URBAN PRODUCTIVITY AND FACTOR GROWTH IN THE LATE NINETEENTH CENTURY*

by

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This paper uncovers a series of empirical facts regarding the sources of U.S. urban growth in the 1880s. We use a large theoretical literature to provide motivations for a number of potential sources of growth, particularly those based on geographical proximity externalities. These sources are characterised and linked to empirical proxies. Then we estimate the covariation of these empirical proxies with the growth rate in output, capital and labor respectively. We find that traditional (neoclassical), several geographic externality, and socio-political factors all covary significantly with aggregate growth, though in very specific ways. For example, the size of a city (a measure of the degree of urbanization) is uncorrelated with output growth, positively correlated with labor growth, and negatively correlated with capital growth. No one extant theory of growth accounts simultaneously for all the phenomena that we observe. *Journal of Economic Literature* Classification Numbers: O18, O47 & R11.

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Empirical studies of aggregate growth have proceeded, principally, by controlling for relative input growth in order to account for productivity (or per capita output) growth. This emphasis provides only limited insights regarding how economic factors influence aggregate growth, because one needs to understand their impacts on productivity growth *and* input growth if mechanisms are to be properly characterized and modeled. In this paper, we work to address this by identifying the sources associated with historical growth in productivity and factors for cities and then distinguishing between them. As such, this research augments Barro (1991) other studies that work to identify the key factors that drive cross-sectional per capita output growth.[1] Importantly, though, our work goes beyond this to provide new insights into what factors may be important for growth in inputs and the mechanisms involved in this growth.

The United States of the 1880s, marked by explosive urban growth and a relatively isolated economy, provides an excellent context for examining urban growth. We therefore construct a dataset from city-industry U.S. Census data from 1870, 1880, and 1890. Our strategy is to identify empirical proxies for the sources predicted to cause growth and then estimate the correlations of these factors with productivity, labor, and capital growth. In so doing, we can identify whether particular factors are associated with aggregate growth through specific pathways rather than focusing on output per capita only. Through our research, we also establish important empirical stylized facts regarding urban growth in productivity, labor, and capital over the period.

Our results are striking and often contradict those of other researchers. Typical relations are seen regarding growth in productivity and inputs and neoclassical factors. For example, convergence in productivity is consistently observed. However, in contrast to many theories and recent empirical studies, we find that externality-based factors have no strong direct relationship with productivity growth. Generally, externality-based factors appear to influence aggregate growth exclusively through growth in inputs. In addition,

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[1] There has been much recent work on urban and regional growth. See, for example, Glaeser et.al. (1992), Barro and Sala-i-Martin (1992), Young (1992), Hulten and Schwab (1993), Henderson (1994) and

effects of these factors differ across inputs. Localization is positively correlated with capital growth and negatively correlated with labor growth. Meanwhile, urbanization has the opposite relation.

The paper is organized as follows. The next section describes the theoretical basis of our empirical approach. The construction and characteristics of our dataset are discussed in Section II. Section III discusses our empirical framework and results. Conclusions and directions for future research are included in a final section.

I. Determinants of Urban Productivity and Factor Growth

Our goal is to identify the economic and social variables which affect productivity and factor growth. We begin with a standard Cobb-Douglas aggregate production function:

$$Y_{c,t} = A_{c,t} K_{c,t}^{\alpha} L_{c,t}^{\beta},\ \alpha, \beta > 0 \tag{1}$$

where Y is a city's output, A is the city technology level, K is the city capital level, and L is the city employment level. City-level growth is then a weighted function of the growth in productivity and inputs:

$$g_{c,t}^{Y} = g_{c,t}^{A} + \alpha g_{c,t}^{K} + \beta g_{c,t}^{L} \tag{2}$$

where:

$$g_{c,t}^{X} = \log\left[\frac{X_{c,t+1}}{X_{c,t}}\right], \text{ for } X = \{Y, A, L, K\}.$$

Productivity and factor growth rates, however, are determined by a deeper set of economic and social relationships. Defining Z^A, Z^K, and Z^L as exogenous or initial conditions of state variables determining productivity, capital, and employment growth, respectively, we rewrite (2) incorporating this endogeneity:

Henderson, Kuncoro and Turner (1994).

$$g_{c,t}^{Y} = g_{c,t}^{A}(Z_{c,t}^{A}) + \alpha g_{c,t}^{K}(Z_{c,t}^{K}) + \beta g_{c,t}^{L}(Z_{c,t}^{L}) \qquad (3).$$

Given equation (3), we identify the individual elements of Z^A, Z^K, and Z^L by concisely summarizing the insights of a vast theoretical literature which has focused on this task. Theoretical sources of productivity and factor growth can be grouped broadly into three categories. *Traditional economic factors* are variables that are derived from basic theory involving convex technologies and utility functions. *Geographic production externalities* are spatial characteristics, which can be population- or industry-specific, that generate spillovers that increase growth. Finally, *other external factors* are socioeconomic, political, and economic factors that are thought to impact growth. Specific variables included in each of these categories are examined briefly below. This discussion also identifies the form of the empirical proxies used to represent these variables in our estimation.

Traditional Economic Factors

The neoclassical growth model offers sharp predictions on the effects of factor prices, productivity levels, and factor utilization on relative growth rates. First, with free trade and knowledge flows, there is a tendency for productivity growth rates to converge, implying that the level of productivity is negatively correlated with the rate of productivity growth. A similar convergence relation is implied for relative factor utilization. Thus, capital (labor)-intensive cities should induce more labor (capital) inflows than less capital (labor)-intensive cities. In addition, factor prices and factor accumulation should be positively correlated. Finally, if capital and labor are technological complements, capital and labor growth will be positively related. These variables are easily represented by city-level aggregate measures, such as the city-wide capital-labor ratio, which we use in our empirical analysis.[2]

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[2] The importance of such traditional variables is, of course, implicit in Solow (1956). More recently, these have been discussed by King and Rebelo (1993). See Barro and Sala-i-Martin (1992) for a recent empirical analysis at a regional level.

Geographic Production Externalities

We have compressed the variety of approaches used to characterize these externalities[3] into three general categories: urbanization, localization, and specialization.

Urbanization

Urbanization is the degree to which a city is large and embodies the size and breadth of urban regions. Diverse consumption possibilities and local demand spillovers across industries are but two of many theorized mechanisms by which urbanization might have a positive impact on growth in factors and productivity. Although the majority of theories based on such ideas predict positive correlations between relative growth rates and city size, others have emphasized potential diseconomies of urbanization arising from congestion and other effects.[4] The obvious aggregate city-level variables to represent urbanization, total population, is used as an empirical proxy.[5]

Localization

Localization is the degree to which an industry's economic activity takes place in one or a small number of geographical areas. Industry localization, the computer industry in Silicon Valley being one recent example, has been linked to externalities that operate at the city-industry level. Theory predicts that localization positively impacts both

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[3] Agglomeration economies have been emphasized, in particular, by the urban economics literature allowing for endogenous movements of capital and labor -- see Miyao (1987) for a review. Knowledge spillovers and endogenous technological change have been part of the new growth theory. See Barro and Sala-i-Martin (1995) for a survey.

[4] The classic studies of the significance of economies of urbanization come from Rosenberg (1963), Jacobs (1969, 1984), and Henderson (1988). There are many different bases for economies of urbanisation. For instance, the lure of 'bright lights', that is, diverse consumption possibilities, has been argued as a reason for the desire of workers to live in large cities (Schlesinger, 1933; Jacobs, 1984). And local demand spillovers have been postulated as a motive for firms to locate in a city (Fujita, 1989; Krugman, 1991a). Nonetheless, city size can be a drain on further growth. Urbanization coincides with increased congestion resulting in higher rents and commuter costs for workers. These have a negative impact on productivity growth and factor accumulation. The extensive optimal city size literature focuses largely on the optimal degree of urbanization (Mills, 1967; Henderson, 1988; and Hall, 1991).

[5] In Bostic, Gans and Stern (1994), past population growth was also used a proxy for urbanization. Its exclusion here does not alter qualitatively any of the empirical results presented below.

productivity growth, through *intraindustry* knowledge spillovers, and factor accumulation,[6] although diseconomies may operate here also.[7]

Since the effect of localization on city growth depend on the number of localized city-industries, including localization in our empirical specification requires defining a localized city-industry. This is accomplished by determining a threshold share of national employment a city-industry would need to employ to be considered localized.[8] For example, if the threshold is 10% of employment, the computer industry in Silicon Valley, to be considered localized, would need to employ more than 10% of national employment in the computer industry. We then define a city's degree of localization as the share of the city's employment contained in localized industries.[9] As localization is an industry-specific externality, effects will likely vary across industries. Our measure will thus tend to dampen observed effects as it does not capture this intraindustry variation.[10] In constructing localization measures for our analysis, we use various thresholds for defining a localized city-industry (5%, 10%, and 20%).

Specialization

Specialization is the degree to which a city's output is dominated by a single or a number of closely related sectors. Specialization, a city-level concept, differs from

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[6] Arthur (1988), Porter (1990), Marshall (1920), and Hoover (1937) discuss how localization promotes intraindustry knowledge spillovers, which in turn increase rates of productivity growth. Marshall (1920), David and Rosenbloom (1990), Krugman (1991a), Rotemberg and Saloner (1990), and Greif and Rodriguez (1992) all have modeled the positive relation between localization and labor and capital growth.

[7] For example, protection of proprietary information, including intellectual property, will be more costly in highly localized environments.

[8] We could also use output to base our definition of whether an industry is localized.

[9] To see how this measure is constructed let $\overline{\mathrm{LOC}}$ denote the threshold level of a city-industry's share of national employment above which it is considered localized. Define Λ_c, with i as the index for city-industries, as

$$\Lambda_c \equiv \left\{ i \middle| \mathrm{LOC}_{c,i} \geq \overline{\mathrm{LOC}} \right\}$$

where $\mathrm{LOC}_{c,i} = \dfrac{L_{c,i}}{\sum_c L_{c,i}}$. Our measure of localization then becomes, $\mathrm{LOC}_{c,t} = \sum_{i \in \Lambda_{c,t}} L_{c,i,t} \big/ L_{c,t}$

[10] Understanding how localization effects vary across industries is an important subject open for future research.

localization in that it deals directly with a city's *sectoral composition*.[11] No theoretical consensus exists as to the effect of specialization on factor accumulation and productivity growth.[12] Empirical measures of specialization must capture the degree to which a city is concentrated in a small number of sectors. To do this, we employ a slightly modified Herfindahl index.[13] The level of specialization for city c at time t is therefore

$$\mathrm{SPEC}_{c,t} = \sum_{i=1}^{I} (L_{i,t} / L_{c,t})^2$$

where L is the amount of labor, and I is the total number of industries in the city. Because potential specialization effects are industry-specific and vary across industries for a given period, this measure again will tend to understate overall effects.

Other Factors

The literature has also focused on other externalities that potentially affect growth. The level of available human capital, the presence of appropriable returns from innovation, government activity (expenditures and taxation), and social forces such as immigration all are thought to have important roles in aggregate growth.[14] Unfortunately, of these, obvious empirical proxies exist only for the government variables and immigration at the city-level for our period of study.

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[11] The distinction between specialization and localization should be emphasized, as it has been repeatedly confused by other authors. The agglomeration effects which operate through the localization of industry are, in many ways, distinct from those which operate through the specialization of cities.

[12] For example, Jacobs (1984) argues that specialization, by introducing down side risk, ultimately promotes factor outflows and productivity reductions. On the other hand, Mokyr (1990) and Henderson (1988) highlight positive potential impacts of specialization on city growth.

[13] The Herfindahl index is also used as a measure of specialization in Henderson (1994).

[14] See Romer (1992) and Rotemberg and Saloner (1990) for a discussion of human capital and growth, Romer (1990), Jacobs (1984), and Porter (1990) for opposing views of appropriability and its role in growth, and Barro (1990) for a model of government activity influencing aggregate growth. Significant immigration into urban areas in the United States occurred during this period, making it particularly important for our analysis.

II. Data

The United States *Census of Manufacturers*,[15] first reported at the city level in 1880, was used to construct the proxies for the variables discussed in the previous section. This source provided data in three areas. First, we obtained a breakdown of manufacturing inputs and outputs by city-industry for 1880 and 1890. Data included the number of operating firms, the dollar value of capital, wages, and materials, the level of employment, and the dollar value of output for every city-industry included in our sample. Secondly, aggregate manufacturing sector data for levels of capital, employment, total labor income, and value added were also compiled. Given this detailed city-industry and manufacturing sector data, we were able to compute levels and growth rates for capital, employment, wages, and value-added at both the city-industry and aggregate city level. Additionally, we constructed city output-employment and capital-labor ratios, as well as the geographic externality variables described earlier. Finally, we collected aggregate city-level data on population, government expenditures, and taxation rates, and the population share which was foreign-born. Table 1 lists all of the variables in the dataset.[16]

As it provides a great deal of insight into the economic structure of the time period, our dataset is an important source for identifying and understanding the economic processes at work during the United States' early industrial history. In addition, this data can serve as a benchmark for comparative analyses of economic growth over time. Table 2 presents summary statistics for the variables. Average city growth over the decade -- over 160%, or over 12% annually -- is extraordinarily high. Further, the high rate of output growth corresponds with high rates of input growth. Average city capital and labor growth

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[15] *United States Census: Census of Manufacturers*, 9th, 10th and 11th Cenuses, Government Printing Office, Washington D.C., various years.

[16] Our data was drawn from data on the top 100 cities in the U.S. in 1880. Due to geographical proximity (as between Manhattan and Brooklyn), some cities have been combined, leaving us with 79 overall metropolitan regions. For the remainder of this paper, metropolitan region and city will be used interchangeably. There were 195 total "industries" used for our analysis. However, it should be noted that the Census data, and our dataset, include a greater number of industries than this. Industries that were so similar as to be viewed as indistinguishable, such as "Wood, sawed" and "wood, planed," were aggregated into a larger "industry" ("Wood") before any analyses were conducted.

is over 200% and 120%, respectively. These growth rates are all highly correlated with each other (see Table 3), which is consistent with traditional theories of aggregate growth.

The levels and correlations between our other measures are also informative. Output per worker is highly correlated with each of the growth measures, while the capital-labor ratio is only marginally correlated with output growth or labor growth. Additionally, the capital-labor ratio and output per worker are correlated with each other. Finally, the relative wage measure, the only observed input price, is correlated with both employment and capital growth, as well as the level of output per worker.

Regarding the production externalities, localization is positively correlated with the two other measures, while specialization and urbanization are slightly negatively correlated. The empirical relevance of the conceptual distinction drawn earlier between localization and specialization is highlighted in Figure 1, a scatter plot of their joint distribution. These variables are correlated, but are in no way identical. This distinction is further emphasized in Table 4, which lists the 10 most localized and specialized cities, respectively. A number of cities which are localized, such as New York and Pittsburgh, are not particularly specialized. Others which are specialized, such as Petersburg, VA and Bay City, MI, are non-localized.

Importantly, the heterogeneity of urban America emphasized by historical accounts (Weber, 1989; Schlesinger, 1993) is apparent in our sample. First note the relatively large standard deviations in growth rates and city statistics in Table 2. In addition, this variation can be seen by examining the distributions of our measures. Figure 2, panel (i) presents the distribution of output growth. No growth range dominates the sample and there are a number of cities with growth rates above 400%. Additional evidence is provided in Table 5, which lists the input and output growth rates of the 10 largest and 10 smallest cities in the sample. Note that the most influential cities in the American growth experience, such as Chicago, New York, and San Francisco, are scattered throughout the sample in no easily discernible fashion.

Figure 2, panels (ii) through (iv) present the distributions of the geographic production externality measures. As with the distribution of output growth, significant variation is seen here. The distribution of urbanization is consistent with theories which posit that the distribution of city sizes arises from the exploitation of scale economies in larger cities and subsequent trading with smaller metropolitan areas. These "systems of interdependent cities" (Henderson, 1988) are characterized by a small number of dominant cities, as reflected in the sample. The distribution of specialization, by contrast, is probably more a result of its functional form (the Herfindahl measure) than any structural tendency for a small number of specialized cities. Interestingly, the distribution of localization, excepting those cities that are completely unlocalized, is fairly uniform across the unit interval.

III. Estimation Framework and Results

We focus on a small number of regressions which demonstrate our main empirical findings regarding the relationship between factor and productivity growth and the initial levels of variables which, according to economic theory, affect each of these. To review briefly, theories predict that productivity growth is related to the initial level of output per worker (the convergence hypothesis), the initial level of externalities (inter- and intra-industry agglomeration), and economic and social control variables (regional dummies and government expenditure).[17] Capital and labor growth, in contrast, are related to each other, the initial level of the capital-labor ratio (regional factor adjustments), the initial levels of externalities (feedbacks with inter- and intra-industry concentration), and a set of economic and social control variables (regional dummies, government expenditures, the share of foreign-born, and relative wages). In our analysis, we are principally interested in the sign of coefficients, and we limit ourselves to those results which were robust to a wide range of empirical specifications and corrections for various forms of potential econometric error.

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[17] Note that our model, where productivity growth is a function solely of initial levels of economic variables, contrasts with other models of aggregate growth. For example, Henderson (1986) models the level of productivity as a function of levels of externality variables. See Romer (1992) for a discussion of the effects of considering levels versus changes in measuring the impact of spillovers associated with human capital.

To present our main conclusions regarding productivity growth and relative factor adjustment, we impose constant returns in production ($\beta = 1 - \alpha$)[18] and take a first-order (linear) approximation to the underlying functional relationship between productivity and factor growth and their determinants. Expressing (2) in intensive (per capita) form, transforming this into growth rates, and introducing the underlying growth factors produces the following regression equations:

$$\begin{aligned} g^{y}_{c,t} = \alpha \cdot g^{k}_{c,t} + \gamma_{\text{REG}} \cdot \text{REGION}_{c} + \gamma_{\text{CONV}} \cdot y_{c,t} + \gamma_{\text{URB}} \cdot \text{POPN}_{c,t} + \\ \gamma_{\text{LOC}} \cdot \text{LOC}_{c,t} + \gamma_{\text{SPEC}} \cdot \text{SPEC}_{c,t} + \gamma_{\text{GOV}} \cdot \text{GOVEXP}_{c,t} + \varepsilon^{y}_{c} \end{aligned} \tag{4a}$$

$$\begin{aligned} g^{k}_{c,t} = \theta_{k} \cdot k_{c,t} + \theta_{\text{REG}} \cdot \text{REGION}_{c} + \theta_{\text{URB}} \cdot \text{POPN}_{c,t} + \\ \theta_{\text{LOC}} \cdot \text{LOC}_{c,t} + \theta_{\text{SPEC}} \cdot \text{SPEC}_{c,t} + \theta_{\text{GOV}} \cdot \text{GOVEXP}_{c,t} + \varepsilon^{k}_{c} \end{aligned} \tag{4b}$$

where $y_{c,t} = Y_{c,t} / L_{c,t}$ and $k_{c,t} = K_{c,t} / L_{c,t}$.

In estimating this simultaneous equation system, we allow for correlation between the unexplained portion of growth in output per worker (y) and the unexplained portion of growth in the capital-labor ratio (k). In particular, there may be a common unobserved shock to each city which affects both productivity and relative factor growth over the period. Because of this potential correlation, we estimate (4a) using instrumental variables, a consistent estimation strategy in a recursive system with correlation in errors across equations. The model is identified by the fact that the initial level of the capital-labor ratio, k, enters the capital-labor growth equation but does not enter the output growth equation.

The principal empirical results are presented in Table 6. In column (i), we present the estimates from the first-stage regression explaining growth in the capital-labor ratio. The first important result is that the level of the capital-labor ratio in 1880 is related, negatively, to the growth rate of that ratio. This correlation is implied by the process of

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[18] So that $y_{c,t} = A_{c,t} k^{\alpha}_{c,t}$, where $y_{c,t} = Y_{c,t} / L_{c,t}$ and $k_{c,t} = K_{c,t} / L_{c,t}$. The assumption of constant returns to scale can, of course be tested. The following regression can be run: $g^{y}_{c,t} = g^{A}_{c,t} + \alpha g^{k}_{c,t} + (1 - \alpha - \beta) g^{L}_{c,t} + \varepsilon$, testing the null hypothesis that $\alpha + \beta = 1$. We do this under various specifications (with different controls and instruments for productivity, capital and labor growth) and do not reject the hypothesis of constant returns to scale.

relative factor adjustment over time, i.e., a high relative level of capital suggests a high marginal productivity to labor, which in turn attracts labor at a relatively higher rate than new capital to the city. The second result in column (i) is that two of the externality-based measures, localization and population, are correlated with growth in the capital-labor ratio. In particular, the growth rate of the capital-labor is increasing in our localization measure and decreasing in our measure of urbanization, the level of the population. This finding suggests and important asymmetry -- intra-industry agglomeration economies have a greater positive impact on capital than labour accumulation, while the reverse is true for inter-industry agglomeration economies. Finally, specialization, a measure less cleanly tied particular economic theories of factor enhancement, is not significantly correlated with growth in the capital-labor ratio. Of course, this does not indicate whether these externalities-based variables have a positive or negative correlation with both, one or neither capital or labor growth individually. Such possibilities are explored below.

Column (ii) presents our 2SLS estimates of growth in city output per employed worker. There are three main findings in column (ii). First, not surprisingly, the growth in output per worker is increasing in the growth rate of the capital-labor ratio, i.e., increases in the relative share of capital are labor-productivity improving. Second, we find strong evidence for intercity convergence -- the growth in output per worker is related in a strong and negative way to the initial level of output per worker. Finally, and perhaps most surprisingly, there is no significant correlation between the agglomeration measures and output per worker growth. At least for the sample and period studied, there is no statistically significant relationship between our measures of a set of geographically-based externalities and labor-productivity growth.[19]

In addition to identifying the factors associated with productivity growth, we are interested in hypotheses regarding the role of neoclassical adjustment mechanisms and geographic externalities in shaping the absolute growth rate of each factor (capital and

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[19] These findings resemble the results presented by Romer (1992) who studied the relationship between human capital externalities and economic growth. Using a similar two equation procedure (although holding labor growth as exogenous), Romer found that neither the level or growth of human capital affected

labor). Because of our small sample, we again use first-order approximations of the function which relates input growth to its determinants:

$$g_{c,t}^{K} = \delta_{L} \cdot g_{c,t}^{L} + \delta_{\text{REG}} \cdot \text{REGION}_{c} + \delta_{\text{CONV}} \cdot K_{c,t} + \delta_{\text{URB}} \cdot \text{POPN}_{c,t} + \delta_{\text{LOC}} \cdot \text{LOC}_{c,t} + \delta_{\text{SPEC}} \cdot \text{SPEC}_{c,t} + \delta_{\text{GOV}} \cdot \text{GOVEXP}_{c,t} + \delta_{\text{IMMIG}} \cdot \text{IMMIG}_{c,t} + \varepsilon_{c}^{K} \tag{5a}$$

$$g_{c,t}^{L} = \varphi_{K} \cdot g_{c,t}^{K} + \varphi_{\text{REG}} \cdot \text{REGION}_{c} + \varphi_{\text{CONV}} \cdot L_{c,t} + \varphi_{\text{URB}} \cdot \text{POPN}_{c,t} + \varphi_{\text{LOC}} \cdot \text{LOC}_{c,t} + \varphi_{\text{SPEC}} \cdot \text{SPEC}_{c,t} + \varphi_{\text{GOV}} \cdot \text{GOVEXP}_{c,t} + \varphi_{\text{IMMIG}} \cdot \text{IMMIG}_{c,t} + \varepsilon_{c}^{L} \tag{5a}$$

Unfortunately, this statistical model is underidentified -- we lack valid instruments for capital growth in the labor growth equation and vice versa. We, therefore, limit ourselves to an extremely exploratory fact-finding mission -- the conditional correlation between input growth and its theoretical determinants.

Our results are in Table 7. The principal insights of the previous table are confirmed. In particular, there is a strong indication that the comparative statics of neoclassical adjustment are at work -- capital growth is negatively correlated and labor growth is positively correlated with the capital-labor ratio. The correlation between the absolute level of input growth and our measures of agglomeration also are consistent with the results in Table 6 but yield some additional information about the relationship. Localization is positively correlated with capital growth and negatively correlated with labor growth. In contrast, urbanization has a reverse pattern -- negative correlation with capital growth and positive correlation with labor growth. The Herfindahl measure of urban specialization, the agglomeration measure without a theoretical relationship to factor growth, is uncorrelated with factor growth.

Before interpreting our results, we present evidence that they are robust to different empirical specifications, variable definitions, and sources of econometric error (see Table 8). With respect to productivity growth, column (i) shows the estimates from Table 6. In column (ii), we relax the assumption of constant returns to scale in the productivity equation by regressing output growth on labor growth, capital growth, and the theoretical

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productivity growth, but both were significantly correlated with investment.

determinants of productivity growth. As before, instruments are used to obtain consistent estimates of the endogenous input growth terms. Once again, we observe that productivity growth is again significantly correlated with the initial level of output per worker and uncorrelated with each externality-based measure. Additionally, we explore whether thresholds for our geographic externality measures drive our results. In columns (iii) and (iv), we use localization as an example and re-estimate the relation utilizing localization thresholds of 5% and 20%, respectively. While the coefficients vary across specifications, the principal qualitative findings are robust across each measure.

The second set of findings from Table 6 concerns the determinants of input growth. In particular, we found that growth in the capital-labor ratio is negatively related to its initial level, positively correlated with the level of localization, and negatively correlated with the level of urbanization. We explore these results further in Table 9, where we present the estimates which result under different definitions of the localization variable. As with the productivity growth estimates, the sign and significance of the observed correlations does not change. Similar results obtain when we employ alternative measures of all of our geographic externality measures.

IV. Interpretation and Conclusions

Our results offer important insights into productivity and factor growth. They consistently support Neoclassical hypotheses regarding productivity and relative factor convergence over time and thus they are consistent with the cross-national of Barro (1991) and others. While we do not want to stress the magnitude of any single estimate too strongly, our estimate of the rate of productivity convergence is much higher than those of other studies that examine later periods or larger regions (Barro and Sala-i-Martin, 1992). By contrast, our finding of no direct relationship between productivity growth and geographic externalities conflicts sharply with recent studies that have identified such relationships (Glaeser, Kallal, Scheinkman, and Shleifer (1992)).

In contrast to productivity growth, growth in inputs is closely associated with the geographic externality variables. Intra-industry spillovers (as represented by localization) seem to enhance capital growth while inter-industry spillovers (represented by urbanization) appear to have an opposite impact. These support various theories, including those of Greif and Rodriguez (1992) for localization and Mills (1967) and Henderson (1988) for urbanization. The opposite relation holds for labor growth, with localization negatively and urbanization positively related to growth. The localization result is puzzling, as it is not predicted by the literature (for example, Marshall, 1920; Krugman, 1991a), while Jacobs (1969, 1984) and Krugman (1991b) predict the positive role for urbanization. Finally, neoclassical predictions are borne out in nearly every case, as convergence relations are consistently observed.

Taken together, these results support our initial assertion that the exploration of input growth is vital for a complete understanding of growth mechanisms. By solely examining growth in productivity and ignoring the endogeneity of inputs, one would have overlooked the important role that geographic externalities play in overall growth. Further, this approach generated insights into the precise pathways by which economic variables are related to growth and offers guidance for future investigation of the nature of these pathways. For example, our work demonstrated a significant relation between government expenditures and labor growth. More precision on the interaction between government activities and economic growth is a fruitful area for future work. Additionally, as mentioned earlier, the impact of geographic externalities likely varies across industries. Future research might attempt to characterize this variation.

An important caveat for our results is that historical context is extremely important. Because other periods have substantial economic, spatial, and social differences, the relations observed for the urban United States in the 1880s may not be generalizable to other places and time periods. A deeper examination of the historical forces at work is essential for closely linking our work with similar efforts that have focused on different historical contexts.

Table 1: List of Variables

<u>Growth Measures</u> (1880-1890)

Output growth rate
Capital growth rate
Labor growth rate
Output growth rate (logarithms)
Capital growth rate (logarithms)
Labor growth rate (logarithms)

<u>Traditional Adjustment Measures</u>

Relative wage, 1880
Output-Labor ratio, 1880
Capital-Labor ratio, 1880

<u>Externalities-Based Measures</u>

Urbanization:

Total population, 1880
Growth in population, 1870 to 1880
Total level of output, 1880
Total level of employment, 1880

Localization:

Share of city employment in localized industries, $\overline{LOC} = 10\%$, 1880

Specialization:

Specialization in Employment (modified Herfindahl index), 1880

<u>Other Variables</u>

Geographic regional dummies (North-East, Lakes, South, West)
Immigrant share, 1880
1880 per capita property value in the city
Total government expenditure per capita , 1880
Total property tax rates, 1880

Table 2: Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Output Growth, 1880-1890	1.6202	1.3669	0.0396	9.3067
Capital Growth, 1880-1890	2.0096	1.6684	0.1762	8.9791
Labor Growth, 1880-1890	1.2207	1.0997	-0.1219	5.7618
Relative Wage, 1880	383.8952	84.3478	143.4775	730.6798
Output-Labor Ratio, 1880	767.6079	191.7251	322.0395	1596.6652
Capital-Labor Ratio, 1880	1036.0461	302.5176	417.8565	1892.5380
Population, 1880 ('000s)	113.0220	245.9664	19.7430	1924.6830
Population Growth, 1870-1880	0.4930	0.7561	-0.1649	6.4867
Localization (Employment, 10%)	0.1420	0.2412	0.0000	0.9231
Specialization (Employment)	0.1106	0.1250	0.0097	0.6845
Immigrant Share	0.2399	0.1044	0.0164	0.4815
Government Expenditure per capita, 1880	15.2377	11.0359	2.2144	55.3586

Table 3: Covariance Matrix

	Out. Gth	Cap. Gth	Lab. Gth	Out-Lab Ratio	Cap-Lab Ratio	LOC
Output Growth	1.0000					
Capital Growth	0.8642	1.0000				
Labor Growth	0.8941	0.8638	1.0000			
Output-Labor Ratio	0.1966	0.4290	0.4316	1.0000		
Capital-Labor Ratio	-0.0845	-0.1863	0.0609	0.3416	1.0000	
Localization	-0.2769	-0.2594	-0.3245	-0.1155	0.0506	1.0000
Population	-0.0524	-0.0656	-0.1098	0.0722	-0.0881	0.5000
Specialization	-0.1701	-0.1942	-0.1884	-0.3560	0.0721	0.5018
Pop Growth, 1870-80	0.2196	0.3653	0.2300	0.3228	0.0021	-0.0396
Wage	0.1949	0.3671	0.3779	0.8644	0.2461	-0.1052
Immigration Share	-0.0156	-0.0452	-0.0622	0.1822	0.3179	0.3340
Gov. Exp. per capita	-0.2435	-0.2201	-0.2834	-0.0543	-0.0767	0.4238

	POP	SPEC	Pop Gth 70-80	Wage	Immign	Gov. Exp
Output Growth						
Capital Growth						
Labor Growth						
Output-Labor Ratio						
Capital-Labor Ratio						
Localization						
Population	1.0000					
Specialization	-0.1471	1.0000				
Pop Growth, 1870-80	-0.0448	0.0264	1.0000			
Wage	0.0874	-0.3420	0.2575	1.0000		
Immigration Share	0.2296	0.0984	0.1796	0.2236	1.0000	
Gov. Exp. per capita	0.4139	0.0624	-0.1008	0.0753	0.2403	1.0000

Figure 1: Localization Versus Specialization

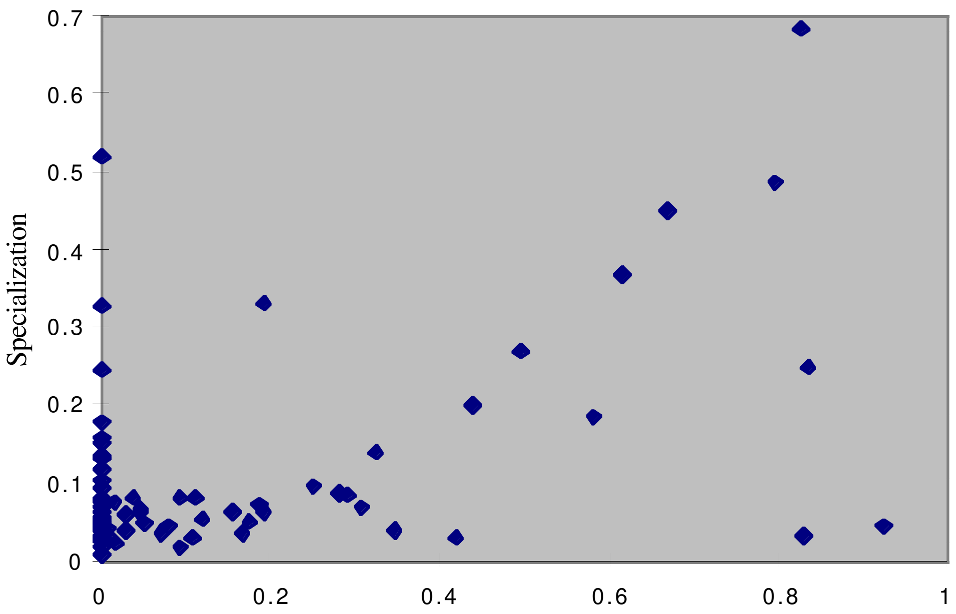


Table 4: Growth Rates and the Presence of Externalities for Localized and Specialized Sample Cities

Localized Cities

	City	LOC	Out. Gth	Cap. Gth	Lab. Gth	POP	SPEC
1.	New York	0.9231	1.2418	1.3922	0.3729	1924683	0.0461
2.	Lawrence	0.8334	0.0396	0.8266	0.2359	98626	0.2499
3.	Philadelphia	0.8294	1.1484	1.0312	0.4251	888826	0.0332
4.	Fall River	0.8269	0.7741	0.4834	0.3779	48961	0.6845
5.	Lynn	0.7939	1.0709	1.4479	0.7017	65837	0.4884
6.	Manchester	0.6688	0.3335	0.4803	0.4164	32630	0.4499
7.	Springfield (OH)	0.6149	0.5361	1.0077	0.6859	20730	0.3674
8.	Pittsburgh	0.5821	0.7952	1.1442	0.6014	235071	0.1858
9.	Paterson	0.4954	0.6653	1.2238	0.2239	51031	0.2718
10.	Portland	0.4369	0.6844	0.6232	-0.1219	33810	0.2009

Specialized Cities

	City	SPEC	Out. Gth	Cap. Gth	Lab. Gth	POP	LOC
1.	Fall River	0.6845	0.7741	0.4834	0.3779	48961	0.8269
2.	Petersburg	0.5219	1.0567	1.2281	0.3152	21656	0.0000
3.	Lynn	0.4884	1.0709	1.4479	0.7017	65837	0.7939
4.	Manchester	0.4499	0.3335	0.4803	0.4164	32630	0.6688
5.	Springfield (OH)	0.3674	0.5361	1.0077	0.6859	20730	0.6149
6.	Bay City	0.3331	1.3933	1.2794	1.0983	20693	0.1903
7.	Augusta	0.3296	3.2788	2.7553	2.7464	21891	0.0000
8.	Paterson	0.2718	0.6653	1.2238	0.2239	51031	0.4954
9.	Lawrence	0.2499	0.0396	0.8266	0.2359	98626	0.8334
10.	Wheeling	0.2480	0.3907	0.7449	0.2427	30737	0.0000

Table 5: Growth Rates and the Presence of Externalities for the Most and Least Urbanized Sample Cities

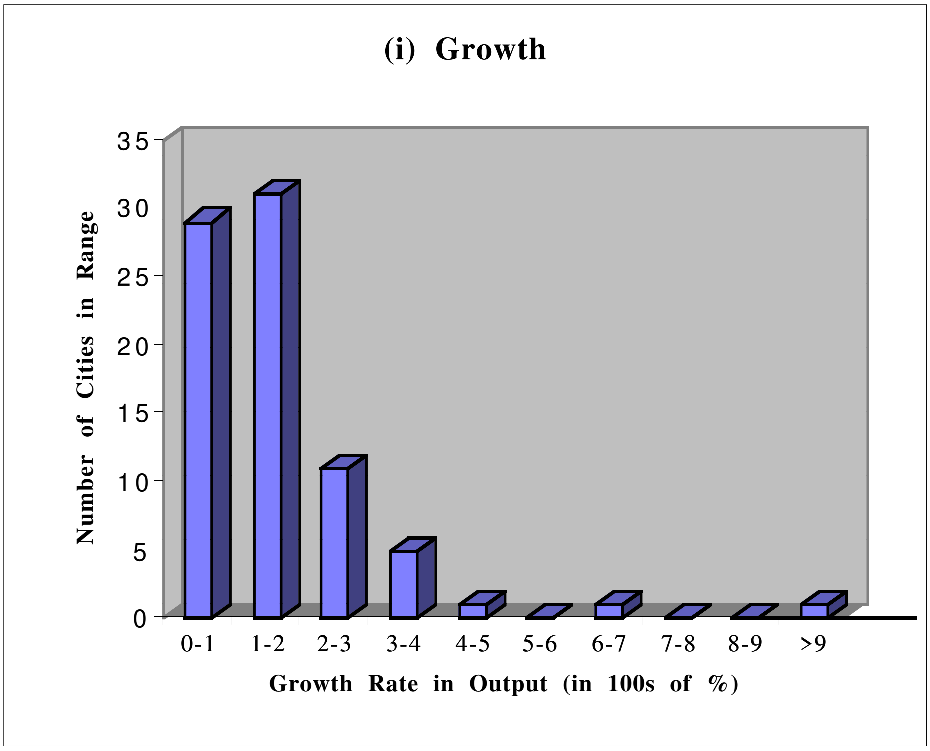
Most Urbanized Cities

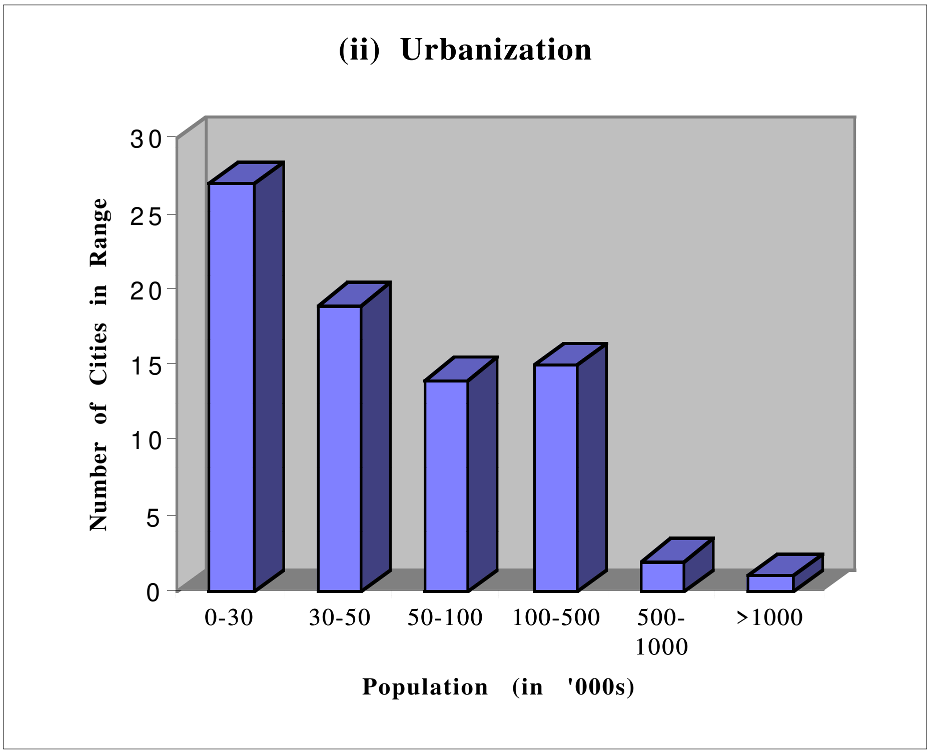
	City	POP	Out. Gth	Cap. Gth	Lab. Gth	LOC	SPEC
1.	New York	1924683	1.2418	1.3922	0.6729	0.9231	0.0461
2.	Philadelpia	888826	1.1484	1.0312	0.4251	0.8294	0.0332
3.	Chicago	503185	2.6527	4.2370	1.6459	0.3444	0.0385
4.	Boston	462223	1.2017	1.5988	0.6043	0.1653	0.0364
5.	St. Louis	350518	1.7468	1.7935	1.2487	0.1055	0.0297
6.	Baltimore	332313	1.2322	1.4030	0.4865	0.2797	0.0897
7.	Cincinnati	305292	1.4697	1.0752	0.8442	0.1731	0.0519
8.	San Francisco	268514	0.9796	1.2173	0.7729	0.0294	0.0396
9.	Pittsburgh	235071	0.7952	1.1442	0.6014	0.5821	0.1858
10.	New Orleans	216090	1.4917	2.0728	1.6537	0.1166	0.0555

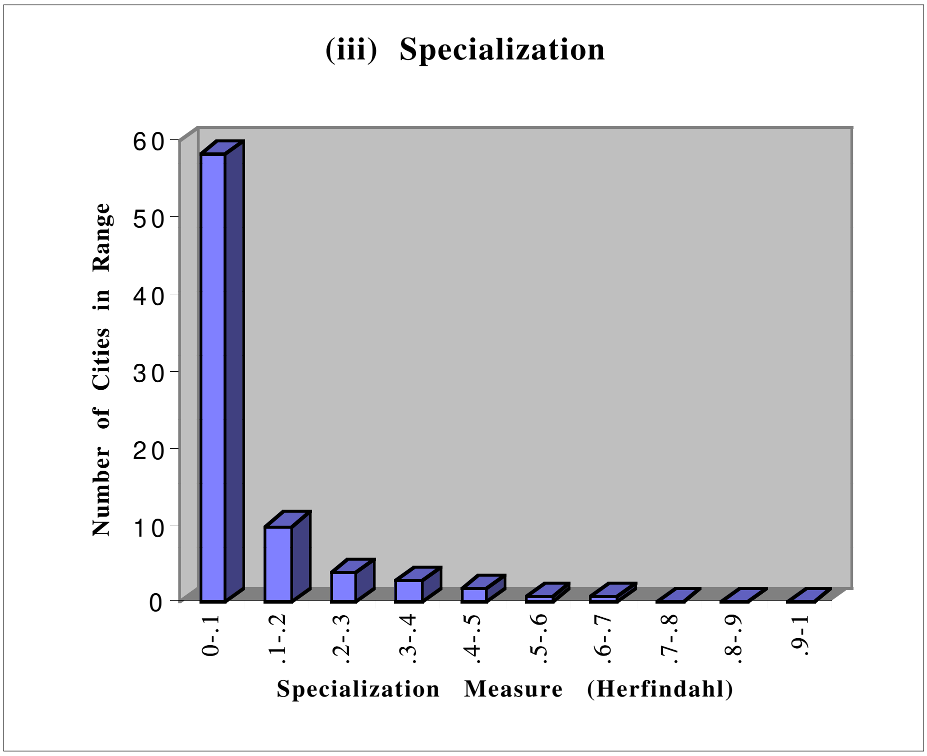
Least Urbanized Cities

	City	POP	Out. Gth	Cap. Gth	Lab. Gth	LOC	SPEC
1.	Springfield (IL)	19743	1.9250	1.1298	0.9252	0.0000	0.0185
2.	Poughkeepsie	20207	0.8947	0.3009	0.5197	0.0000	0.0299
3.	Elmira	20541	1.5185	1.5549	0.8955	0.0000	0.0554
4.	San Antonio	20550	9.3066	8.6901	5.7618	0.0000	0.0796
5.	Bay City	20693	1.3933	1.2794	1.0983	0.1903	0.3331
6.	Springfield (OH)	20730	0.5361	1.0077	0.6859	0.6149	0.3674
7.	Salt Lake City	20768	2.3328	2.8982	1.4644	0.0000	0.0834
8.	Oswego	21116	0.4588	1.3951	0.6018	0.0000	0.0382
9.	Taunton	21213	0.5352	0.9313	0.2546	0.0000	0.1532
10.	Sacramento	21420	2.7150	2.3812	3.8809	0.0000	0.0322

Figure 2: Sample Distributions






(iii) Specialization
Number of Cities in Range
60
50
40
30
20
10
0
0-.1
.1-.2
.2-.3
.3-.4
.4-.5
.5-.6
.6-.7
.7-.8
.8-.9
.9-1
Specialization Measure (Herfindahl)

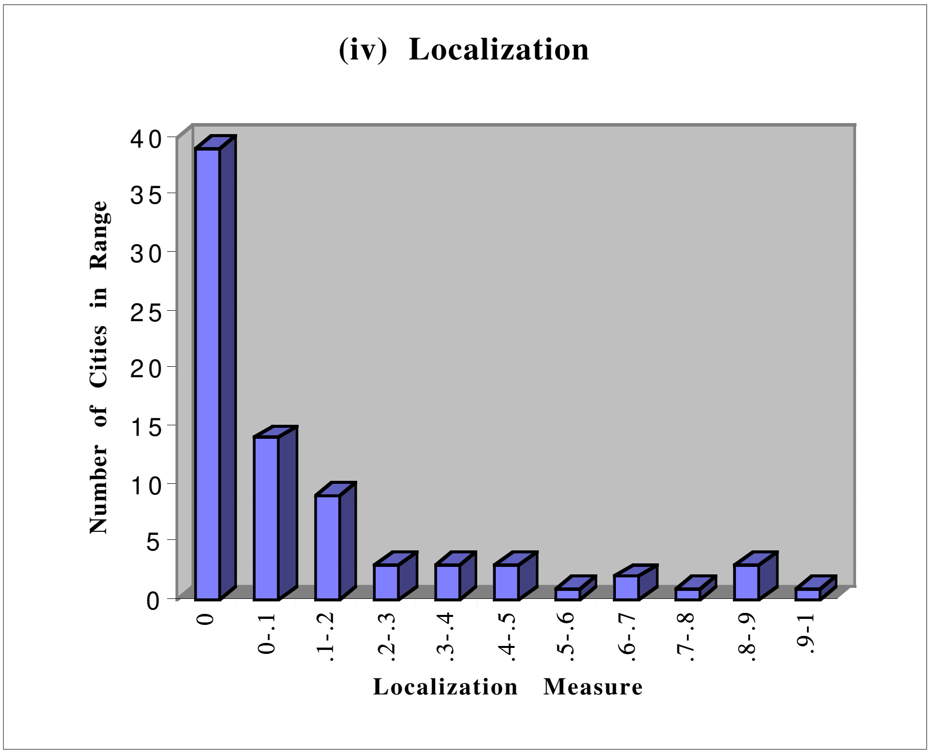

(iv) Localization
Number of Cities in Range
40
35
30
25
20
15
10
5
0
0
0-.1
.1-.2
.2-.3
.3-.4
.4-.5
.5-.6
.6-.7
.7-.8
.8-.9
.9-1
Localization Measure

Table 6: Productivity Growth Estimates

(standard errors in parentheses)

	Dependent Variables (Logs):	
	Growth in Capital-Labor Ratio	Growth in Output Per Capita (2SLS)
North-East	**4.7167**	**2.8728**
	(0.9175)	(0.7598)
Lakes	**4.7681**	**2.8989**
	(0.9210)	(0.7763)
South	**4.9334**	**2.8310**
	(0.9383)	(0.7797)
West	**4.7528**	**2.8852**
	(0.9315)	(0.7959)
Capital-Labor Ratio, 1880 (Log)	**-0.5981**	
	(0.0784)	
Growth in Capital-Labor Ratio (Log)		**0.2636**
		(0.0787)
Output-Labor Ratio, 1880 (Log)		**-0.4801**
		(0.1064)
Localization (Employment, 10%)	**0.2813**	-0.0350
	(0.1412)	(0.1301)
Specialization (Employment)	-0.3235	-0.2808
	(0.2375)	(0.2248)
Population, 1880 (Log)	**-0.0600**	0.0312
	(0.0282)	(0.0244)
Government Expenditure, 1880 (Log)	0.0459	0.0330
	(0.0519)	(0.0309)
Relative Wage, 1880 (Log)	0.0675	
	(0.1159)	
Immigration, 1880 (Log)	**0.1465**	
	(0.0519)	
Adjusted R-squared	0.4559	0.5200

Boldface indicates significance at 5%

Table 7: Input Growth Estimates

(standard errors in parentheses)

	Dependent Variables (Logs):	
	Growth in Capital	Growth in Labor
North-East	**4.4820**	**-4.4681**
	(0.9546)	(0.8358)
Lakes	**4.5397**	**-4.4851**
	(0.9561)	(0.8397)
South	**4.7325**	**-4.5143**
	(0.9654)	(0.8590)
West	**4.5381**	**-4.4247**
	(0.9624)	(0.8503)
Capital Growth (Log)		**0.7698**
		(0.0586)
Labor Growth (Log)	**0.9355**	
	(0.0712)	
Capital-Labor Ratio, 1880 (Log)	**-0.5934**	**0.4774**
	(0.0787)	(0.0776)
Localization (Employment, 10%)	**0.2626**	**-0.2834**
	(0.1429)	(0.1283)
Specialization (Employment)	-0.3066	0.0395
	(0.2386)	(0.2158)
Population, 1880 (Log)	**-0.0571**	**0.0564**
	(0.0284)	(0.0256)
Government Expenditure, 1880 (Log)	0.0380	**-0.0634**
	(0.0362)	(0.0321)
Relative Wage, 1880 (Log)	0.1060	0.0853
	(0.1235)	(0.1122)
Immigration, 1880 (Log)	**0.1483**	**-0.1064**
	(0.0520)	(0.1122)
Adjusted R-squared	0.8443	0.8439

Boldface indicates significance at 5%

Table 8: Productivity Growth Estimates: Robustness
(standard errors in parentheses)

	Growth in Output Per Capita (i)	Growth in Output (ii)	Growth in Output Per Capita (iii)	Growth in Output Per Capita (iv)
North-East	**2.8728**	**5.0157**	**3.0137**	**2.8427**
	(0.7598)	(1.1697)	(0.7259	(0.7218)
Lakes	**2.8989**	**5.0274**	**3.0475**	**2.8700**
	(0.7763)	(1.1737)	(0.7355)	(0.73618)
South	**2.8310**	**4.8056**	**2.9873**	**2.8019**
	(0.7797)	(1.1255)	(0.7422)	(0.7332)
West	**2.8852**	**4.9365**	**3.0369**	**2.8543**
	(0.7959)	(1.1561)	(0.7573)	(0.7526)
Capital Growth (Log)		0.2406		
		(0.1417)		
Labor Growth (Log)		**1.2072**		
		(0.2887)		
Growth in Capital-Labor Ratio (Log)	**0.2636**		**0.2529**	**0.2635**
	(0.0787)		(0.0807)	(0.0778)
Output-Labor Ratio, 1880 (Log)	**-0.4801**	**-0.8277**	**-0.4855**	**-0.4764**
	(0.1064)	(0.1777)	(0.1012)	(0.1046)
Localization (Employment, 10%)	-0.0350	0.1607		
	(0.1301)	(0.1859)		
Localization (Employment, 5%)			0.0397	
			(0.1209)	
Localization (Employment, 20%)				-0.0585
				(0.1265)
Specialization (Employment)	-0.2808	**-0.5179**	-0.3744	-0.2757
	(0.2248)	(0.2906)	(0.2357)	(0.1906)
Population, 1880 (Log)	0.0312	0.0105	0.0213	0.0322
	(0.0244)	(0.0327)	(0.0277)	(0.0222)
Government Expenditure, 1880 (Log)	0.0330	0.0824	0.0326	0.0324
	(0.0309)	(0.0476)	(0.0309)	(0.0309)
Adjusted R-squared	0.5200	0.8501	0.5218	0.5205

Boldface indicates significance at 5%

Table 9: Capital-Labor Growth Estimates: Robustness

(standard errors in parentheses)

	Localization Threshold of:		
	5%	10%	20%
North-East	**4.6911**	**4.7167**	**4.6870**
	(0.8918)	(0.9175)	(0.9105)
Lakes	**4.7190**	**4.7681**	**4.7157**
	(0.8912)	(0.9210)	(0.9106)
South	**4.9236**	**4.9334**	**4.8762**
	(0.9121)	(0.9383)	(0.9275)
West	**4.7208**	**4.7528**	**4.7053**
	(0.9031)	(0.9315)	(0.9217)
Capital-Labor Ratio, 1880 (Log)	**-0.5731**	**-0.5981**	**-0.6164**
	(0.0774)	(0.0784)	(0.0793)
Localization (Employment, 10%)	**0.3197**	**0.2813**	**0.2926**
	(0.1287)	(0.1412)	(0.1420)
Specialization (Employment)	-0.4531	-0.3235	-0.2195
	(0.2502)	(0.2375)	(0.2061)
Population, 1880 (Log)	**-0.0807**	**-0.0600**	**-0.0522**
	(0.0311)	(0.0282)	(0.0261)
Government Expenditure, 1880 (Log)	0.0422	0.0459	0.0488
	(0.0346)	(0.0519)	(0.0350)
Relative Wage, 1880 (Log)	0.0825	0.0675	0.0819
	(0.1137)	(0.1159)	(0.1152)
Immigration, 1880 (Log)	**0.1550**	**0.1465**	0.1483
	(0.0508)	(0.0519)	(0.0517)
Adjusted R-squared	0.4720	0.4559	0.4580

Boldface indicates significance at 5%

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