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Does High Technology Matter?

An Application to United States Regional Growth

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and
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U.S. regional data show that jobs created through the birth of high-tech firms — though small-scale — help explain why growth rates differ between states. A high birthrate for firms is negatively correlated with growth, but innovative activity at technology's frontiers seems to raise the standard of living.

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The International Economics Department, International Economic Analysis and Prospects Division (IECAP), prepares regular reports on the long-term prospects for growth of the global economy, and the implications for developing countries. This paper is part of IECAP's research program on sources of growth, why growth rates differ, and how structural change affects long-term growth prospects.

Boltho and King studied the influence of high technology on output growth by using cross-section data on U.S. states. Drawing eclectically on the sources-for-growth literature, they estimated a base equation that explains about half of the differences in per capita gross state product growth rates in the 48 contiguous states in the decade 1976-86. Using microdata on employment in high-tech activities, they conducted tests to see how important high-tech was — as measured by how many jobs were created by new firms — in explaining growth differences between regions.

They found that:

- Starting income levels, changes in the investment share of output, and changes in the labor participation rate influence regional growth rates.

- A higher overall birthrate for firms on average for 1976-86 is negatively correlated with growth.

- But the share of new jobs created in new high-tech activities has a powerful, positive effect on per capita income growth. This supports the hypothesis that innovative activity at technology's frontiers helps raise living standards.

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Does High Technology Matter?
An Application to United States Regional Growth

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I. INTRODUCTION

The major longer-run determinant of rising living standards, in industrial and developing countries alike, is clearly the rate of growth of labor productivity. This, in turn, is strongly influenced by the growth of technology which many would consider "the ultimate constraint on the rate of growth of national income" (Lewis, 1978, p. 155). Hence, rapid innovation and/or rapid diffusion and adaptation of technology would seem to be at least necessary, if not sufficient, conditions for rapid growth. It is an open question, however, whether all technologies will be equally suitable and growth promoting. As the "choice of techniques" literature has amply shown, the adoption of new technology, while very important, need not be a short-cut to rapid growth acceleration in a developing country.

For developed countries, however, the usual argument has been that innovation is crucial, in particular if this innovation is at the frontier of technology. In other words, it is not just technological progress per se, but the rapid expansion of what have been dubbed "high technology" activities that should ensure rapid productivity growth. In part this would be because of the high level of productivity in high-tech sectors themselves. In part it could stem from forms of export-led growth, since it could be expected that the income elasticity of demand for the products of high-tech on world markets would be above average. In addition, the introduction of high-tech could facilitate the achievement of dynamic scale economies and might act as a magnet pulling in resources from other areas.

If all this is true, then explanations for inter-country growth rate differences should include some variable proxying high-tech activities. However, beyond bland generalizations about the successes of Japan or Silicon Valley, there does not seem to have been much serious testing of the growth-promoting properties of high-technology. Indeed, the same casual empiricism could lead one to very different conclusions--after all, it has often been economies at the frontier of technology and basic research which have grown relatively slowly

(e.g. Britain or the United States), and imitator countries that have been most successful (e.g. Italy or South Korea). It is true that a recent paper has shown that innovative activity, proxied by patents data, did contribute to growth in a cross-country context (Fagerberg, 1987), but there is no necessary correspondence between high technology and the intensity of patenting.

Possibly the major problem encountered in trying to test any proposition about high-tech has been data availability. There is no internationally standardized definition of what constitutes a high-tech activity, nor are comparable data readily available for a sufficiently large number of countries and/or time periods. For the United States, however, the Small Business Administration (SBA) has recently compiled a comprehensive database covering changes in employment between 1976 and 1986, for high technology,[1] low technology and "other" technology sectors.

Equally important, for present purposes, the data are available on a state-by-state basis. The existence of this information allows, therefore, some simple testing of the relationship between growth and the introduction of advanced technology. If the latter is a major contributor to prosperity, then one would expect that regions with above-average employment growth in high-tech sectors would also record above average growth rates of <u>total</u> output, and vice versa. Such an approach may thus add one further element to our knowledge of "why growth rates differ," even if the question in this instance would not be asked for countries but only for regions within a country. Section II briefly outlines the simple methodology that was followed to test for this proposition, Section III presents the results obtained, while the Conclusions briefly summarize the various arguments.

II. APPROACH

In principle, the most appropriate method for testing whether the introduction of high-tech activities contributed to growth would appear to be one

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1 A high technology industry is defined as one in which "more than 8 per cent of the employees [are] in scientific, engineering, and technical occupations and at least 5 percent in the more narrow class of scientific and engineering occupations." (Office of Technology Assessment, 1984, p.118). To the 20 three-digit SIC industries fulfilling these criteria are added four more sectors that figure in a separate list of high-tech industries classified by the share of direct and indirect R&D spending in product sales (<u>ibid</u>). In 1976, employment so defined represented 7.4 percent of the United States' private sector workforce.

that started with some standard explanation of why regional growth rates differ, gleaned from theory and existing empirical work. To this could then be added a proxy for high-tech activities, in order to see whether the conventional explanation could be strengthened.

Unfortunately, no such standard or conventional explanation is easily forthcoming. There are, instead, numerous, and often conflicting, approaches to why growth rates may differ across countries or regions. Some of the better known explanations are:

i) The role of differential growth in factor supplies, in line with the neo-classical approach;

ii) The importance of a dynamic export sector able to promote a process of export-led growth;

iii) The strength of "leading" or "lagging" sectors (such as manufacturing or government), following the old Physiocratic thesis that some parts of the economy are more important than other;

iv) The retarding influence of "institutional sclerosis";

v) The degree of relative maturity or backwardness, on the hypothesis that a low starting point allows catching up possibilities.

While in theory any of these approaches could be used, in practice several of them may not be feasible. For one thing, the time period imposed by the existing database (1976-86) is relatively short--a full explanation of inter-state growth rate differences would ideally require data stretching over two or three decades. Moreover, testing a proper specification of these various models might not be possible because of the unavailability of many of the required statistical series. Finally, not all the approaches may be equally appropriate for an explanation of regional growth rate differences within a single country.

A straightforward application of neo-classical theory could either use a growth-accounting methodology (Denison, 1967) or estimate an aggregate production function. The absence of state-by-state capital stock data, however, prevents this. In any case, such an approach would only provide a very proximate explanation. Neither capital nor labor are fully independent of the growth process itself, and particularly so in a regional context in which factor

mobility is very high. Growth of factor inputs, in other words, could be a function of output growth as demand created its own supply by drawing in resources from other states.

Data unavailability also prevents the testing of the export-led growth hypothesis (Beckerman, 1962). This is disappointing because of the crucial role exports are bound to play in a state context. Regions are usually a good deal more open than countries and for many firms ". . . local demand is likely to be trivial compared with the optimum production capacity; . . . the viability of regional enterprises must largely depend on the strength of demand from outside the region" (Dixon and Thirwall, 1975, p.207).[2] On the other hand, an explanation that privileged exports would also only be proximate. Since initial exchange rate undervaluation could not be invoked as a reason for successful export performance, the latter would have to be explained by reference to those underlying factors that make a state attractive to "footloose" industry (e.g., provision of public services, tax incidence, wage levels, sunshine, etc.).

A very similar conclusion would probably emerge if one adopted the hypothesis that manufacturing was "the engine of growth" (Kaldor, 1966). Since most tradables are manufactures, this thesis would mesh with the export-led approach[3] and be similarly unrevealing about the final cause of growth rate differences. As for the role of the public sector (Bacon and Eltis, 1974), causation is ambiguous, particularly so in a regional context. Financial or physical crowding-out are highly unlikely. Indeed, crowding-in would be more plausible since high levels of state expenditure could encourage the immigration of both people and firms. On the other hand, a relatively large public sector might reflect a relatively high level of local taxation that would, in turn, discourage growth by diminishing the state's attractiveness to business. Both positive and negative effects can be found in the literature (Helms, 1985; Ram, 1986).

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2 This judgement, made for the relatively small regions of the United Kingdom, may sound extreme for some of the much larger states that exist within the United States. Yet even in the latter context, external demand is likely to be of paramount importance.

3 Manufacturing, in addition, could also promote growth through import-substitution.

The "institutional sclerosis" thesis (Olson, 1982) links growth rate differences to the hypothesis that as countries or regions get older, established interests (such as professional associations, cartels, unions), strengthen their power at the expense of society as whole. In contrast to many of the other hypotheses, this one has been subject to some empirical testing, but the results obtained would seem inconclusive. One study finds support for the thesis that the "older" the state, the lower its growth rate (Vedder and Gallaway, 1986). Another, however, looking at a somewhat longer time-period, obtains results that fail to support the hypothesis (Wallis and Oates, 1988).

Much less inconclusive are the results obtained at the international level for a somewhat different formulation of the "maturity" hypothesis--the idea that countries at lower levels of development (and, hence, living standards) can grow rapidly by catching up with more advanced countries (Baumol, 1986; Fagerberg, 1987). Unless one believes that "cumulative causation" is at work (i.e., that richer regions attract a country's best resources), the effect of relative backwardness can be expected to be even stronger in a national than in an international context, thanks to the higher degree of factor mobility present within countries. Less developed regions should benefit not only from catch-up possibilities, but also from an inflow of industry attracted by lower wage levels. This thesis has received recent confirmation for the United States (Barro and Sala i Martin, 1989).

The foregoing suggests that any approach to the question of why state-by-state growth rates differ within the United States is bound to be eclectic. An obvious first step would be to consider initial income levels. The lower these are, the greater the potential may be for future growth. A second set of factors should look at the attempts made to exploit this potential, such as, for instance, investment through the period.[4] Third, some variables should be introduced to measure a state's attractiveness to mobile industry (e.g., wage levels, tax rates, degree of work force unionization, etc). Fourth, it would

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4 State-by-state investment data are only available for the manufacturing sector; the absence of full data, however, should not matter much given the sector's importance in any explanation of regional growth rate differences. More unfortunate is the unavailabiltiy of any data beyond 1982.

also seem necessary to account for labor supply, e.g., by looking at changes in population growth or in participation rates (even though such variables are not completely independent from income growth). And finally the role of innovative activity as proxied by the growth of employment in high-tech sectors should be examined.[5]

III. RESULTS

In line with the considerations outlined above, a basic equation was estimated whose dependent variable was the growth of per capita income (Gross State Product, or GSP) in each of the 48 contiguous states over the 1976-86 decade.[6] The choice of the two terminal years, imposed by data availability, should not bias the results unduly. For one thing, monetary and other macroeconomic conditions tend to be broadly similar throughout the country at any given period of time, which is a good reason for using this type of sample for studying the contribution of microeconomic factors (such as "high tech") to growth. For another, the overall state of the economy differed little between the two years. Thus, pressures on capacity were roughly similar (the rates of U.S. unemployment were 7.7 and 7.0 percent respectively), the real price of oil was virtually identical, and though the real value of the dollar was higher in 1986 than a decade earlier, the difference was less than 4 percent. The one major difference between the two years was in real interest rates, which were some three times higher in 1986 than in 1976, but it is unlikely that this factor should have influenced some states more than others.

In the basic equation (i.e., before introducing micro-data on technology) income growth was related to per capita income at the beginning of the period, changes in the investment/GSP ratio, changes in labor force participation rates, a number of variables standing for state attractiveness, and changes in the

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5 Special events or exogenous shocks can also influence states' fortunes over time. In the decade 1976-86, agricultural and mining output were affected by sharp price fluctuations, particularly marked in the case of oil. Hence, allowance may have to be made for the impact of such changes by, for instance, introducing changes in the share of output in these sectors into any estimated equation.

6 Alaska, Hawaii, and the District of Columbia were dropped from the sample due to the inherent differences between these areas and the rest of the country.

shares of agricultural and mining output to allow for any special effects arising from sharp price fluctuations in these two sectors through the period. The first two columns of Table 1 present selected regression results.

As expected, the coefficient on state income at the beginning of the period is negative and highly significant. Positive and also significant is the change in the investment share between 1977 and 1982 (unavailability of state-by-state investment figures after 1982 imposed the choice of such a short time-span).[7] Together, theses two forces confirm that regional growth is strongly related to "the potential for imitation [and] the efforts mobilized for exploiting this potential" (Fagerberg, 1987, p.93). A further positive influence is exercised by changes in the participation rate (defined as employment over total population), though the statistical significance of this variable is lower.

Less successful were attempts to account for state attractiveness (beyond what is already picked up through the use of 1976 per capita output). Coefficients on initial tax levels, for instance, while usually negative, were seldom statistically significant. Similarly negative, and thus in line with a priori expectations, was the influence of the initial wage level, but this variable was, predictably perhaps, less significant than initial GSP per capita. The rate of labor force unionization at the beginning of the period was not statistically significant. Nor was a variable standing for both state attractiveness and labor inputs: the growth of population in the preceding decade (1966-76).

Nearly equally inconclusive were tests for the importance of agricultural or mining output. Despite sharp price swings throughout the decade, no perceptible effects could be found from changes in the share of farm output in GSP, and only a very small non-significant positive effect from changes in the share of mining production (as shown in column 2 of Table 1).[8]

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7 ICORs were also tested, but not found to be significant.

8 The effect becomes significant, however, in equation (4) once allowance is made for "high-tech" variables.

Table 1. Selected Regression Results

	"Base" equations		"High-tech" equations	
	(1)	(2)	(3)	(4)
	Dependent variable: DLYP			
Intercept	0.90	0.87	0.89	0.81
	(4.9)	(4.6)	(6.0)	(6.1)
LYP_{76}	-0.36	-0.28	-0.27	-0.24
	(4.0)	(3.8)	(4.1)	(4.0)
DLKS	0.14	0.15	0.07	0.08
	(3.6)	(3.8)	(2.0)	(2.7)
DLEMP	0.23	0.25	0.35	0.42
	(1.7)	(1.9)	(2.6)	(3.5)
DLMIN		0.02		0.06
		(1.0)		(3.4)
SBH			0.99	1.27
			(3.5)	(4.8)
BNM			-0.25	-0.28
			(2.7)	(3.5)
Adj. R-square	0.51	0.51	0.68	0.74
F-statistics	17.1	13.1	20.7	23.1

Notes: Estimated for the 48 contiguous states of the United States; figures in brackets are t-ratios.

- D = percentage change over 1976-86 period;
- L = natural logarithm;
- YP = GSP per capita in constant prices;
- YP_{76} = GSP per capita in 1976;
- KS = share of manufacturing investment in GSP, at current prices, 1977-82;
- EMP = total employment in percent of population;
- MIN = share of mining production in GSP, at current prices, 1976-86;
- SBH = Share in Births of High-tech, defined as employment creation in high-tech new firms from 1976 to 1986, divided by employment creation in all new firms;
- BNM = Births Normalized by Mean employment, defined as cumulative 1976-86 employment change in all new firms, measured at two-yearly intervals, normalized by average state employment during the decade.

The equations reported are imperfect; they were, however, obtained from data spanning a short period of time. Had it been possible to investigate the reasons for inter-state growth differences over several decades, the results would almost certainly have been greatly improved. Nevertheless, they are clearly significant. State income, in particular, has both the expected negative sign, as well as a robust t-statistic.

Having obtained a "base" equation, the next step was to determine whether high technology activities played an important supplementary role in the explanation of growth rate differences. To do this, a number of variables were tried using the 1976-86 Small Business Administration (SBA) database.[9] This source provides information, at two-yearly intervals, on total employment, employment in new firms,[10] employment in firms that ceased operations, and employment in existing firms that either expanded or contracted. In each of these categories, the data are subdivided into three categories: high-tech; low-tech; and other tech.

The best results obtained are shown in columns 3 and 4 of Table 1. The new variables, introduced in these equations, are defined as follows: SBH is the share of births in high-tech, defined as employment creation in high-tech new firms, from 1976 to 1986, divided by employment creation in all new firms. BNM is births normalized by mean employment, that is, the cumulative 1976-86 employment change in all new firms, measured at two-yearly intervals, normalized by average state employment during the decade. It is clear that the share of high-tech employment in the total growth of employment due to new births of firms strongly improves the fit of the equation. Innovative activity at the frontier is an important contributor to the growth of incomes per capita (even though high-tech employment accounts on average for less than 10 percent of the total workforce).

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9 Data are from the U.S. Establishment and Enterprise Microdata (USEEM) files developed by The Brookings Institution for the Small Business Administration. For further information, see Office of Technology Assessment, 1984.

10 In this paper, "firms" refers to an enterprise or group of enterprises. For example, McDonald's would be a firm, while each individual McDonald's restaurant would be referred to as an "establishment."

Interestingly, an overall high average birth rate of new firms over the period, BNM, has a strong negative impact on productivity growth. This is a robust result which is likely to reflect two separate forces. First, many new firms (though clearly not high-tech ones) may not be very productive in their early stages of operation and may need time to mature and achieve scale economies. Second, the widespread creation of new firms (of which many may not last long) could well be concentrated in low productivity service sectors. This would depress rather than boost overall per capita growth.

Since the "birthing" process itself is adverse to growth, the contribution of "high-tech" can only be well measured if this factor is distinguished clearly from births in general. By normalizing high-tech employment creation by total employment created through births, the SBH variable succeeds in distinguishing the contribution of high-tech.

The introduction of these two new variables clearly improves the statistical properties of the "base" equations. Not only are the summary measures of goodness of fit higher, but the statistical significance of several coefficients is also raised. From these results, a prima facie case can be made for the importance of high-technology activities in influencing the growth rate of an economy. It should not be forgotten, however, that causation could still be ambiguous. While the rapid growth of high-tech activities could well be a crucial determinant of overall growth, the latter may, at the same time, be a force attracting production of high-tech goods and services. Some mutual causation, in other words, cannot be ruled out.

IV. CONCLUSIONS

This note studies the influence of "high technology" on the growth of output by using cross-section data on U.S. States. An eclectic approach to the "sources-of-growth" literature leads to the estimate of a "base" equation which explains about half of the differences in per capita GSP growth rates of the 48 contiguous States in the decade 1976-86. Through the use of micro-data on

employment in high-tech activities, tests are then conducted to see whether the importance of high-tech, as measured by employment creation in new firms, enhances the explanation of growth differences.

The results obtained confirm first, the importance of starting income levels and of changes in the investment share in output, as well as of participation rate changes, in influencing regional growth rates. In addition, it appears that a high overall birth rate of firms, on average during the period, is negatively related to growth during that period. However, the share of employment created in new firms that occurs in high-tech activities does have a powerful and positive influence on per capita income growth. This provides support for the hypothesis that innovative activity at the frontier of technology contributes to rising living standards.

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