MANAGEMENT STRATEGY, INVESTMENT IN IT, AND PRODUCTIVITY

by

Kenneth C. Laudon

Kenneth L. Marr

David Sessions

Stern #IS-95-7

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

MANAGEMENT STRATEGY, INVESTMENT IN IT, AND PRODUCTIVITY

by

Kenneth C. Laudon
New York University

Kenneth L. Marr
Hofstra University

David Sessions
Hofstra University

June 1995

Submitted to the
Hawaii International Conference on Systems Sciences (HICSS)
January 1996

The research reported here was supported by grant from the National Science Foundation, Division of Information, Robotics, and Intelligent Systems (NSF IRI8619301), 1986-1990. We are grateful for support from the Center for Research on Information Systems (New York University, Stern School of Business) in assistance obtaining additional data sets for this study. We would also like to thank TRAC, Syracuse University, and Sue Long (Director) for support in obtaining additional data.

e-mail: klaudon@stern.nyu.edu
phone/fax: (914) 271-6321

Working Paper Series
STERN IS-95-7

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Management Strategy, Investment in IT, and Productivity

Kenneth C. Laudon (New York University)
Kenneth Marr (Hofstra University)
David Sessions (Hofstra University)

Abstract

Previous literature on IT and productivity does not take into account different organizational goals and different management strategies for achieving these goals. But productivity and ROI relationships can easily differ as organizational goals and management strategies differ. Therefore, we argue, it is no longer appropriate to ask, "Does IT lead to productivity enhancement." or "Is the ROI on IT investments large or small or nonexistent?" The better question is under what conditions of organizational climate and management choice does IT enhanced productivity result.

To illustrate the powerful effect of organizational goals and management strategy on IT-productivity relationships, we examine the twenty year history of two of the largest IT users in the world: the Internal Revenue Service and the Social Security Administration. And we find that these two very similar agencies experienced very different results from massive investments in IT despite sharing a similar production function. There is nothing in micro economics however to explain the different strategies pursed by these managers. Instead we must turn to political and sociological models of organizations to understand the social construction of productivity results.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Management Strategy, Investment in IT, and Productivity

In the debate about investment in IT and productivity, managers and organizational strategy are usually not mentioned. Virtually none of the literature describing the so-called "productivity paradox" --the finding that IT does not lead to increases in productivity--examines the role of management in producing productivity. But clearly managers do have a powerful role in shaping the consequences of IT investment and the strategies which organizations pursue when making IT investments are also critical for understanding the impacts of IT .

In this paper we examine the production expansion strategies pursued by managers over a twenty year period (1970-1990) at two of the largest users of computing equipment in the US: the Social Security Administration (SSA) and the Internal Revenue Service (IRS). Using Cobb-Douglas production models to allow for diminishing returns and parsimony, we estimated the input elasticities, the stability of elasticities over time, and compared the estimates across agencies (to see if they faced similar production functions).

The results are surprising and puzzling. The managers at one agency expanded output by investing in labor exclusively for the first ten years (1970-1980), and then radically altered course and increased IT investment by a factor of 60 while it cut labor by 25%. The second agency followed a much more conservative expansion strategy of adding both labor and capital IT in roughly equal amounts over a twenty year period. The first agency received high productivity returns on IT investment, while the second agency received almost none. Its workers were no more productive in 1990 than they were in 1970.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

The results are surprising because of the variation in management strategies. The results are puzzling because analysis shows both agencies faced the same production function and factor costs!. They should have followed the same rational expansion path. The paper examines the political and cultural environment which shaped the decisions because the economic model cannot explain these results.

IT Related Productivity Changes: Theory and Measure

Digital information technology--perhaps more than any other single technology in industrial history-- promised to have enormous impacts on economic efficiency and productivity because of its direct impact on an important factor of production, namely, information and knowledge. In advanced information economies, where information and knowledge workers account for 60% of GDP (Wolff and Baumol, 1987), it makes sense to believe that the vast improvements in computer hardware and software over the last 20 years, and the vast increases in IT investment both in factories and offices, would surely lead to widespread and powerful gains in productivity as a direct result of IT investments. But while US spending on IT surged in the period 1970-1990, little formal evidence exists linking IT investment to productivity.

Empirical research conducted over the last twenty years at the economy-wide , sector, and organizational level supports the finding that investments in IT have brought mixed results. In some instances, IT apparently led to order of magnitude increases in productivity (Barua, et. al., 1991 ; Siegel and Griliches, 1991; Brynjolfsson and Hitt, 1993), while in others IT has not recovered its costs or shows positive returns only in

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

certain applications (Loveman, 1988, 1991; Weill, 19992; Berndt and Morrison, 1992; Cron and Sobol, 1983; Strassman, 1990; Roche, 1988; 1991; 1992; Parsons, et. al., 1990). Aggregate level data for the entire economy is now showing positive returns to IT investment, and in one of the best studies to date, based on 367 large firms, Brynolfsson and Hitt report truly fantastic gross returns on investment (ROI) for IT averaging 58% in manufacturing and 81% in services (Brynolfsson and Hitt, 1993).

Despite more positive recent data, there remains substantial evidence that much investment in IT does not lead to productivity enhancements. Many explanations have been given for why this may happen. Four reasons are usually given: mismeasurement of outputs and inputs; lagged effects due to learning; dissipation of benefits outside the firm; mismanagement--irrational or ignorant or self-interested behavior, and the presence or absence of external cultures which shape management decisions (Brynjolfsson, 1993; Panko, 1991; Roche, 1991; Laudon, 1986; Laudon and Marr, 1994).

Few authors have questioned the theory behind the debate. The productivity paradox arises not just because IT professional and public expectations are bruised by the negative findings, but also because the findings do not match the theory. The temptation is to question the findings rather than the theory.

Much of the research on IT and productivity is conducted within the theoretical framework of micro economics. Here, firms are portrayed as rational profit maximizing entities with perfect information and unlimited analytic abilities. Managers, it is assumed, pursue short term profit maximization and also have complete information and unlimited reasoning powers. After nearly a hundred years of experience, it is now well understood

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

that this theory is neither descriptive or predictive of the behavior of specific, real-world firms or managers. Nevertheless, when practitioners of this theory confront empirical evidence that managers invest in IT even though no measurable productivity benefits result, they can only assume the measures are wrong or the managers are irrational. Oddly, wildly positive findings are not questioned. For instance, the finding of Brynolfsson and Hitt (1993) that ROI on IT investment is 81% for manufacturing and services is completely unexpected in micro economic theory. This finding suggests that managers are truly irrational because they should, according to theory, invest in factors until the returns are roughly equal.

Most investigations of IT-based productivity ignore the organizational processes which bring about productivity impacts (or the lack thereof) (the exception is Weill, 1992). Yet the inescapable conclusion after reviewing the literature on IT and productivity is that the results in investment are variable, and perhaps dependent on historical period (with earlier investments having lower returns, but also lower returns being associated with periods of high technological change and competence destroying change) , management and staff learning, organizational stability, and organizational variables not yet identified. (Tushman, 1986). The lack of theoretical sophistication in this area hampers our understanding of precisely how IT may or may not impact productivity.

What we suggest in this paper is that we need a new theory about the relationship between managers, strategy, and productivity. In this new theory, it would be entirely possible for managers to invest heavily in IT and not show productivity results in the near

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

term. The findings therefore that IT does not always lead to productivity enhancement should not be thought of as an anomaly, but should be expected in many cases.

Managers, Strategy, and IT Induced Productivity

Our contention in this paper is that managers make choices about the allocation of IT resources according to their perceptions of organizational strategy. Organizational strategies

are planned actions in pursuit of strategic goals. For profit maximizing firms, there are two generic strategies at the business level: differentiation and/or low cost provider. For firms and managers which choose differentiation, the ROI and productivity benefits of investing in IT may be quite different from firms and managers which choose lowering costs as a strategy. Different organizational strategies will lead to different returns on IT investment.

Differentiation as a business level strategy generally requires long term investments in product design, business process change, and organizational knowledge bases (core competencies). Becoming the low cost provider however may be achievable in a much shorter time frame because in many instances expensive labor can be replaced by capital relatively quickly.

The diversity and time-frame of organizational strategies has a direct bearing on the productivity benefits of IT, or any capital investment. A recent survey of 500 firms documented the diversity of expected payoffs from IT investment (See Figure 1).

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

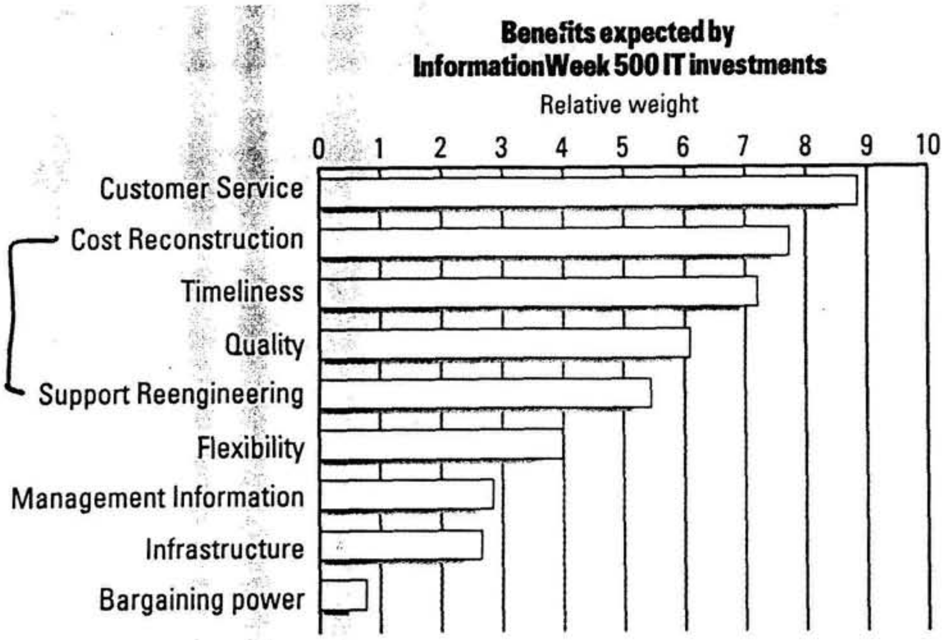
Figure 1 The Diversity of Expected Payoffs from IT Investment

Source: Erik Brynjolfsson, "Technology's True Payoff," Informationweek, October 10, 1994. Permission required.

Clearly some of the benefits of IT investment envisaged by managers will take a relatively long time to achieve, but ultimately may contribute to the productivity of workers through their impact on either cost or differentiation. Customer service, timeliness, quality, flexibility, management information and infrastructure investments are elements of *differentiation strategies.* The time focus of these kinds of goals is typically 2-5 years. Cost reconstruction, and reengineering, are elements of *low-cost provider strategies* which typically have a shorter time focus. Organizational strategies have a bearing on what types of applications are developed. Weill has found, for instance, that the productivity benefits for investment in transaction processing applications is positive, while ROI for management information system investments and infrastructure is zero or

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Figure 1



Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

negative. Both ROI and productivity benefits for, say, quality or customer service may be quite long.

One can easily imagine scenarios under which the benefits from investing in IT are zero and investing in more labor may have large impacts. For instance, buying PCs for every computer illiterate attorney in a law firm may have no impact on production, whereas hiring more attorneys will have predictable and large increases in output. For a law firm, one good young lawyer may be worth a thousand PCs, and investing in PCs may have a relatively small impact on the fortunes of the firm.

It is often assumed that when managers face demands for higher levels of production, they should pursue a single strategy: employ more IT. But of course managers do have an alternative to capital investment in IT. They can--and do-- expand production by investing in labor. Sometimes this labor investment is in the form of more employees, and sometimes in the form of more training and education of the existing labor force. In fact, economics tells us that managers should invest in labor and IT depending on their contribution to total output (their elasticities), which in turn depends on the specific production function, and the factor costs, which the manager faces. Moreover, For each production function, for each set of factor costs, there is an optimal expansion path leading to the highest output with least input of resources. Rational managers should pursue this path which may involve investment in both labor and IT capital.

Below we explore the impact which different organizational strategies has on the productivity benefits of IT investments at two of the largest IT user sites in the US for the period 1970-1990: Social Security Administration (SSA) and Internal Revenue Service (IRS). Based on detailed IT investment, employment, and output data over twenty years, we found that only one agency had achieved significant productivity benefits while the

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

other achieved no results whatever. These results cannot be explained by traditional microeconomic theories. We argue that IT-induced productivity benefits resulted in one case because of a conscious management strategy to achieve cost reduction, while in the other case IT benefits did not result because management was pursuing a different strategy--in this case maximization of total revenues. We extend this analysis to the larger economy and examine how this new theory helps us understand recent claims that IT is finally having positive productivity benefits at the sector level.

4.0 Information Technology at SSA, IRS, and the FBI, 1970-1990

The Social Security Administration (SSA) and the Internal Revenue Service (IRS), are among the largest and in some areas the most sophisticated users of information technology in the civilian economy of the US SSA began developing automated large file handling techniques with IBM as early as 1940. The IRS began using digital computers much later, in the early 1960s.

SSA employs 65,000 workers to maintain earnings data on over 200 million American citizens who are current or former labor force participants, distributes 40 million checks each month, and administers a number of complex, earnings based social welfare programs the largest of which is the Old Age and Survivors Insurance program. SSA maintains a centralized organizational structure established in 1936, including a large centralized mainframe-based data center in Baltimore, Maryland, connected via satellite to 10 regional centers and 1300 local SSA offices throughout the country. Following the near collapse of its data processing systems in the late 1970s, SSA began a $2 billion program to rebuild its systems and re-design its organizational and work processes (SSA, 1993).

IRS employs 120,000 workers to maintain earnings data on 200 million working Americans and 4.4 million other reporting entities, and to administer the tax laws of the United States. IRS maintains a centralized organizational structure originally established in the 1920s including a large centralized mainframe data center in Martinsburg, Virginia, connected via a variety of telecommunications links to 10 regional service centers where paper tax returns are initially processed into computer tapes which are then transported

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

physically to Martinsburg. Despite massive increases in computer processing power, by most accounts the IRS administrative systems neared collapse in the late 1980s. IRS systems have changed little since the early 1960s except for hardware upgrades, and the system is at the limits of its performance capability. The IRS is currently engaged in a $6-8 billion modernization program. (National Research Council 1992; GAO 1995).

Data

The findings reported here are based upon a larger study of long term historical trends in information processing at the three agencies in the period 1940-1994. The study is based on 155 interviews with agency management, users, and vendors at federal, state and local levels in the period, General Accounting Office investigators, members of Congress, Congressional staff, 1985-1994. In addition we gathered detailed quantitative data from a variety of private, federal agency, federal budget, and Congressional documents on the following variables:

Employment: Detailed occupational data on each agency, 1940-1990.

Workload: Detailed data on the number of forms processed (SSA and IRS), clients, services provided to clients, and (FBI) fingerprints stored and record requests processed, 1940-1990. Other related work load data not reported here was also collected.

Installed base: Detailed data on specific installed mainframe and mini computer machines, capacities (MIPS), and manufacturer. This data was gathered from GSA (General Services Administration Annual surveys, interviews, and agency reports).

Budgets: Detailed budgetary data on investment in information technology capital (communications, data processing, and office equipment expenditures, 1940-1990), non-information technology capital, labor, services, and real-estate.

Wages: Detailed wage data on employees, 1940-1990.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Only the analyses concerning organizational strategy and IT impacts on productivity are reported here. The analysis is limited to the period 1970-1990 because this period contains the most precise data, and it is the period of intensive investment in IT. Forthcoming papers describe occupational and employment impacts, patterns of budgetary growth, and patterns of technological advancement and diffusion.

Measures

Our interest in this paper is in identifying and understanding the relationship between productivity and the installed base of computing power over a twenty year period. There is little doubt that we have reasonably precise measures of IT capital installed (both monetary values and physical (MIPS) and the size of the labor force. Measuring the dependent variable, productivity, is less precise in this data. The dependent variable varies by agency but focuses in all cases on the labor productivity with respect to the primary work loads of the agencies. In the case of SSA, the dependent variable is the total number of clients served by the agency in each year divided by the total number of employees at SSA. At the IRS the dependent variable, productivity, is measured by the number of tax forms processed per employee. In the case of the FBI, productivity is measured by the number of fingerprints of all kinds (computerized and non-computerized) stored by the FBI per employee.

As with all productivity measures, ours suffer a variety of problems. Not all the work at any of these agencies is entirely captured by these measures. IRS has a large number of people devoted exclusively to processing tax forms and also a significant number of employees devoted to tax compliance and enforcement. At SSA there are actually only a few employees devoted to maintaining the records while most employees are devoted to providing service to SSA clients. For the IRS and SSA, the nature and quality of the work that is being performed also changed over time. This is a problem that occurs for measuring productivity changes for any service based organization. We know of no data source that measures changes in the output quality of any of these three

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

agencies. One source of quality changes is the changing complexity of the work load. Although we developed several measures of complexity of work for this time period, none contributed useful information to the problem of productivity at these agencies or altered the results reported here.[1]

The best measure we have of productivity changes is thus the simple one of the measure of total output divided by total labor, which is the measure used by the Bureau of Labor Statistics in estimating changes in government productivity [U.S. Dept. of Labor, BLS 1988]. While our measures of productivity our admittedly gross, we feel they roughly shadow real changes in productivity at these agencies no matter how that is measured. Our data extend over a twenty year time frame and they roughly track the changes in productivity experienced in non-governmental information work sectors like FIRE (Finance, Insurance, Real-estate). For these reasons we believe our measures reflect real changes in productivity at these agencies.

Model Specification

For both the IRS and SSA data sets the objective was to relate the output (Forms for the IRS and Clients for the SSA) to information available on capital and labor inputs. For both agencies the inputs were employees and installed MIPS. Both sets of data were time series representing annual totals for twenty one years (1970 to 1990, inclusive). To allow for diminishing returns and parameter parsimony Cobb-Douglas production models were used. All inputs and outputs were measured in units. Thus both models were of the general form:

$$y_t = \beta_0 \prod_{i=1}^{K} X_{it}^{\beta 1} e_t$$

Where:

y_t= output of the agency (forms or clients processed)

β_0= CONSTANT

X= factor of production, e.g., MIPS, employees, lagged MIPS, or structural variable

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

$B1=$ parameter estimate

The objectives of the modeling process were to estimate the input elasticities, evaluate elasticity stability over time and investigate input elasticity estimates across equations. The latter was undertaken to determine if the two agencies faced similar production functions. Both models were screened for cointegration properties (e.g. Charemza and Deadman 1992), no useful properties were found.

In order to meet the modeling objectives standard hypothesis testing was undertaken. All models were validated using a 5% level of significance. In addition to the standard hypothesis tests used in model development the following additional hypothesis tests were run:

Parameter Stability: Tests were made to determine if there were significant changes in input elasticity estimates over time.

Cross-Equation Parameter Comparisons: A test was run to determine if the inputs' elasticities were significantly different across the two fitted equations.

Results

(a) the agencies experienced very different productivity results despite massive investments in IT over a 20 year period (Figure 2). IRS productivity (forms/employee) remained relatively stable as both MIPS and employees were added to achieve higher levels of output. At IRS, MIPS increased by a factor of 30, as employment doubled. At SSA, productivity declined until the mid 1980s, but then took a sudden surge upwards. During the period at SSA, MIPS

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Figure 2A

Figure 2 IRS

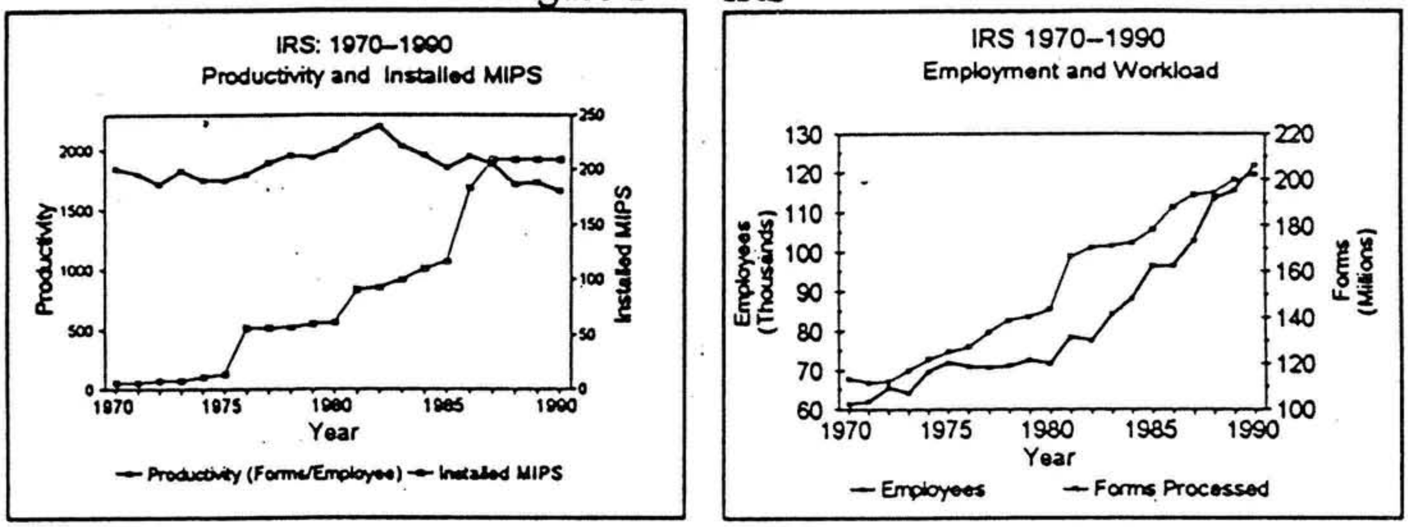
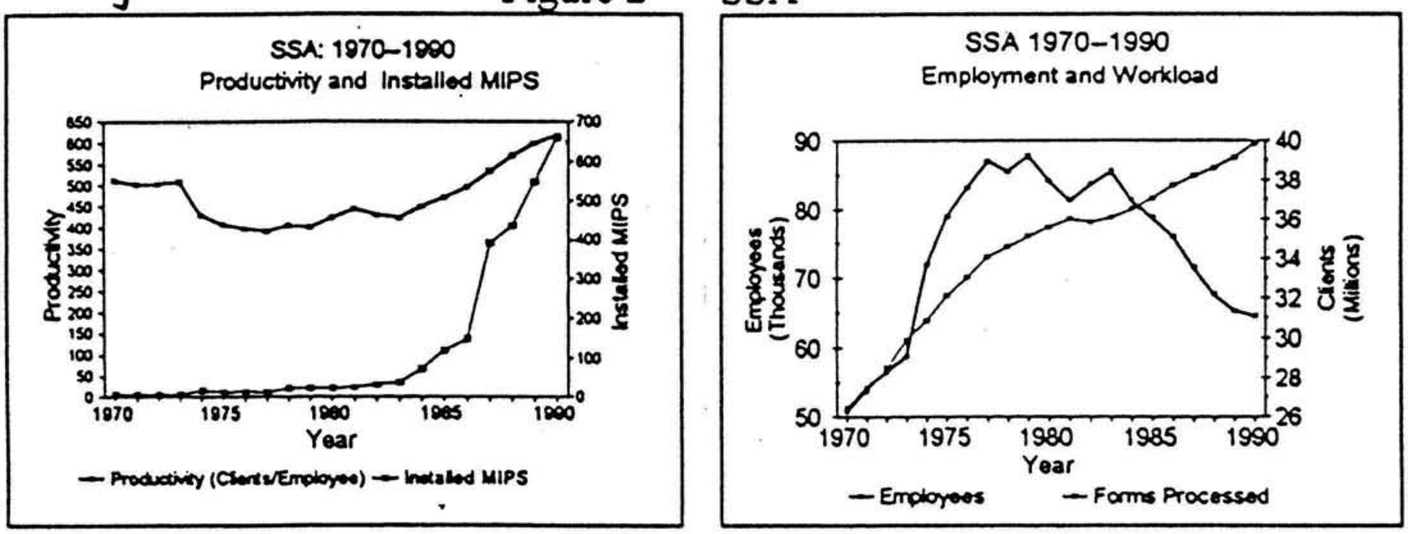


Figure 2B

Figure 2 SSA



Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

increased by a factor of 73 and employment doubled up to the mid 1980s and then took a sudden downward spiral.

(b) the agencies followed very different IT capital and labor strategies to achieve expansion of output (Figure 3A and 3B). The IRS has undertaken a much more direct stroll up the productivity surface though the agency seems to show some tendency to invest in labor and capital in jumps. The IRS (3A) followed a more balanced strategy of adding both MIPS and labor, with different emphasis at different times. In the early years, the emphasis was on MIPS, but in the later years, employees were added faster than MIPS.

The plot in Figure 3B clearly shows that SSA has followed some extreme directions in its expansion path over the twenty year period, investing mainly in employees for the first decade, then attempting to substitute MIPS for employees for the next decade.

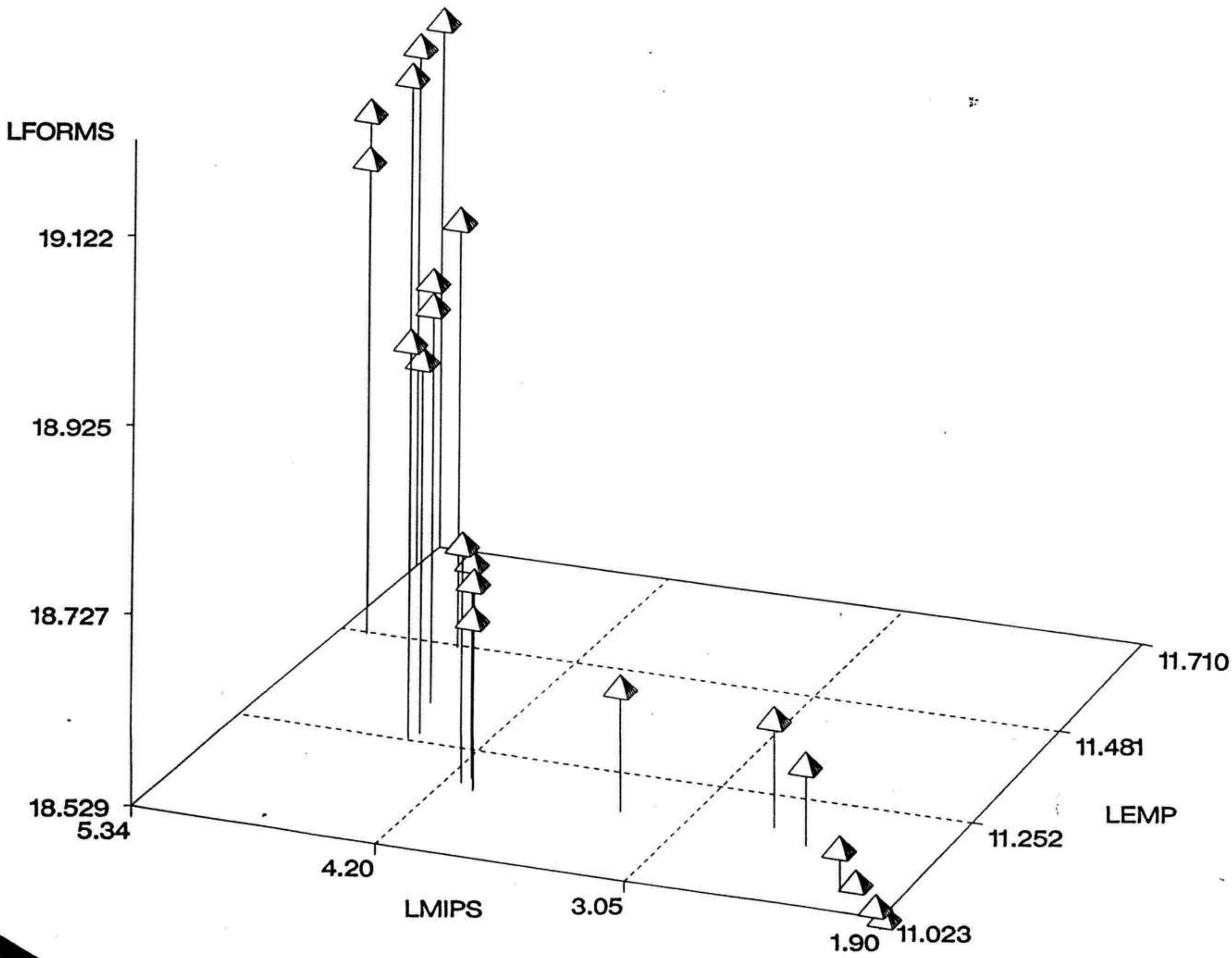
(c) an analysis of the production functions for these agencies does not explain these different outcomes from IT investments. The results of the individual model fitting are given in Tables I and II.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

IRS: Actual Values in LOG Space

(Smoothed MIPS at T = 7)

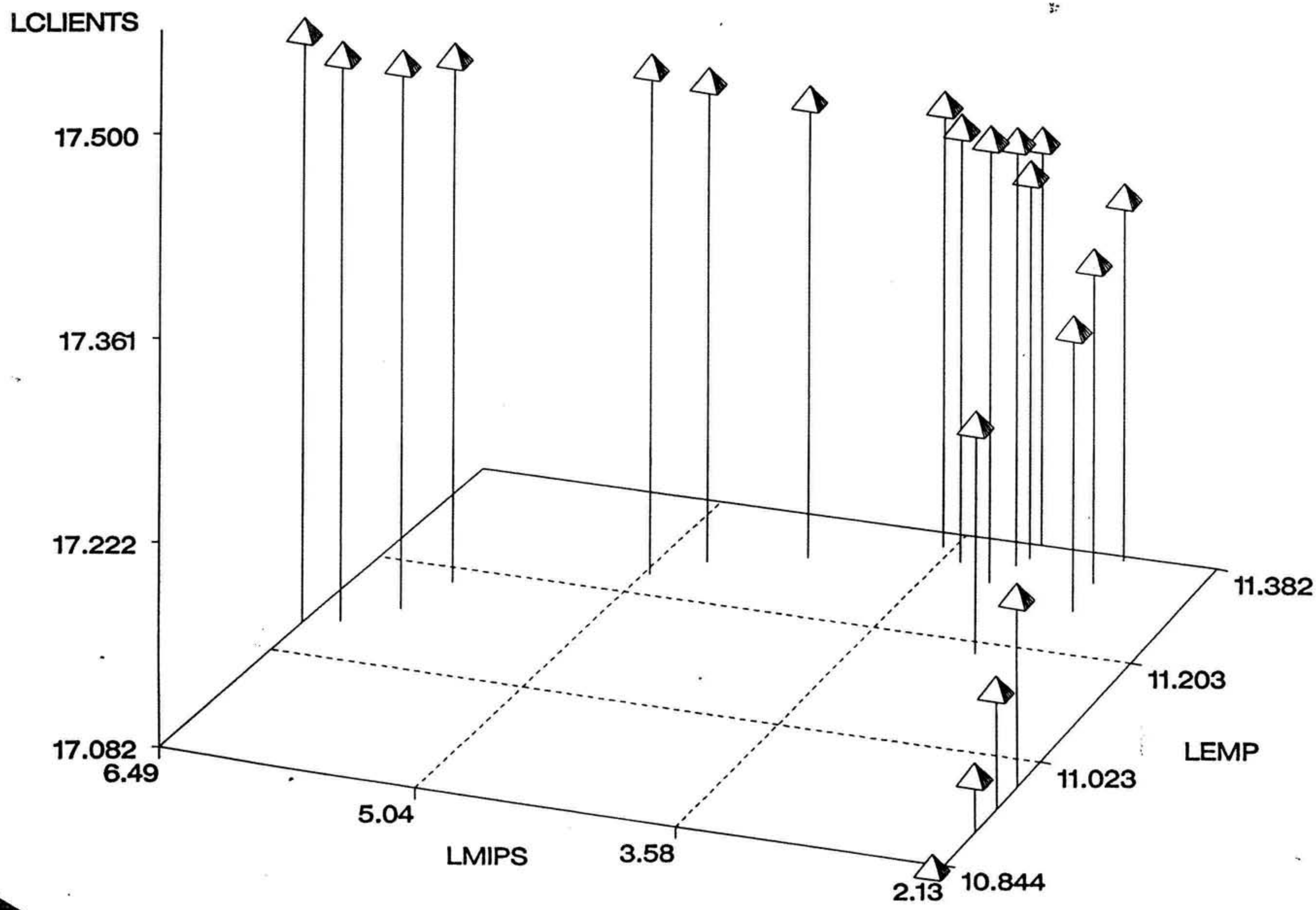
Fig 3A



Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

SSA: Actual in LOG Space

Fig 3B



Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

TABLE 1
Production Model: Internal Revenue Service (1970-1990)

VARIABLE DEFINITIONS: LFORMS - LOG(FORMS)
LEMP - LOG(EMPLOYEES)
LMIPS - LOG(MIPS)
D - 1 if Year > 1981, 0 ow.

Source	DF	Squares	Square	F Value	Prob>F
Model	3	0.88564	0.29521	970.879	0.0001
Error	17	0.00517	0.00030		
C Total	20	0.89081			

Root MSE	0.01744	R-square	0.9942
Dep Mean	18.82672	Adj R-sq	0.9932

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	p-value
INTERCEP	1	15.607539	0.44948057	34.724	0.0001
LEMP	1	0.250697	0.04144405	6.049	0.0001
LMIPS	1	0.083092	0.00676870	12.276	0.0001
D	1	0.128538	0.01465045	8.774	0.0001

TABLE II

Production Model: Social Security Agency (1970-1990)

VARIABLE DEFINITIONS: LCLIENTS - LOG(CLIENTS)
LEMP - LOG(EMPLOYEES)
LMIPS - LOG(MIPS)
D - 1 if Year > 1978, 0 ow. **SAS Autoreg Procedure**

Maximum Likelihood Estimates

SSE	0.001155	DFE	14
MSE	0.000082	Root MSE	0.009081
SBC	-117.054	AIC	-123.029
Reg Rsq	0.9978	Total Rsq	0.9946
Durbin-Watson	1.3263		

Variable	DF	B Value	Std Error	t Ratio	Approx Prob
Intercept	1	13.9004872	0.14128	98.391	0.0001
LEMP	1	0.2877441	0.01245	23.106	0.0001
LMIPS	1	0.0106645	0.00515	2.071	0.0574
LAGMIPS	1	0.0451443	0.00545	8.276	0.0001
D	1	0.0459085	0.00474	9.680	0.0001
A(2)	1	0.9044541	0.08822	10.252	0.0001

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

As can be seen in the tables, both models were highly significant with high explanatory power. In both agencies installed MIPS is powerfully related to outputs. The IRS model required the inclusion of a structural dummy variable starting in 1981 to handle the mandated increase in tax forms.[1] Similarly, the SSA model required the inclusion of a structural dummy.

Perhaps the most significant differences between the two models is the inclusion of a lagged MIPS variable in the SSA model. The inclusion of lagged MIPS in the SSA model possibly indicates that SSA has tendency to be slower in full utilization of newly installed MIPS than is the IRS. Certainly the ramp up of SSA IT spending and MIPS capacity increase is much steeper than that of IRS. The SSA model also differed with respect to the presence of serially correlated residuals, thus this model was fit using an autoregressive errors model estimated by maximum likelihood.

The parameter estimates for the effect of employees was 0.25 in the IRS model and 0.29 in the SSA model. Thus a one percent increase in employees would be expected to translate to a 0.25% increase in output in the IRS agency and a 0.29% increase in output at the SSA. These values were very close across the equations. The interpretation of the parameter for MIPS is similarly straightforward for the IRS, indicating that a 1% increase in MIPS would be expected to produce a 0.083% increase in output.

The interpretation for the elasticity of MIPS in the SSA is made more problematical by the presence of the lagged MIPS term. The lagged term indicates that productivity in the SSA in any one year is related (substantially) to the level of MIPS in the prior year as well as the level of MIPS in the current year. Thus a 1% increase in MIPS in a given year might be expected to increase output by .01% in that year and .045% in the following year.

[1] This model further required the averaging of MIPS between 1975 and 9176. Such averaging suggests that not all MIPS installed in 1976 were fully utilized in that year. A lagged MIPS variable did not contribute to this model in general.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

To enable comparisons of the Effect of MIPS across equations we introduce the concept of *effective MIPS* for the SSA agency. The productivity of effective MIPS can be estimated by substituting current MIPS into lagged MIPS using the relationship LAGMIPS = 0.34109 + 0.908177*LMIPS derived from regressing lagged LMIPS on LMIPS. Using this substitution, the effective MIPS coefficient becomes:

$$\beta_2 LMIPS + \beta_3 LAGMIPS = \beta_2 LMIPS + \beta_3 (\alpha_0 + \alpha_1 LMIPS)$$
$$= \alpha_0 \beta_3 + (\beta_2 + \beta_3 \alpha_1) LMIPS$$

Where and are the least squares estimates for the regression of LAGMIPS on LMIPS. The first term, $\alpha_0 \beta_3$, adds to the constant in the model and $(\beta_2 + \beta_3 \alpha_1)$ is the coefficient for effective MIPS with a value of 0.051661 in this example. This estimate suggests that a 1% increase in effective MIPS would be expected to result in a .052% increase in output in from the SSA.

To summarize, MIPS is strongly related to output in both agencies. Based on these results, what would managers have to do to raise output by 1%? At IRS, a 10% increase in MIPS (approximately 21 MIPS) or a 4% increase in employment (approximately 4,800 employees). At SSA, to achieve a 1% increase in output, managers had a choice of adding 20% more MIPS (about 130 MIPS) or adding 3% more employees (about 1950 employees). Alternatively, managers could have chosen a mixture of labor and IT capital to enhance output.

The reader should note that at the SSA the effect of adding MIPS is considerably less than at the IRS (.05 at SSA versus .08 at IRS) . SSA built up rapidly one of the largest computer installations in the civilian world (650 MIPS) by 1990 and clearly the agency was beginning to experience declining returns on IT investment under the given production

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

process. IRS, on the other hand, had installed only around 200 MIPS and could effectively expand output with additional MIPS.

(d) the input elasticities have not changed radically over the twenty year period. This means a MIP in 1970 has about as much impact on output as a MIP in 1990. Likewise with employees. In other words, there has not been a transformation of the production function over twenty years which can be related to improvements in IT.

These data sets cover 20 years during which there have been significant changes in computer technology. It is therefore important to determine if the productivity surfaces have remained stable over time. The presence of the structural change dummies indicate that some change has occurred over the twenty years. Further test were carried out to determine if input elasticity changes had occurred over two time periods that divided the data. Using the joint hypotheses that the coefficients on the inputs had not changed between the two periods the p-values for IRS and SSA were 0.2190 and 0.1828 respectively. It would seem that there is no strong evidence to suggest that the input elasticities have changed radically over the twenty years covered in this study.

(e) the different strategies and outcomes pursued by IRS and SSA cannot be explained by dissimilarities in their production functions or different factor costs. The production functions are essentially similar. Both agencies face the same costs of equipment and labor, and the same civil service rules.

Both input parameter estimates appear to be similar across the two agencies which leads to a consideration of the possibility that the two agencies face the same shape productivity surface, at least up to an additive constant. This question is complicated by

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

the presence of lagged MIPS in the SSA model. Thus the question was modified using the effective MIPS concept for SSA. Both equations were estimated using Seemingly Unrelated Regression methods with cross equation hypothesis tests using SAS Proc SYSLIN (Judge et al. 1984). The joint null hypothesis were constructed in the following way, (using the notation MODEL.PARAMETER):

H_0 : IRS.LEMP - SSA.LEMP = 0,

: IRS.LMIPS - SSA.LMIPS - .908117*SSA.LAGMIPS = 0

This joint null could not be rejected at a 5% level of significance (p-value = 0.1377). This indicates that there is some evidence to suggest that the two agencies face similar productivity surfaces (up to an additive constant and some structural change). See Figure 4 for a graphic illustration of the respective production functions.

Some caution is appropriate in claiming similarity between and stability within the IRS and SSA productivity models. These are small data sets and thus actual differences may be undetectable using such limited data. However, it would seem that the relationship between the basic inputs and outputs studied have not radically changed within and across the two series.

Discussion

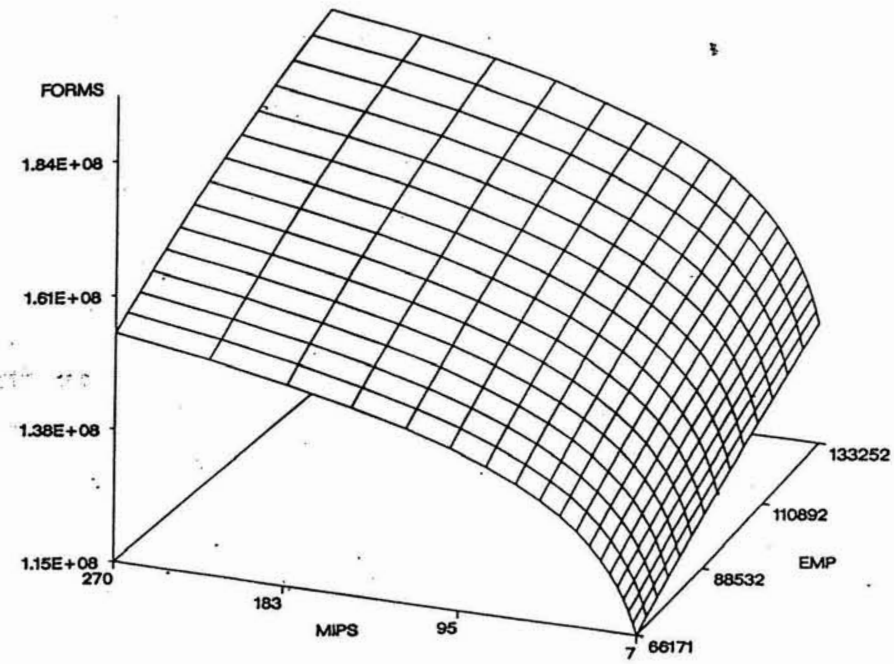
If one accepts that these two agencies face comparable productivity surfaces (at least in terms of their input elasticities), then one is left with several interesting questions. Why did these agencies pursue such radically different strategies of expansion? Why did one agency achieve high levels of productivity--apparently related to very investments in It--and why did another similar agency achieve so little productivity returns?

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Figure 4

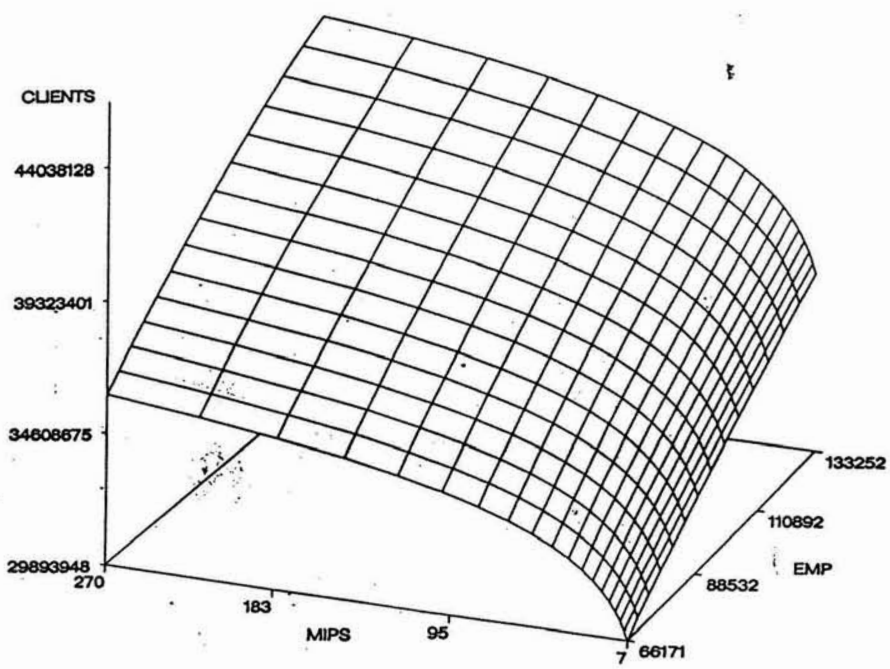
IRS: Estimated Production Function

Smoothed Mips at T=7, No Structural Change



SSA: Estimated Production Function:

No Structural Change and Using Effective MIPS



Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Assuming that these agencies face similar costs there should be a "best" expansion path. It is quite possible that neither agency chose the "best" expansion path, but it seems obvious that they did not both choose the "best" expansion path! Indeed to understand the management strategies for expanding, we must leave the micro economic model and use political and sociological models.

A brief review of the political and social environment of the two agencies in this period sheds a good deal of light on how they used information technology differently and obtained different results. SSA entered the 1970s as an exemplar of leading edge mainframe technology use in the Federal government. But during the 1970s several new programs were added to their agenda (Supplemental Security Income, Black Lung, Medicaid) which brought millions of new clients and thousands of pages of new regulations to learn and implement for SSA employees. At the same time, SSA failed to upgrade their systems as the number of clients rapidly increased with an aging population. Several efforts at system modernization failed in the mid and late 1970s, and by 1980 systems nearly failed on several occasions to issue checks on time. Employment had ballooned by 30% in the 70s to cope with rising demands and failing systems. Senior executive turnover began to accelerate in the late 1970s, and internal conflicts with a unionized labor force expanded. Both Executive agencies (OMB, Office of the President, DHEW) and Congressional Committees became severely critical of SSA (OTA, 1986)

As the leading accomplishment of the New Deal, SSA was an unpopular agency in the Reagan administration. The President appointed several temporary Commissioners to head the agency, who in turn developed a plan in 1980 to modernize the agency's systems throughout the decade of the 1980s. This billion dollar Systems Modernization Plan was accepted by the White House on one condition: SSA would have to terminate 25,000 employees as evidence that the systems modernization would in fact lead to higher levels of productivity. This deal was ultimately agreed to by key Congressional Committees who oversaw SSAs budget. SSAs senior management agreed in principle, but had a difficult time implementing the cutbacks. After firing one acting Commissioner, a new permanent

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Commissioner was appointed in 1986 (the first permanent Commissioner in the Reagan era) who agreed to implement the cutbacks. Several internal senior management shifts also occurred in 1986, including the creation of a new office of Deputy Commissioner of Systems--a CIO like position. (OTA, 1986). From a peak employment of 87,000 in 1979, SSA has shrunk its labor force by 23,000 positions.

In the end, SSA had little choice but to greatly reduce its labor force, develop new business procedures, new supporting software in order to survive the 1980s, and demonstrate that it could become more productive. The goals of the agency were to greatly enhance and expand service to clients, and the strategies "chosen" by management in response to powerful external pressures was to radically expand MIPS while radically cutting the labor force. The productivity numbers ultimately produced by SSA managers can only be understood within this social and political environment.

Very different conditions obtained at the IRS. As a money gathering agency in a period of stagflation (the 1970s) , and later in the 1980s high budget deficits, the IRS was a very popular agency in the Executive Branch and in Congress. There is nothing more important to the White House and the Congress (or to any government) than the collection of taxes. As a result, historically there has been little in-depth, critical oversight of the agency (Burnham, 1989). Through much of the 1970s the IRS experienced a relatively stable legal-regulatory tax environment, and its systems developed in the 1960s were sufficient. The Carter administration turned down a major effort to re-build IRS systems (OTA, 1977). However, changes in tax law in 1984, 1986 and 1987 began to wreak havoc on existing systems and personnel, and made for great confusion in the agency. By the mid-1980s IRS systems fell far behind in issuing tax refunds. The IRS lobbied Congress for more people and more computing hardware using misleading data, alleging ever increasing non-compliance (even though later analyses found these reports ignored simple adjustments, see Long and Burnham, 1990). Several efforts to patch its systems in the 1980s failed, and in one instance led to a significant loss of tax receipts. Despite this chaos, there was little senior management turnover in the agency and neither the White House or Congress demanded that senior managers be held accountable. Instead, both the President and Congress accepted IRS' claims that it simply needed more

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

employees and more computers to solve its problems. There never were any demands for IRS to "modernize" its systems to the point where people would be fired. Quite the opposite. The President and Congress approved in this twenty year period a doubling of IRS employment, from 61,000 in 1970 to 121,000 in 1990. Currently in 1995 IRS is involved in its third attempt at modernization: a $6-8 billion Tax System Modernization program (GAO, 1995).

In the case of the IRS, then, the goals of the organization were to effectively increase the total amount of taxes collected, and the strategy chosen by management--largely in the absence of outside pressure to "be efficient" and with no demands for employee count reductions--was to add both MIPS and employees in prodigious amounts. The result was an expansion in output, but with stagnant productivity despite huge investments in IT.

Conclusion

We believe that, based on our findings, it is no longer worthwhile to ask the question , "Does investment in IT lead to greater productivity." The reason is that the relationship between productivity and IT is powerfully effected by the organizational goals and management strategies being pursued by individual firms. This argument may apply to industries and sectors as well. In some industries, say banking, the pursuit of market share may require IT investments with little regard to productivity or short term ROI. How long these kinds of investments can continue may depend on the surplus produced in other sectors of the business.

References

Barua, A.; Kriebel, C.; and Mukhopadhay, T. "Information Technology and Business Value: An Analytic and Empirical Investigation." University of Texas at Austin, Working paper, May 1991.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Belsley, David; Edwin Kuh, and Roy E. Welsch. Regression Diagnostics. New York: John Wiley, 1980.

Berndt, Ernst R., and Catherine Morrison, "High-Tech Capital Formation and Economic Performance in U.S. Manufacturing Industries: An Exploratory Analysis," Working Paper, Alfred P. Sloan School of Management, WP #3419EFA, April 1992.

Brynjolfsson, Erik; Hitt, Lorin. "Is Information Systems Spending Productive? New Evidence and New Results." International Conference on Information Systems, Orlando, Florida, December 1993.

Brynjolfsson, Erik, "The productivity paradox of information technology," Communications of the ACM, 36, 12, December 1993.

Burnham, David. A Law Unto Itself: Power, Politics, and the IRS. New York: Random House, 1989.

Charremza, Wojciech W. and Deadman. Derek F. (1992). "New Directions in Econometric Practice," Publ. Edward Elgar.

Cron, W. and Sobol, M., "The Relationship Between Computerization and Performance," Information and Management, 6:171-181, 1983.

General Accounting Office, Tax System Modernization. Washington D.C.: GAO, December 1995.

Judge, George G., Griffiths, William E., Carter Hill, R., Lutkepohl, Helmut and Lee, Tsoung-Chao, 1984. "Theory and Practice of Econometrics," Publ. John Wiley and Sons. Second Editon.

Laudon, Kenneth C. , Dossier Society. New York: Columbia University Press, 1986.

Laudon, Kenneth C. and Marr, Kenneth L., "Productivity and the Enactment of a Macro Culture," International Conference on Information Systems, Vancouver, December 1994.

Loveman, Garry. "An Assessment of the Productivity Impact of Information Technologies." Working paper. Management in the 90s. MIT, Cambridge Mass., 1988.

Loveman, Garry. "The Productivity of Information Technology Capital." Working Paper. Management in the 90s. MIT: Cambridge, Mass., 1991.

Malone, Thomas W., and Joanne Yates and Robert Benjamin, "Electronic Markets and Electronic Hierarchies," Communications of the ACM, Vol 30 (6), June 1987.

National Research Council, Review of the Tax Systems Modernization of the Internal Revenue Service. Washington D.C.: National Academy Press, 1992.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Office of Technology Assessment, A Preliminary Analysis of the IRS Tax Administration System. Washington D.C.: U.S. Congress, OTA, March 1977.

Office of Technology Assessment, The Social Security Administration and Information Technology, A Case Study. Alan F. Westin and Kenneth C. Laudon. Washington D.C.: U.S. Congress, 1986.

Osterman, J.F., "Productivity and IT Capital Stock, 1972-1978." Industrial and Labor Relations Review, 1986, vol. 39, 1, 175-186.

Panko, Raymond R., "Is Office Productivity Stagnant," MIS Quarterly, vol 15, 2, June 1991.

Parsons, D.J., Gottlieb, C.C. and Denny. M., "Productivity and computers in Canadian banking." Uinversity of Toronto, Department of Economics, WP 9012, June 1990.

Roach, Stephen S., "Technology and the Services Sector: The Hidden Competitive Challenge," Technological Forecasting and Social Change, Vol. 34, Number 4, December 1988.

Roche, Stephen S., Services Under Siege-The restructuring imperative. Harvard Business Review, (September-October, 1991).

Roche, Stephen S., "Policy Challenges in an Era of Restructuing," Special Economic Study, Morgan Stanley, January 1992.

SAS Institute. *SAS Version 6.08*. SAS Circle, Cary, NC. 1994.

Siegel, D. and Griliches, Z. "Purchased services, outsourcing, computers, and productivity in manufacturing." National Bureau of Economic Research, WP #3678., April 1991.

Social Security Administration. Information Systems Plan. Baltimore, Md., 1993.

Strassman, Paul. The Business Value of Computers, Information Economics Press, New Canaan, Conn., 1990.

Tushman, Michael L., and Anderson, Philip. "Technological Discontinuities and Organizational Environments," Administrative Sciences Quarterly. vol. 31, September 1986, pp. 439-465.

U.S. Bureau of the Census, Statistical Abstract of the United States, Washington d.C., 1991, Table 657.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

U.S. Department of Justice. Annual Report of the Attorney General of the United States. Washington D.C.: Department of Justice, 1993.

U.S. Department of Labor, Bureau of Labor Statistics, BLS Handbook of Methods, Bulletin 2285, April 1988.

U.S. Department of Labor, Bureau of Labor Statistics. Productivity Measures for Selected Industries and Government Services, Bulletin 2349, February 1990.

Weill, Peter. "The Relationship Between Investment in Information Technology and Firm Performance," Information Systems Research, Vol. 3(4) December 1992, pp. 307-333.

Wolff, Edward N. and Baumol, William J. "Sources of Postwar Growth of Information Activity in the U.S.," C.V. Starr Center for Applied Economics, New York University, no. 87-14, June 1987.

Data Sources Notes

General: Several federal sources were used in parts of the study to fill in gaps in data, and fill-in background knowledge on budgetary expenditures. See the following:

Executive Office of the President. "Budget of the United States Government". United States Government Printing Office, (various years).

"Annual Report Commissioner and Chief Counsel Internal Revenue Service" (various years)

U.S. Department of Commerce, Bureau of the Census. *Statistical Abstract of the United States.* (various years)

Social Security Administration. *Social Security Bulletin: Annual Statistical Supplement, 1991.* Superindendent of Documents, U.S. Gov. Printing Office.

Employees:

There are several sources of total employment and none of the sources agree with each other. The annual Executive Budgets of the U. S. Governent provide the best source since it has contained employment data since the 1940, is subject to more reviews than most other sources and it is widely available to the public. In addition, we would like to thank TRAC at Syracuse Univeristy, and Sue Long, for providing us with detailed employee head count data for the years 1970-1990.

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07

Workload measures

Social Security Administration publishes annaual statistics on the number of SSA clients. The Table 5.A4 (pl63) of the 1991 Statistical Supplment of the SSA Bulletin contains number of OASDI (Old-Age, Survivors, and Disability Insurance) beneficiaries and is the Workload data used for SSA.

Internal Revenue Service publishes an "Annual Report: Commissioner and Chief Counsel: Internal Revenue Service", which contains tax return data. A summary of this data is found in "Statistical Abstract of the United States". These sources agree and both were used.

Federal Bureau of Investigation publishes an annual report that contained the fingerprint data (total number of prints in the FBI's files) but discontinued this in the 1980s. From 1980 on we relied on agency annual reports and interviews with FBI officials. In addition, we relied on annual reports of the Department of Justice, of which the FBI is a Bureau.

Computer Capacity (MIPS)

MIPS capacity data is derived from GSA annual reports of computer inventory in the federal government. (See also Eindor, 1985]. We would like to thank the Babbbage Institute at the University of Minnesota for supplying us with the detailed GSA annual surveys of computer inventory in the federal government, 1970-1990.

1

Center for Digital Economy Research
Stern School of Business
Working Paper IS-95-07