = \ln Q_{it} - \ln Q_{js} - 1/2\,(\pi^K_{it} + \pi^K_{js})\,(\ln K_{it} - \ln K_{js}) - 1/2\,(\pi^L_{it} + \pi^L_{js})\,(\ln L_{it} - \ln L_{js}) - 1/2\,(\pi^M_{it} + \pi^M_{js})\,(\ln M_{it} - \ln M_{js}).$$

The resulting levels indexes, A^S_{it}, are expressed relative to the efficiency of the "base" region in the base year, $A^S_{00} = 1$. We have used the U.S total and 1970 as the base region and year, and thus all of the productivity index numbers should be interpreted as a proportion of national productivity in 1970.[8]

After calculating the regional Solow level index numbers using equation (6), we then link measured productivity to the technical efficiency terms in the underlying production function (1) in the second stage of the analysis. The true growth rate of efficiency is derived from (1) and equals

$$(7) \quad \hat{A}_{1t} = \gamma_1 \hat{B}_{1t} + \lambda_1 t = \hat{Q}_{1t} - \varepsilon^K_{1t}\hat{K}_{1t} - \varepsilon^L_{1t}\hat{L}_{1t} - \varepsilon^M_{1t}\hat{M}_{1t} - \varepsilon^B_{1t}\hat{B}_{1t} ,$$

where is ε^X_{1t} is the elasticity of output with respect to input X.

A comparison of the Solow residual $\hat{A}^S_{1t}$ with the true efficiency term $\hat{A}_{1t}$ reveals that public capital's contribution to output has been ignored and that the income shares π^X_{1t} are assumed equal to the corresponding output elasticities ε^X_{1t}. This second assumption does not pose a problem for income shares of the variable private factors (labor and intermediate input) when the economy is in competitive equilibrium and they are paid the value of their marginal products. However, it is not true that $\varepsilon^K_{1t} = \pi^K_{1t}$ in general even under competitive assumptions. The problem arises because the price of capital services, P^K_{1t}, can rarely be observed directly. Therefore, capital income is usually imputed from the "adding-up" condition that factor payments exhaust total income, with capital income measured as the residual. The residual measurement of capital income therefore imposes the condition that income shares sum to one (i.e., $\pi^K_{1t} = 1 - \pi^L_{1t} - \pi^M_{1t}$). Thus whenever the elasticity of scale of private inputs $\varepsilon_{1t} = \varepsilon^K_{1t} + \varepsilon^L_{1t} + \varepsilon^M_{1t}$ is different from one, π^K_{1t} misstates capital's true output elasticity.

These various sources of bias can, however, be accounted for explicitly to yield an exact relation between the growth rate of the Solow residual and the true efficiency term. With some manipulation, it can be shown that

$$(8)\qquad \hat{A}^S_{it} = \lambda_{it} + [\gamma_{it} + \varepsilon^B_{it}]\,\hat{B}_{it} + [\varepsilon_{it} - 1]\hat{K}_{it}\ ,$$

where ε_{it} is the scale elasticity. This expression indicates that the growth rate of the measured Solow residual is the sum of three factors: (i) the rate of growth of public capital weighted by the indirect and direct contributions of public capital, (ii) the growth rate of private capital weighted by a correction for any error that is introduced by the assumption of constant returns to scale in private inputs, and (iii) the true growth rate of technical progress.

Equation (8) relates the growth of the Solow residual to its component elements and forms the empirical basis for our test of the various theories of regional growth (variants of (8) are also the basis for the marginal cost mark-up model of Hall (1988) and the externality model of Caballero and Lyons (1990a, 1990b). However, since the convergence hypothesis involves the level of technical efficiency rather than its growth rate, one final step is needed to complete the second stage our analysis. By assuming that γ_i, ε^B_i, ε_i, and λ_i are constant over time, we can integrate (8) over time to obtain[9]

$$(9)\qquad \ln A^S_{it} = \ln A_{i0} + \lambda_i t + [\gamma_i + \varepsilon^B_i]\ \ln B_{it} + [\varepsilon_i - 1]\ \ln K_{it}.$$

The various hypotheses discussed above are special cases of this equation, and we will therefore use the stochastic version of (9) in the empirical work presented below.[10]

IV. Data

The data needed to estimate the parameters of equation (9) are described in full in our earlier papers (Hulten and Schwab 1984, 1991). Our analysis is restricted to manufacturing industries. Most of our regional data were obtained from the Census of Manufactures and the Annual Survey of Manufactures and then reconciled to Bureau of Labor Statistics totals. We use gross output as our measure of output in this paper, and thus our private inputs include capital, labor, and intermediate inputs (corrected for the purchased services problem). Since regional output deflators are not available from any source, we have used the national deflators from the U.S. Bureau of Labor Statistics. This introduces a potential bias in our results, since any error in the price deflator translates directly into an error in measuring real output and thus into an error in measuring the left hand side of (9).[11]

Our data on public capital are the same as those used in Munnell (1990); a full description of the data are included in Appendix A of that paper. Briefly, Munnell used annual data on state capital outlays to allocate BEA estimates of the national stock of public capital among the states. Her data set includes estimates of total public capital for each state as well as separate estimates of state stocks of highways and water and sewer facilities. Since the Munnell data are available only for the period 1970-1986, our analysis is limited to those years.

Table 1 presents summary statistics on our measures of manufacturing input, output, and the Solow residual. Table 1 also includes summary statistics on regional output per worker, capital per worker, and public capital. It is clear from this table that the manufacturing sector grew much faster in the South and West . Gross output rose 3.75 percent per year in the Sun Belt during the 1970-1986 period as compared to only 1.53 percent per year in the Snow Belt.[12] Labor input grew by more than 1 percent per year in the Sun Belt but fell in the Snow Belt. Public capital grew more rapidly in the Sun Belt (2.09 versus 1.30 percent).

It is highly significant for our subsequent analysis that the differential grow rates of regional output were due almost entirely to the differential growth in inputs. Regional differences in the growth rates of the Solow residual (MFP) were relatively small, with the Snow Belt actually enjoying a slight advantage over the Sun Belt (1.41 percent per year versus 1.23). It was also the case that the level of MFP in the various regions of the country were very similar at the beginning and end of our sample period. It is also clear that the growth rates of capital per worker and output per worker were roughly the same in the Sun Belt and Snow Belt regions over this period. Our conclusions about MFP convergence during the years 1970-1986 can thus be extended to the convergence in output per worker due to capital-deepening. Our data would thus suggest a theory of regional economic growth that stressed the cross-sectional equality of productivity, prior to any econometric analysis.

This impression is reinforced by decomposing the total variation of MFP into variation across time within in regions and variation across regions. Slightly less than one-half of the the variation in the level of MFP is due to cross sectional variation, with the balance due to variation over time. For the growth rates of MFP, however, virtually all of the variation is variation over time, i.e. there is almost no variation in the growth rate of MFP across regions. Given the substantial differences in the growth rates of public capital stock in different regions, the lack of variation in the growth rate of MFP suggests that the two variables are essentially uncorrelated.

Table 1 covers a fairly short period 1970-1986, and it is possible that convergence (in terms of MFP or capital per worker) was essentially complete by that time. Regional gross output data are not available prior to the mid-1960s, but regional value added data are available beginning in 1951. In Table 2, we briefly shift the focus to value added as a measure of output in order to extend the analysis back in time. That table indicates that there has been no significant compression (or divergence) in MFP, in output per worker, or in capital-deepening since 1951.

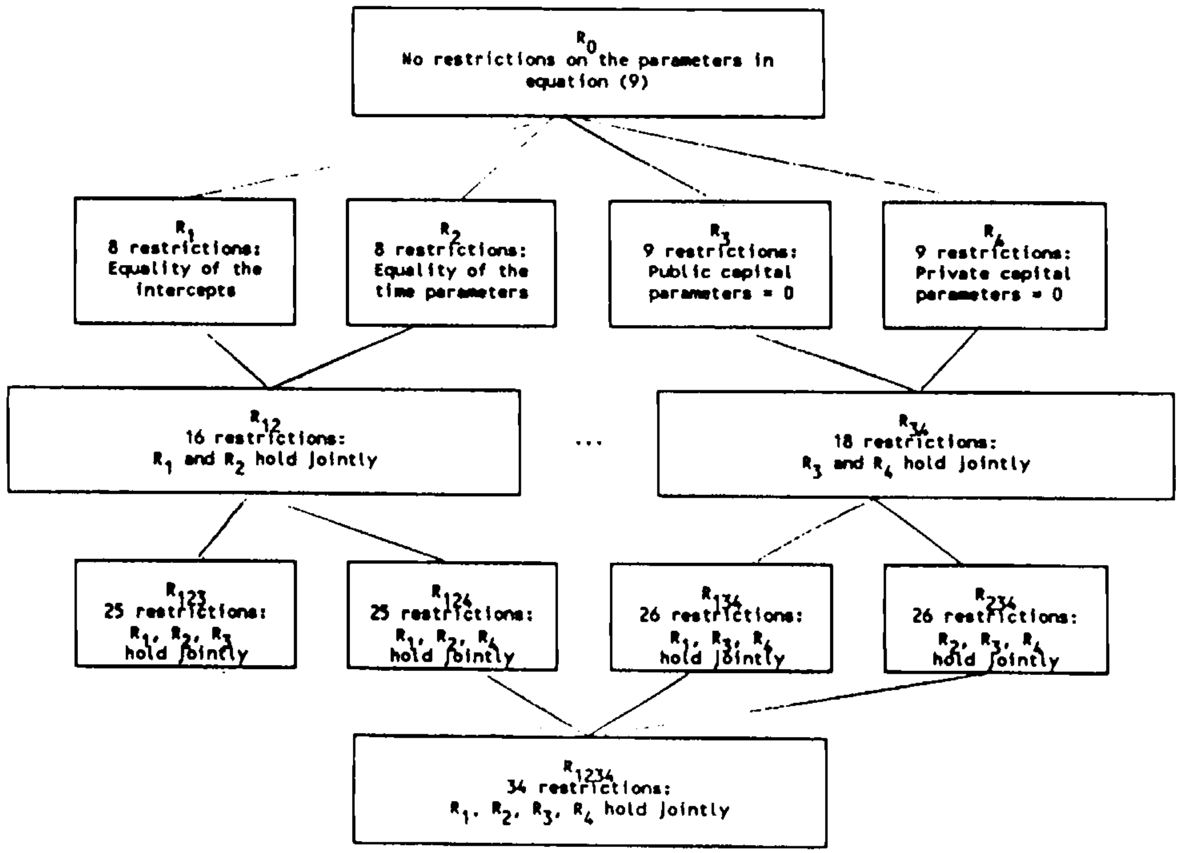
V. Econometric Results I: Hypothesis Tests of Competing Models

While the data shown in Tables 1 and 2 are suggestive, they do not constitute a formal test of the alternative hypotheses about regional growth. An econometric test can, however, be obtained by estimating the parameters of the system of nine linear equations, each relating the natural logarithms of the level of regional MFP to a constant, the natural log of private capital in the region, the natural log of public capital and time. In other words, we implement the model (9) without any parameter restrictions across equations Moreover, since we use index number procedures to account direct inputs of capital and labor, we impose no restrictions on the form of $F^i(\cdot)$. Our paper thus differs from much of the other econometric literature on regional growth, in which parameters are constrained to be equal across regions, except possibly for regional fixed effects. Indeed, one of our objectives is to test the validity of the cross-regional parameter restrictions which we have shown to be tests of the alternative theories of growth discussed above.

The nesting scheme of the various cross-equation restrictions is shown in Figure 1. The box at the top level represents the case in which the system (9) is estimated without any parameter restrictions (designated R_0). The four boxes on the next line represent, respectively, the equality restrictions on each of four sets of parameters (designated R_1, R_2, R_3, R_4). R_1 tests for the equality across regions of the intercept of the MFP regressions allowing all other parameters to vary, and thereby tests for equality of initial MFP levels among the regions. Similarly, the restrictions in R_2 test for the equality of the regional growth rates of technical change (the coefficients on t). If this restriction cannot be rejected, we cannot reject the hypothesis that regional technical change _exhibits_ _neither_ _convergence_ _nor_ _divergence_. R_3 and R_4 test whether the MFP elasticity of public capital and the scale elasticity of private inputs are _zero_ in all regions, and thus test for endogenous growth effects associated with public and private capital, respectively (i.e., test for the importance of public capital externalities and increasing returns to scale in private inputs).

The boxes on the third level test whether the restrictions on the second level can be imposed jointly, two at a time. There are six possibilities for these pair wise restrictions: R_{12}, the initial levels of MFP are equal (R_1) _and_ the growth rates of technical change are also equal (R_2), letting the

Figure 1



R_0
No restrictions on the parameters in equation (9)
R_1
8 restrictions: Equality of the intercepts
R_2
8 restrictions: Equality of the time parameters
R_3
9 restrictions: Public capital parameters = 0
R_4
9 restrictions: Private capital parameters = 0
R_{12}
16 restrictions: R_1 and R_2 hold jointly
...
R_{34}
18 restrictions: R_3 and R_4 hold jointly
R_{123}
25 restrictions: R_1, R_2, R_3 hold jointly
R_{124}
25 restrictions: R_1, R_2, R_4 hold jointly
R_{134}
26 restrictions: R_1, R_3, R_4 hold jointly
R_{234}
26 restrictions: R_2, R_3, R_4 hold jointly
R_{1234}
34 restrictions: R_1, R_2, R_3, R_4 hold jointly

other parameters vary freely across regions; R_{13}, the initial levels of MFP are equal (R_1) and the elasticity of MFP with respect to public capital are also equal (R_3); and so on for R_{14}, R_{23}, R_{24}, and R_{34}. Only the boxes for R_{12} and R_{34} are shown in Figure 1, for ease of exposition, but these are also the joint hypotheses of particular interest, since the restrictions of R_{12} imply identical regional paths for technical change and R_{34} imply that there are no endogenous growth effects linked to public or private capital.

The four boxes on the fourth line of Figure 1 show the possible combinations in which three of the four restrictions hold jointly (they are designated R_{123}, R_{134}, R_{124}, and R_{234}). Finally, R_{1234} on the bottom level is a test of all the restrictions simultaneously. If all of the restrictions hold jointly, the regional paths of MFP are identical and are not influenced by the amount of public capital in each region, nor by increasing returns to scale effects. This situation is, of course, very unfavorable to the convergence and endogenous growth explanations of the evolution of regional manufacturing industry in the U.S.

Table 3 presents the sum of squared errors and F statistics associated with the various possible restrictions. It is apparent from this table that the data do not reject (at the 1 or 5 percent levels of significance) any of the restrictions imposed by themselves. If, for example, the public capital parameter, γ_i, is constrained to be zero in each region, the resulting model,

$$(9') \qquad \ln A^S_{it} = \ln A_{i0} + \lambda_i t + [\varepsilon_i - 1] \ln K_{it} ,$$

cannot be distinguished from the original (9). Similarly, Table 3 indicates that, _mutatis_ _mutandi_, a model that makes A_{i0} or λ_i the same across regions, or makes $(\varepsilon_i - 1)$ zero, cannot be distinguished from (9). Further, the data do not reject any of the pairs of restrictions imposed jointly. It is only when the fourth level of three-way restrictions is reached that one set of restrictions, R_{134}, is rejected; the data do not accept the simultaneous equality of the initial levels of MFP, a zero elasticity of MFP with respect to public capital, and constant returns to the private inputs, implying that the model $\ln A^S_{it} = \ln A_0 + \lambda_i t$ is not a valid model. However, all of the other three-way restriction do hold jointly. Finally, the simultaneous imposition of all restrictions simultaneously, R_{1234}, is also rejected, so that $\ln A^S_{it} = \ln A_0 + \lambda t$ is not an appropriate model.[13]

Table 3 thus provides very little good news for the convergence or endogenous growth explanations of regional manufacturing growth. The predictions of these models simply do not dominate other explanations in which convergence and endogenous growth play no role.

VI. _Econometric Results II: Estimation of Restricted Models_

The results presented in Table 3 are compared with a base-line assumption that all parameters, including the elasticities of MFP with respect to public and private capital, vary across regions. In this section we approach the problem from a slightly different point of view by restricting the elasticities of public and private capital to be equal across regions. This is consistent with the recent literature on regional growth (e.g., Holtz-Eakin 1992, Garcia-Mila, McGuire, and Porter 1993, Munnell 1990, and Aschauer 1990) This shift in perspective make it easier to compare our results to other recent research. Moreover, because there are so many parameters in the unrestricted version of the models in the previous section, it is hard to estimate any particular parameter precisely and to interpret the resulting coefficients. Finally, restricting the elasticities to be equal across regions is consistent with the data. As shown in Table 3, we cannot reject the hypothesis that all of the elasticities with respect to public and private capital are equal to zero, and thus we certainly cannot reject the hypothesis that they are all equal to one another.

The results of this alternative approach are shown in Table 4. The first column of Table 4 reports the results obtained from the estimation of the most constrained version of these models where the initial level of MFP and the growth rate of MFP are all assumed to be equal across regions. Interestingly, the results are similar to those found in the earlier literature on public capital: the coefficient on public capital is statistically significant and reasonably large given that the direct effect of public capital is already accounted for in the purchased service component of $F^i(\cdot)$. The private capital coefficient suggests that there are mildly decreasing returns to scale and the point estimate of the time parameter implies a rate of MFP growth of 0.8 percent per year.

It is common in this literature to include a measure of capacity utilization in order to control for the cyclical effect of demand fluctuations on the Solow residual. Many, however, view this practice with some skepticism. As Berndt and Fuss (1986) and Hulten (1986) show, there is no theoretical justification for including capacity utilization in a productivity model since the effects of the business cycle should be reflected in the output elasticity of private capital. Capacity utilization is particularly problematical in regional studies since regional capacity utilization measures are not available.

Setting these concerns aside for the moment, column (5) in Table 4 adds the Federal Reserve Board's national capacity utilization data for manufacturing to the model in column (1). As shown in column (5), when we add capacity utilization the picture does not change very much, though the error sum of squares does fall significantly.

Regional fixed effects are introduced in column (2) by allowing for separate regional intercepts (New England is taken as the base region). As in previous studies, the addition of these regional fixed effects causes the public capital variable to become statistically insignificant (and negative as well). The same is true for private capital, implying constant returns to scale. Five of the regional intercepts are significant at conventional levels, and the rest are marginally significant at low levels. Adding capacity utilization does not change this picture, except to reduce the sum of squared errors and improve the significance of the regional intercepts.

Column (3) allows for regional time effects while holding the intercepts the same for all regions (i.e., we impose a common level of MFP at the outset to see if the times paths of MFP diverge). We find that this yields a larger estimate of the public capital coefficient than the base case of column (1), and that it implies strongly decreasing returns to scale. Half of the regional time effects are significant. As before, adding capacity utilization does not change the results.

The last step taken in Table 4 is to go beyond the fixed effects model and allow both the intercepts and time coefficients to vary across regions. The results, shown in column (4), are consistent with the fixed effects model of column (2): the public and private capital variables are insignificant, half of the intercept dummy variables are significant, and none of the regional time dummies are significant. However, the addition of the capacity utilization variable does make a difference. When it is included, the public capital coefficient is significantly negative, implying that public capital externalities reduce MFP with an elasticity of -.24. This is a highly implausible result, and it casts doubt on the usefulness of using an aggregate capacity utilization adjustment.

How do the results of Table 4 accord with the hypothesis tests of the preceding table? The constraints imposed in Table 4 on the public and private capital parameters only restrict them to be equal, and not to be equal to zero as in Table 3. Moreover, Table 3 considers a wider range of parameter restrictions (i.e., on the time variable). However, with these differences in mind, it is clear that the proceeding up the hypothesis tree in Figure 1 using Table 4 F-statistics produces similar conclusions about the models that the data wants to reject (i.e., some difference in initial levels, no difference in the growth rates of MFP, and no effect of public capital).

We note, finally, that we tested several variants of the our models. Following Fernald (1992), we carried out an analysis of (9) using deviations from time trend rather than the log-level of variables in order to control for demand fluctuations and to reduce any simultaneous equation bias resulting from the endogeneity of K and B. The results of this exercise were similar to the results obtained using the capacity utilization variable.

We also tested the assumption of perfect competition using a Hall (1988) marginal cost mark-up model. In an imperfectly competitive market where the ratio of price to marginal cost is a constant μ, the income shares of labor and intermediate input are equal to the true output elasticities divided by μ (i.e., $\pi^{L}_{it} = \varepsilon^{L}_{it} / \mu$ and $\pi^{M}_{it} = \varepsilon^{M}_{it} / \mu$). If capital's share is calculated as a residual so the shares sum to 1, then it is not difficult to show that Hall's model implies that (9) becomes

$$(9'') \qquad \ln A^{S}_{it} = \ln A_{i0} + \lambda_i t + [\gamma_i + \varepsilon^{B}_{i}] \ln B_{it} + [\varepsilon_i - 1] \ln K_{it} + (\mu - 1)\, [\pi^{M}_{it} \ln (M_{it} / K_{it}) + \pi^{L}_{it} \ln (L_{it} / K_{it})].$$

We estimate this model by including the share weighted log of the intermediate input-capital and the labor-capital ratios to the models shown in Table 4. As shown in equation (9″), the coefficient on this variable represents an estimate of $(\mu - 1)$. Under perfect competition price equals marginal cost, μ equals 1, and the coefficient on $\pi^{M}_{it} \ln (M_{it} / K_{it}) + \pi^{L}_{it} \ln (L_{it} / K_{it})$ will equal zero; if firms have market power then price will exceed marginal cost and this coefficient will be positive.

Estimates of different versions of this Hall model are shown in Table 5. In those specifications where we include capacity utilization variable, our estimate of $(\mu - 1)$ is always positive and significant; in those specifications where we exclude capacity utilization variable, our estimate of

(μ - 1) is always insignificant. Estimates of all of the other parameters in Table 5 are quite similar to the corresponding estimates in Table 4.

VII. Conclusions

This paper has proposed a framework for testing three of the leading explanations of comparative regional growth based on different predictions about the times paths of technical efficiency. While the tests are limited to the manufacturing industry and not all of the variants of the competing theories are tested, the tests do provide evidence against two of the major competitors. Specifically, the absence of MFP convergence or divergence is not compatible with the predictions of the technological convergence or endogenous growth models. Moreover, an inspection of the trends in output per worker and capital per worker for the 1970-86 and the 1951-86 periods using different output concepts does not offer any encouragement for the capital-deepening variant of the convergence hypothesis.

We have also found that the externalities associated with public capital are, for the most part, not statistically significant and the point estimates of the elasticity of MFP with respect to public capital in some versions of the model are negative. Of course, this applies only to manufacturing, but it lends little support to the argument that public capital externalities are an important engine of growth. If externalities are not significant in this important sector, where do they play an important role in regional economic development?

We also find that manufacturing is subject to constant returns to scale at the regional level. This result suggests that agglomeration economies may play only a limited role in regional economic growth.

Our findings suggest that manufacturing industry was open to flows of capital, labor, <u>and</u> technology, and this is more congenial to the traditional equilibrium approach to location theory than to the other two models which are imported from international growth analysis. The main engine of <u>differential</u> regional manufacturing growth over the period 1970-86 seems to be inter-regional flows of capital and labor, while the growth of multifactor productivity is essentially uniform across regions (although there appears to be some variation in the initial levels of efficiency).

Several aspects of our results deserve emphasis in this summing up. First, the statistical results reported above refer to a relatively short, and recent, time period: 1970-86. It may well be the case that technological convergence and public capital externalities were important in an earlier stage of U.S. regional development. However, our estimates of a limited version of our model for the period 1951-86 (which by necessity could not consider public capital and relied on value added rather than gross output) yielded virtually the same results. Second, it cannot be emphasized too strongly that we have assumed that the Law of One Price holds. If there is significant regional variation in the deflators used to estimate real output, our results could be dramatically altered.

Third, our finding that public capital externalities were not an important source of regional manufacturing growth does not mean that public capital formation is irrelevant. It may well have played an essential role in facilitating the movement of capital, labor, and intermediate inputs which we find are the main sources of differential regional growth. Furthermore, because the impact of lumpy infrastructure projects like the Interstate Highway System may be highly non-linear, there may be extended periods during which the average product of public capital is high but its marginal product is almost zero. But, even with these caveats, our results are relevant for the question of whether undetected externalities might thus have led governments to supply too little public capital _in recent years_. We find no evidence of under-supply in the regional manufacturing data.

Notes

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[1] As noted by Baumol (1986), the convergence hypothesis has a long tradition and an extensive literature. Recent contributions include Dollar and Wolff (1988), De Long (1988), Baumol et. al. (1989), Barro (1991), and Mankiw, Romer and Weil (1990).

[2] The endogenous growth model was developed by Romer (1986), Lucas (1988), and Rebelo (1991). The survey by Sala-i-Martin (1990a, 1990b) provides an extensive description of the main variants of the endogenous growth model and their relation to optimal growth theory.

[3] Our focus on regional manufacturing industry is motivated in part by the importance on manufacturing in the regional model developed by Krugman (1991), and also by the fact that data on inputs and output are better for this sector of the economy. However, the narrower industrial focus of this paper means that our results are not strictly comparable to those based on broader measures of regional output such as total private gross state product.

[4] This specification of the public capital externality assumes that the only source of spillovers in each region is the quantity of public capital within that region. This reflects the assumption that the highway system of one region gives rise to positive spillovers, but the highways of an adjacent region have no effect at all. This is consistent with our interpretation of the region specific externalities as an engine of regionally endogenous growth. However, it is also possible that public capital externalities affect all regions, in which case the relevant argument of $A[\cdot]$ would be total public capital, $B_t = \Sigma_i B_{it}$, or a vector of the public capital in all regions.

[5] It should be noted that the literature on convergence theory has two distinct branches: the one described above and another in which convergence takes place as a country or region moves to its steady-state rate of growth by capital deepening. When the production function has the form $q_t = k_t^{\alpha}$, the convergence equation is given by an equation similar to (2):

$$(2') \qquad \ln q_t - \ln q_0 = (1-(1-\gamma)^t)(\ln \bar{q} - \ln q_0),$$

where $\gamma = (1-\alpha)\eta$ is the speed of convergence parameter (Holtz-Eakin (1991), following Mankiw, Romer, and Weil (1990)). With labor- augmenting technical progress at a rate λ, the steady state values of output and capital per "raw" worker will grow at the rate of technical change, and the speed of convergence parameter becomes $\gamma = (1-\alpha)(\eta+\lambda)$. This is the approach taken by Barro and Sala-i-Martin (1991) and Holtz-Eakin (1991), and both studies find a convergence effect within the regions of the U.S. In this interpretation, the older industrial regions of the U.S. experienced slower growth than the South and West because the older regions were further along in the convergence process and closer to their balanced growth paths. This interpretation has been challenged by Blanchard (1991), who demonstrates that the convergence equation (2') can be derived from the spatial equilibrium model and shows that the convergence parameter of their estimating equation can equally be interpreted as a demand elasticity. We will not attempt an econometric test of (2') in this paper, but will comment on its applicability in our section on regional data.

[6] According to BLS data, trucks and autos accounted for approximately 8 percent of the income accruing to equipment in manufacturing, and thus about one percent of the total income, over the period 1949-83, and that communications and electricity generation equipment, which account for about 9 percent of income accruing to equipment, and, again, about one percent of total income. This low share reflects the fact that public capital is mainly an input to the transportation and communication sectors, to public utilities, and to some service industries, and these sectors pass along their services (and thus the services of public capital) by selling their output to manufacturing industries. Thus, public capital is at best a marginal contributor to the gross output of many industries.

[7] This mode of analysis, also termed "sources of growth analysis," was developed by Solow (1957), Kendrick (1961), Denison (1962), and Jorgenson and Griliches (1967). It is the conceptual basis of the recent studies by the U.S. Bureau of Labor Statistics (1983) and Jorgenson, Gollop, and Fraumeni (1987), and is the framework used in our 1984 and 1991 studies of regional economic growth. The sources of growth analysis has, for the most part, ignored the role of public capital as a source of output growth.

[8] All growth rates are the continuous growth rates of the level Solow index numbers.

[9] The constancy of these parameters imposes restrictions on the underlying technical efficiency function in (1): if, for example, the elasticity of scale is constant at ε, the production function is homogeneous of degree ε. Note, however, that the multiplicative restrictions on the form of the efficiency function does not impose restrictions on the rest of the technology, $F(\cdot)$. In particular, they do not imply that the production function has the Cobb-Douglas form.

[10] An econometric problem that arises when estimating (9) using ordinary least squares should be noted. Private capital (and possibly public capital as well), are endogenously determined and thus may be correlated with the error term in the regression. Instrumental variables might be used to avoid simultaneous equations bias, but a set of valid regional instruments is hard to find.

[11] If the Law of One Price does not hold for manufactured goods within the U.S. market and there is in fact regional variation in output prices, our assumption of one price will overstate real output in those regions where prices are higher than average. This, in turn, overstates the level index of the Solow residual. If, in addition, the regional output prices are changing relative to the average, a bias is introduced into the growth rate of the Solow residual as well.

[12] Throughout the paper, we define the Snow Belt as the New England, Middle Atlantic, East North Central, and West North Central Census divisions. The Sun Belt includes the South Atlantic, East South Central, West South Central, Mountain, and Pacific divisions.

[13] If a 5 percent level of significance is used in the tests of first level of hypotheses (R_1, R_2, etc.) then a different level of significance should be used in tests of the joint hypotheses. An approximate significance on 20 percent would, for example, be assigned to R_{1234}, by the Bonferroni inequality (see Savin 1984).

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Table 1
Summary of the Level and Growth Rate of Manufacturing Gross Output
1970-1986
(U.S. 1970 = 1.000)

	NE	MA	ENC	WNC	SA	ESC	WSC	M	PAC	Total	Snow Belt	Sun Belt
Gross Output												
1970	0.0590	0.1979	0.2767	0.0764	0.1234	0.0573	0.0780	0.0220	0.1094	1.0000	0.6100	0.3900
1986	0.0851	0.2106	0.3623	0.1212	0.2201	0.0978	0.1564	0.0428	0.1935	1.4897	0.7792	0.7105
Growth Rate	0.0229	0.0039	0.0169	0.0289	0.0362	0.0334	0.0435	0.0416	0.0357	0.0249	0.0153	0.0375
Labor												
1970	0.0773	0.2205	0.2620	0.0633	0.1325	0.0579	0.0618	0.0187	0.1053	1.0000	0.6227	0.3767
1986	0.0753	0.1626	0.2198	0.0684	0.1551	0.0628	0.0765	0.0310	0.1353	0.9868	0.5254	0.4611
Growth Rate	-0.0017	-0.0190	-0.0110	0.0049	0.0099	0.0050	0.0134	0.0314	0.0156	-0.0008	-0.0106	0.0126
Private Capital												
1970	0.0580	0.1890	0.2877	0.0552	0.1261	0.0597	0.0898	0.0199	0.1136	1.0000	0.5894	0.4106
1986	0.0902	0.2210	0.3456	0.1004	0.2122	0.0921	0.1727	0.0458	0.1995	1.4812	0.7571	0.7240
Growth Rate	0.0275	0.0098	0.0115	0.0374	0.0325	0.0271	0.0409	0.0521	0.0352	0.0246	0.0157	0.0354
Intermediate Input												
1970	0.0506	0.1838	0.2772	0.0859	0.1258	0.0578	0.0875	0.0245	0.1069	1.0000	0.5976	0.4024
1986	0.0640	0.1757	0.3428	0.1204	0.2003	0.0945	0.1677	0.0371	0.1722	1.3749	0.7030	0.6719
Growth Rate	0.0147	-0.0028	0.0133	0.0211	0.0291	0.0308	0.0407	0.0259	0.0298	0.0199	0.0102	0.0320
Multifactor Productivity												
1970	0.9113	0.9777	1.0192	1.1095	0.9576	0.9839	1.0226	1.0504	1.0202	1.0000	1.0027	0.9945
1986	1.1639	1.1966	1.2869	1.3137	1.2122	1.2285	1.2531	1.2069	1.2285	1.2386	1.2505	1.2251
Growth Rate	0.0153	0.0128	0.0146	0.0106	0.0147	0.0139	0.0127	0.0087	0.0116	0.0134	0.0138	0.0130
Labor Productivity												
1970	0.7630	0.8976	1.0561	1.2075	0.9315	0.9896	1.2630	1.1726	1.0383	1.0000	0.9795	1.0353
1986	1.1303	1.2948	1.6481	1.7721	1.4192	1.5572	2.0444	1.3815	1.4304	1.5096	1.4831	1.5409
Growth Rate	0.0246	0.0229	0.0278	0.0240	0.0263	0.0283	0.0301	0.0102	0.0200	0.0257	0.0259	0.0249
Capital Labor Ratio												
1970	0.7510	0.8570	1.0981	0.8724	0.9522	1.0307	1.4541	1.0622	1.0780	1.0000	0.9464	1.0899
1986	1.1984	1.3592	1.5719	1.4675	1.3687	1.4669	2.2570	1.4790	1.4745	1.5010	1.4411	1.5701
Growth Rate	0.0292	0.0288	0.0224	0.0325	0.0227	0.0221	0.0275	0.0207	0.0196	0.0254	0.0263	0.0228
Public Capital												
1970	0.0516	0.1820	0.1893	0.0847	0.1235	0.0620	0.0920	0.0497	0.1652	1.0000	0.5076	0.4924
1986	0.0645	0.2268	0.2219	0.1119	0.1949	0.0793	0.1364	0.0816	0.1959	1.3132	0.6251	0.6881
Growth Rate	0.0139	0.0138	0.0099	0.0174	0.0285	0.0154	0.0247	0.0310	0.0106	0.0170	0.0130	0.0209

NE = New England, MA = Middle Atlantic, ENC = East North Central, WNC = West North Central, SA = South Atlantic, ESC = East South Central, WSC = West South Central, M = Mountain, PAC = Pacific

Table 2
Summary of the Growth Rate of Manufacturing Value Added
1951-1986

	NE	MA	ENC	WNC	SA	ESC	WSC	M	PAC	Total	Snow Belt	Sun Belt
Value Added	0.0258	0.0164	0.0215	0.0388	0.0451	0.0445	0.0473	0.0570	0.0445	0.0308	0.0222	0.0459
Labor	0.0002	-0.0074	-0.0026	0.0111	0.0190	0.0193	0.0238	0.0368	0.0230	0.0065	-0.0025	0.0219
Private Capital	0.0272	0.0183	0.0207	0.0370	0.0404	0.0428	0.0474	0.0526	0.0443	0.0309	0.0223	0.0442
Multifactor Productivity	0.0182	0.0166	0.0175	0.0197	0.0192	0.0173	0.0160	0.0538	0.0155	0.0171	0.0176	0.0170
Labor Productivity	0.0256	0.0238	0.0241	0.0277	0.0261	0.0252	0.0235	0.0202	0.0216	0.0244	0.0246	0.0240
Capital Labor Ratio	0.0270	0.0257	0.0233	0.0259	0.0213	0.0235	0.0236	0.0158	0.0214	0.0245	0.0248	0.0223

NE = New England, MA = Middle Atlantic, ENC = East North Central, WNC = West North Central, SA = South Atlantic, ESC = East South Central, WSC = West South Central, M = Mountain, PAC = Pacific

Table 3
Error Sums of Sqaures and F Statistics

Hypothesis	Error Sum of Squares	Restrictions Relative to R_0	F Statistic Relative to R_0
R_0	.14727	..	..
R_1	.15436	8	0.7041
R_2	.16030	8	1.2940
R_3	.16102	9	1.2138
R_4	.16857	9	1.8802
R_{12}	.17119	16	1.1877
R_{13}	.17977	17	1.5188
R_{14}	.17918	17	1.4912
R_{23}	.17415	17	1.2562
R_{24}	.18093	17	1.5730
R_{34}	.18118	18	1.4967
R_{123}	.19732	25	1.5905
R_{124}	.19653	25	1.5654
R_{134}	.31317	26	5.0693
R_{234}	.19872	26	1.5721
R_{1234}	.58580	34	10.2469

Table 4
Parameter Estimates of Alternative Restricted Models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.102214 (3.988)	-0.315016 (1.681)	0.126697 (3.533)	-0.660555 (2.037)	-0.378122 (3.880)	-0.910440 (5.912)	-0.351948 (4.979)	-1.42213 (5.846)
MA	--	0.174645 (2.133)	--	0.361255 (2.504)	--	0.223457 (3.579)	--	0.476241 (4.560)
ENC	--	0.245769 (3.015)	--	0.423950 (2.729)	--	0.283020 (4.558)	--	0.522270 (4.653)
WNC	--	0.200081 (5.137)	--	0.278372 (4.846)	--	0.227019 (7.635)	--	0.335459 (8.046)
SA	--	0.120506 (1.911)	--	0.215552 (2.253)	--	0.156855 (3.263)	--	0.288187 (4.163)
ESC	--	0.087153 (5.088)	--	0.127440 (4.225)	--	0.094803 (7.266)	--	0.140694 (6.466)
WSC	--	0.195922 (4.797)	--	0.245046 (4.018)	--	0.215640 (6.930)	--	0.288537 (6.542)
MT	--	0.060219 (1.591)	--	0.065613 (0.945)	--	0.078654 (2.728)	--	0.081865 (1.636)
PAC	--	0.191201 (2.653)	--	0.338488 (2.787)	--	0.237179 (4.313)	--	0.454201 (5.155)
Time	0.008445 (8.241)	0.010567 (7.225)	0.006314 (3.755)	0.015121 (5.448)	0.009906 (9.993)	0.012336 (10.959)	0.007492 (5.225)	0.016974 (8.461)
Time*MA	--	--	-0.002131 (0.859)	-0.005766 (1.976)	--	--	-0.001712 (0.814)	-0.005071 (2.412)
Time*ENC	--	--	0.007321 (3.439)	-0.003467 (1.235)	--	--	0.007512 (4.163)	-0.003097 (1.532)
Time*WNC	--	--	0.008035 (4.117)	-0.003878 (1.465)	--	--	0.008342 (5.041)	-0.003497 (1.833)
Time*SA	--	--	-0.002247 (1.058)	0.001049 (0.332)	--	--	-0.001937 (1.076)	0.003106 (1.359)
Time*ESC	--	--	0.004258 (2.824)	-0.002564 (0.987)	--	--	0.004339 (3.396)	-0.002015 (1.076)

Time*WSC	--	--	0.009938 (5.925)	0.002267 (0.746)	--	--	0.010056 (7.073)	0.003223 (1.472)
Time*MT	--	--	-0.000853 (0.393)	-0.002950 (0.867)	--	--	-0.000488 (0.266)	-0.001322 (0.538)
Time*PAC	--	--	0.001227 (0.520)	-0.004016 (1.515)	--	--	0.001630 (0.814)	-0.004545 (2.379)
Ln Public Capital	0.081694 (3.526)	-0.036604 (0.472)	0.158439 (4.704)	-0.117309 (1.034)	0.079613 (3.711)	-0.094269 (1.590)	0.150372 (5.263)	-0.244341 (2.961)
Ln Private Capital	-0.044530 (2.606)	-0.046562 (1.029)	-0.105826 (4.556)	-0.076725 (1.094)	-0.043099 (2.724)	-0.024187 (0.702)	-0.100638 (5.109)	-0.040135 (0.793)
Capacity Utilization	--	--	--	--	0.005806 (5.082)	0.005961 (10.191)	0.005731 (7.501)	0.006087 (11.150)
R^2	.3661	.7689	.6801	.7906	.4603	.8673	.7718	.8922
SSE	.53478	.19494	.26987	.17668	.45531	.11192	.19250	.09098
F-statistic	16.8480	1.7182	8.7689	--	33.0372	3.7976	18.4115	--

t statistics in parentheses

Table 5
Parameter Estimates of Hall Price Marginal Cost Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	0.111867 (4.651)	-0.366781 (2.061)	0.131674 (3.744)	-0.501104 (1.604)	-0.287737 (2.999)	-0.89163 (5.803)	-0.332772 (4.504)	-1.435805 (5.641)
MA	--	0.198808 (2.556)	--	0.296728 (2.137)	--	0.228430 (3.673)	--	0.480014 (4.497)
ENC	--	.280831 (3.615)	--	0.360785 (2.417)	--	0.292247 (4.710)	--	0.525848 (4.602)
WNC	--	0.166374 (4.404)	--	0.222000 (3.903)	--	0.214389 (6.997)	--	0.338376 (7.582)
SA	--	0.136925 (2.287)	--	0.184615 (2.013)	--	0.160044 (3.344)	--	0.290149 (4.130)
ESC	--	0.091689 (5.638)	--	0.146818 (5.018)	--	0.095827 (7.375)	--	0.139978 (6.314)
WSC	--	0.215901 (5.538)	--	0.271294 (4.626)	--	0.220988 (7.098)	--	0.287790 (6.475)
MT	--	0.065067 (1.814)	--	0.119396 (1.760)	--	0.079134 (2.759)	--	0.079699 (1.547)
PAC	--	0.216643 (3.160)	--	0.314981 (2.712)	--	0.242739 (4.428)	--	0.456220 (5.122)
Time	0.011850 (9.893)	0.014131 (8.663)	0.008220 (4.575)	0.019052 (6.682)	0.012374 (10.858)	0.013394 (10.263)	0.008034 (5.162)	0.016821 (7.749)
Time*MA	--	--	-0.001958 (0.806)	-0.006045 (2.169)	--	--	-0.001675 (0.796)	-0.005053 (2.392)
Time*ENC	--	--	0.007331 (3.516)	-0.004480 (1.663)	--	--	0.007508 (4.158)	-0.003050 (1.492)
Time*WNC	--	--	0.006203 (3.052)	-0.004394 (1.735)	--	--	0.007768 (4.376)	-0.003472 (1.809)
Time*SA	--	--	-0.002491 (1.197)	-0.001665 (0.536)	--	--	-0.002023 (1.122)	0.003241 (1.348)
Time*ESC	--	--	0.004061 (2.748)	-0.005407 (2.084)	--	--	0.004276 (3.339)	-0.001888 (0.946)

Time*WSC	--	--	0.009572 (5.807)	-0.003909 (1.171)	--	--	0.009939 (6.957)	0.003497 (1.327)
Time*MT	--	--	0.000358 (0.165)	-0.005130 (1.555)	--	--	-0.000130 (0.069)	-0.001214 (0.480)
Time*PAC	--	--	0.001595 (0.689)	-0.006534 (2.495)	--	--	0.001729 (0.862)	-0.004441 (2.227)
$\pi_M \ln(M/K) + \pi_L \ln(L/K)$	.0260899 (4.737)	0.225726 (4.139)	0.144699 (2.652)	.247597 (3.732)	0.208365 (3.893)	0.073773 (1.579)	0.044449 (0.899)	-0.010626 (0.188)
Ln Public Capital	0.078704 (3.632)	-0.042892 (0.583)	0.150455 (4.542)	-0.083582 (0.769)	0.077584 (3.784)	-0.092869 (1.575)	0.148217 (5.166)	-0.246897 (2.941)
Ln Private Capital	-0.032747 (2.026)	-0.052971 (1.235)	-0.093573 (4.032)	-0.044749 (0.663)	-0.033935 (2.218)	-0.027622 (0.804)	-0.097066 (4.827)	-0.041188 (0.806)
Capacity Utilization	--	--	--	--	0.004806 (4.287)	0.005603 (8.977)	0.005520 (6.901)	0.006140 (9.959)
R^2	.4496	.7941	.6954	.8106	.5108	.8697	.7732	.8922
SSE	.46436	.17369	.25696	.15982	.41275	.10994	.19139	.09096
F-statistic	14.2204	1.2953	9.0718	--	28.9586	3.4161	18.0759	--

t statistics in parentheses