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Technological Change in the Information Age: A Socioeconomic Framework of High-Tech States in the U.S.

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ABSTRACT

This paper examines the technological level of fifty-eight technologically advanced counties in high-tech states in the United States in 1997. The conceptual framework is that selected socioeconomic dimensions influence the level of technological development for advanced communities; i.e., technology does not develop by itself but in concert with pre-disposing characteristics of the environment. The influence of socioeconomic factors was studied through correlation and regression analysis. The findings reveal that for each of the three high-tech subsectors selected for this study, receipts and payrolls are inter-correlated. The receipts and payrolls are correlated between the Information Systems/Data Processing (IS/DP) and Broadcasting/Telecommunications (B/T) subsectors. Regression findings show distinctive influences for each of the three categories. For instance, receipts and payrolls for IS/DP are associated with median family income, per capita number of service employees, and per capita federal grant funds. Those for B/T are associated with population growth and per capita number of service employees; those for Motion Picture/Sound Recording (MP/SR) are related to the percentage of the Latino population and per capita college graduates. Taken together the results highlight the role of IT and its interrelationships with socioeconomic factors. The main source of data is the U.S. Census.

INTRODUCTION

Over the past century technological development has been reshaping the material basis of our society and economy in an ever-increasing pace. Especially, the rapid development and diffusion of the new information technologies have altered the process of production, raised productivity, and improved living standards. This transformation is taking place on a global basis. Yet, there is evidence that this revolution is still in its beginning stages and its effects are not yet fully understood and predictable. But there is general consensus that the advances in the information technology are global, irreversible, and will continue to transform the way we live and work.

As the complexity of technological change accelerates, the need to maximize its benefits and minimize its risk increases. In recent years the subject of technological change and information technology has received a great deal of attention from economists, sociologists, and psychologists (Stein, 1995, p. 38). One issue, which frequently surfaces, is the question of how these sweeping changes will affect the fabric of our lives. Will the revolutionary advances of the information and communication technology (ICT) widen the "digital divide" and increase the gap of inequality, which already is prevalent throughout societies or will we be able to direct these forces to work more equitably for the benefit of everyone? This is the daunting challenge the global economy now faces (ILO, 2001, p. v).

The aim of this paper is to better understand the relationships between socioeconomic factors and technological change and raise some relevant questions that may help policy makers and experts to identify and address potential and already developing social problems based on the recent changes and to increase the social dialogue and partnership amongst employers, workers, government, and civil society.

In the next section, we briefly review some of the existing theories about the change in technology and its impact on wage inequality. Then we turn in Section II to the methodology used in this paper. In Section III we look at the empirical evidence and explain the findings. Finally in Section IV, we discuss the policy implications.

BACKGROUND

"If there is technological advance without social advance, there is, almost automatically, an increase in human misery" (Harrington, 1987, p. 960). The recent technological innovations and their impact on economic performance, especially in industrial countries, seem not only to affect the way we live and work but they also seem to determine the course of action in our society. Technology does not determine society and neither can society script the activities of technological innovation; technological change and innovation depend on many complex patterns of interaction, including individual inventiveness and entrepreneurship (Castell, 1996, p. 5). Fortunately, the advances in technology and the risks associated with its applications can be shaped by social and political choices. Society through state intervention and policy changes can suffocate or accelerate the process of technological change.

Estimated increases in productivity or technological change seem to contribute as much as 85 percent to U.S. economic growth per capita (Landau, 1988). This combined with the speed of technical change over the past several decades changed the material basis of our society. New information technology (IT) is reshaping organizations and business enterprises and redefining work processes and employment structures. "Indeed, the potential of the ICT revolution to transform the global economy has been at the centre stage in international fora and discussions…" (ILO, 2001, p. v). The rapid development of new technologies in the information age is a source of problems for the old socioeconomic structures "…until society and social institutions are able to match perfectly with them" (OECD, 1998, p. 126).

One phenomenon related to technological change that received the attention of many labor and trade economists (Autor, 1997; Baldwin, 2000; Burtless, 1995; Davis, 1998; Feenstra, 1997; Haskel, 2001; Johnson, 1997; and Krugman, 1995) was the emergence of wage divergence in the late 1970s and early 1980s. It is widely believed that the development of the new technology increases the demand for skilled workers, thereby increasing the wage differential between skilled and unskilled workers (Breshnan, 1999, p.1). Some refer to trade as the reason for the wage inequality, others argue that technological change is the primary explanation for the widening gap in inequality of wages—the so called skilled biased technical change. Empirical evidence from the literature on wage inequality is inconclusive and fragmented (Deardorff, 1998, p. 371).

An OECD study (1998, p. 23) predicts that there is a good chance that a) income inequality will further widen and b) that the social costs and problems associated with this inequality will increase. The irre-

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versible nature of the new technologies and the risks and opportunities they provide to all areas of work on a global basis and the fact that "…most of the world's people are unlikely to reap the advantages the new technologies may bring," (ILO, 2001, p. 69) requires the proactive participation of all countries. To utilize the full potential of this transformation, advanced industrialized countries have to address the impact of technological change on socioeconomic factors on both regional and global basis. This is "a steerable revolution whose impact will be shaped by wise and or foolish policies and societal choices" (Mattews, 2000, p. 63).

Very often literature on technological change and wage inequality neglects the link to socioeconomic factors. This paper aims to examine and shed more light on this issue.

DATA AND METHODS

This paper examines the association of technological development with socioeconomic factors for 58 counties selected from 12 high-tech states in the United States. These states were selected as the most high-tech ones, based on criteria in a recent study of the American Electronics Association (2001) which examined national and state trends in employment, wages, exports, venture capita investments, research and development (R&D) expenditures, and computer and internet use at home. The counties consisted of all those in these high-tech states that had complete county data-sets available on technological levels (U.S. Bureau of the Census, 1997).

Our basic model is that socioeconomic factors, such as education, income, service sector composition, ethnicity, and population growth, are associated with the level of technology development. For this research project, our basic model consists of socioeconomic factors that may influence the level of technology.

It is evident that socioeconomic factors and technology are frequently intertwined. For instance, in a county, the presence of highly educated and wealthy population, and high R&D expenditures may increase technology level. At the same time, a county with high technology level may attract highly educated people; may create prosperity and wealth in its citizenry; and may foster R&D. However, in this paper, we are concerned with the directionality of effects from socioeconomic factors towards technology level, not the converse. A study of bi-directional effects would require more sophisticated data collection and variables than we undertook for this study. It is something that we mention later under future research projects.

The study data came from a special series on the information sector of the 1997 Economic Census (U.S. Census, 1997) and from the U.S. Census of Population and Housing of 2000 (U.S. Census, 2001). Although the socioeconomic data were collected three years following the information sector data, they are considered sufficiently stable over the three year period to be suitable for the purposes of our study.

The independent variables that we examined are the following:
Per Capita Federal Grants and Funds
Per Capita Number of Employees in Services
Per Capita Annual Payroll in Services
Per Capita Number of Employees in Educational Services
Per Capita Annual Payroll in Educational Services
Median Household Income
Per Capita College Graduates
Percentage Change in Population, 1990-2000
Percent Black
Percent Asian
Percent Latino
Percent White
Percent Female

These thirteen socioeconomic dimensions of counties variables were selected as being relevant to technology level through prior research studies. We further submitted these variables to preliminary correlation analysis to analyze for possible adverse effects from multicollinearity (Neter et al., 1996). We eliminated seven of them through their very high inter-correlations, which are known to bias regression analysis results (Neter et al., 1996). Six were found to be less inter-correlated and were selected for regression analysis. They are: percentage change in population 1990-2000, per capita college graduates, percentage of Latino population, household income, per capita number of service employees, and per capita federal grant funds. We did not, for instance, include variables for more than one ethnic category due to multicollinearity.

The three dependent variables measure per capita technology levels for the ICT sector in the 1997 Economic Census. These three variables are the main components of the information sector of the 1997 Economic Census (U.S. Census, 1997). They are defined as receipts and payrolls for the following three subsectors: Information Systems/Data Processing (IS/DP), Broadcasting/Telecommunications (B/T), and Motion Pictures/Sound Recording (MP/SR) industries.

Linear regression analysis was conducted to examine the influences of all six independent variables on each of the dependent variables. Statistical processing was done utilizing standard statistical software (SPSS, 2001).

FINDINGS

Correlation analysis (see Table 1) reveals that for each dependent variable category, receipts and payroll of employees are significantly correlated. Also receipts and payroll are significantly inter-correlated between IS/DP and B/T. This makes sense, since today the technologies of information systems and telecommunications are intertwined in systems and services. On the other hand, receipts and payroll for the motion pictures/sound recording industry are not correlated with

Table 1: Correlation matrix of dependent variables

	Receipts for IS-DP/capita	Payroll for IS-DP/capita	Receipts for Broadcasting-Telecomm/cap.	Payroll for Broadcasting-Telecomm/cap.	Receipts for Motion Picture-Sound/cap.	Payroll for Motion Picture-Sound/cap.
Receipts for IS-DP/capita	1.000					
Payroll for IS-DP/capita	0.977**	1.000				
	0.000					
Receipts for Broadcasting-Telecomm/cap.	0.609**	0.612**	1.000			
	0.000	0.000				
Payroll for Broadcasting-Telecomm/cap.	0.529**	0.565**	0.947**	1.000		
	0.000	0.000	0.000			
Receipts for Motion Picture-Sound/cap.	0.031	0.029	0.071	0.042	1.000	
	0.816	0.827	0.598	0.753		
Payroll for Motion Picture-Sound/cap.	0.042	0.040	0.095	0.051	0.968**	1.000
	0.754	0.767	0.479	0.705	0	

** correlation is significant at 0.01 level

Table 2: Standardized regression results for six technology dependent variables

	Receipts for IS-DP/capita Beta Value	signif.	Payroll for IS-DP/capita Beta Value	signif.	Receipts for Broadcast.-Telecomm/cap. Beta Value	signif	Payroll for Broadcast.-Telecomm/cap Beta Value.	signif.	Receipts for Motion Picture-Sound/cap. Beta Value	signif	Payroll for Motion Picture-Sound/cap. Beta Value	signif
Percent Change in Population	-0.063	0.058	-0.270	-0.248	0.259	0.019*	0.279	0.025*	-0.039	0.801	0.027	0.547
College Graduates per capita	-0.152	0.375	0.019	0.111	0.230	0.175	0.308	0.111	0.384	0.115	0.535	0.027*
Percent Latino	0.019	0.850	0.032	0.737	0.048	0.607	0.056	0.600	0.317	0.022*	0.276	0.040*
Median Household Income	0.603	0.000**	0.532	0.001**	-0.066	0.661	-0.822	0.415	-0.179	0.406	-0.238	0.261
Service Employees per capita	0.503	0.000**	0.411	0.002**	0.641	0.000**	0.526	0.000**	0.029	0.869	0.018	0.918
Federal Grant Funds per capita	0.237	0.041*	0.275	0.015*	0.121	0.259	0.930	0.357	-0.120	0.433	-0.148	0.328

* signif. at 0.05
** signif. At 0.01

the other dependent variables. This reflects the facts that differences still persist between motion pictures/sound and information systems and telecommunications. These differences may diminish in the future, as the three types of technologies become more inter-mixed.

Regression findings in Table 2 show distinctive influences for each of the three technology categories. For instance, receipts and payroll for the IS/DP industry are associated with median family income, number of service employees per capita, and per capita federal grant funds. Receipts and payroll for the telecommunication/broadcasting industry are associated with the population growth and number of service employees per capita, while payroll for the motion pictures/sound recording industry is associated with the percentage of the Latino population and per capita college graduates

ANALYSIS AND POLICY IMPLICATIONS

The results of this study raise several important issues. First, the association between the level of income and the number of service employees with the level of receipts in the information and broadcasting/telecommunications industries implies the importance of these positions in the service industry in fostering technology levels in these high-tech counties. This impact may be limited to technologically-skilled employees and hence the potential gains associated with this transformation are likely to be limited. This dynamic needs to be adjusted by appropriate institutions and policy choices. Markets alone cannot dictate the course of this transformation. The extent of the success of technological change depends very much on the socioeconomic context; "technological development, in its final innovative outcomes, is both supply-pushed (by scientific knowledge) and demand pulled (by social and economic needs)" (OECD, 1998, p. 123).

Second, the higher the average household incomes in a county, the higher the magnitude of receipts and payrolls of IS/DP in this county; but this is not true for the two other industries, BT and MP/SR. Counties with higher compensation for workers demonstrate higher intensity of technologies.

Third, the statistically significant correlation between B/T and the rate of growth in population in a county implies that population growth leads to greater intensity of technology in that county. Local and regional B/T industry serves mostly the immediate county, so high population increases market and the intensity level. Although not the focus of the present research, an interpretation with opposite causality is that telecommunications-intensive counties may attract more population through an enhanced multiplier effect – that is telecommunications infrastructure and services to a greater extent foster broader employment growth across economic sectors. The positive effect of services on IS/DP and B/T technology levels reflects greater availability of service workforce and services entities to support these subsectors.

Finally, the statistically significant association between payrolls in motion pictures/sound recording industries and the per capita college graduates in a county may imply enhanced attractiveness from MP/SR industry to these counties. This can be regarded as an increased amenity that draws more college educated, in the same way that theaters, museums, or amusement parks do. The positive association between Latino population and motion picture/sound technology level seems surprising. However, this is less so, considering recent demographic shifts in the U.S. The southwestern states especially California, which have high levels of Latino population, also have high motion picture/sound technology prevalence. This needs to be considered for the future, since high intensity of MP/SR technologies may be more associated with Latino people and culture as a result of demographic shifts in the regions.

Moreover, the literature on the inequality of wages is fragmented and not conclusive. Haskel and Slaughter (2001) examined international trade and technical change by measuring trade as changes in product prices and measuring technical change as the total factor productivity (TFP), which shows the macroeconomic gains from productive innovations. They conclude that changes in prices are behind the rises of the wage inequality. Baldwin and Cain (2000) conclude that none of the economic forces alone can account for the observed wage inequality. They emphasize that education-biased technical progress played important roles in bringing about the increase in wage inequality during the 1980s and 1990s. Autor, Katz, and Krueger (1998) agree that education is played a crucial role in skill-biased technological change such as by computerization. Deardorf (1998) demonstrates that appropriate policies dealing with the changes in wage inequality do not depend on trade or technology.

Our study is different from the perspective of those studies in that we included several socioeconomic variables in order to see the broader aspect of correlation among variables and policy implementations. The emphasis here is more on broad influences on technological change and level of investment in high-tech industries rather than on trade and wage inequalities. Nevertheless, wages are important for IS/DP industry. In particular, higher income stands out as the most important positive influence on technology level. Here, higher income level, and associated higher level of skills, supports greater technology. The absence of income level as a factor of B/T and MP/SR implies that high per capita income and associated high skills are not as important for them.

The current research project can be expanded in a number of ways. One is to expand the sample to consist of all the counties in the United States. This would allow observation of trends and comparisons, for low and medium technology regions as well. Expanded research might also consist of our own survey of selected counties in the U.S. That survey might collect data and also interview responses concerning bi-directionality of effects i.e. not only socioeconomic influences on technology level but the opposite causality. In that case, methods could be applied that take into account feedback loops and bi-directional flows. We could also conduct a study of socioeconomic factors and technology levels in county units in other contrasting countries, to determine if there are cultural and national differences.

In summary, there is a diversity of socioeconomic influences on technology level that depends on technology subsector. For IS/DP industry in a county, a focus on greater income, larger service workforce, and greater federal R&D expenditure can augment technology level. For B/T and MP/SR, expansion in the service workforce appears crucial as well as demographic growth. For MP/SR, ethnic composition of the workforce is crucial, along with greater prevalence of college graduates in the workforce. Since more service-oriented workforce and college graduates are called for, a county focusing on retraining for service industries and upgrading the higher educational level of employees will reduce the problem of accessibility and will have a positive impact on the technological level, which in turn will influence the economic growth in general.

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