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Manufacturing Extension and Productivity Dynamics: Preliminary Evidence

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Overview

This paper presents preliminary results from an investigation of the effects of manufacturing extension on the productivity dynamics of client plants. Previous econometric studies of manufacturing extension had very little time series information. This limited what researchers could say about the relative timing of extension services and performance improvements. In turn, this makes it difficult to attribute performance improvements to the receipt of extension services. In this paper, I use a panel of client and nonclient plants to more carefully analyze the dynamics of extension and productivity. Preliminary results suggest that the timing of observed productivity improvements at client plants is consistent with a positive impact of manufacturing extension. Estimated program impacts are within the range of those found in previous studies.

Introduction

In recent years, a consortium of state, local and federal agencies have created a nationwide network of manufacturing extension centers designed to help the nation’s 370,000 small and medium sized manufacturing enterprises (SMEs) improve productivity and become more competitive. The premise behind manufacturing extension is that smaller manufacturers have failed to adopt modern production technologies and business practices at same rate as their larger counterparts. Proponents of manufacturing extension argue that this explains the persistent performance gap between small and large manufacturers (see National Research Council, 1993). Because SMEs form an important link in the supply chain, they further argue that this performance gap hinders the global competitiveness of the entire U.S. manufacturing sector. Manufacturing extension centers are intended to provide SMEs with unbiased information on modern technologies and business practices that the market has failed to deliver.

As the name might suggest, manufacturing extension is modeled loosely on agricultural extension. Locally based manufacturing extension centers perform education and outreach much like county extension agents do. Following an assessment of a plant's needs, a center might then contract with the plant to provide business or technical assistance[1] or may direct the plant to consultants or vendors that can solve the plant's problems. Even though they are part of a nationwide network, the operation of individual centers varies greatly.

Federal support for manufacturing extension is handled through the National Institute of Standards and Technology's (NIST) Manufacturing Extension Partnership (MEP). Several states have operated extension centers for decades. However, the creation of the MEP in 1989 spurred rapid growth in manufacturing extension programs around the country (see Feller, 1997, GAO, 1995 and National Research Council, 1993 for more details about the development of manufacturing extension programs). In 1995, federal support for manufacturing extension was $138.4 million, up from $6.1 million in 1988 (see GAO, 1995). Since federal support must be at least matched by state and local funds, total expenditures on manufacturing extension activities in the U.S. are much larger.

Naturally, in this time of tight budgets, policymakers want to know if the tax dollars spent on programs, such as manufacturing extension, produce the desired benefits. As part of its enabling legislation, NIST/MEP was directed to evaluate its activities and demonstrate its effectiveness. In addition, the Government Performance and Results Act, passed by Congress in 1993, will soon require all federal agencies to more formally demonstrate the effectiveness of their programs. The lessons learned evaluating manufacturing extension and other programs suggest that fulfilling this mandate will be difficult, as there are several data and methodological issues that must be addressed in order to credibly demonstrate that government programs yield the intended benefits.

Despite the efforts of many researchers employing several different data sets and methodologies, we can still not definitively say that manufacturing extension services cause improved performance at client plants.[2] Although several papers (see Jarmin, forthcoming, Shapira and Youtie, 1997, and Nexus Associates, 1996) demonstrate that client status is associated with increases in productivity, none have shown that extension services caused these increases.

The problem is that researchers can never observe what a client plant would have done had it not received assistance from a manufacturing extension center. Thus, researchers are forced to try to imperfectly replicate this experiment by either comparing client performance before and after receiving services or by comparing the performance of cli-

[1]Typical services provided centers include marketing and sales assistance ISO-9000 certification and changes in plant layout. See NIST (1997) for a collection of case studies about individual projects.

[2]See Jarmin and Jensen (1997), Shapira, Youtie and Roessner (1996) and Feller, Glasmier and Mark (1996) for surveys of studies evaluating manufacturing extension.

ent plants to a control group of nonclient plants. Unfortunately, we can not observe and control for all of the factors that, in addition to manufacturing extension, influence plant performance.

The best way to get around this problem is to randomly assign plants to treatment (i.e., those that receive extension services) and control groups. If this is done, then we can reasonably assume that the only systematic difference between the two groups is client status,
and can then conclude that any observed differences in their performance must be attributable to manufacturing extension.

Unfortunately, controlled randomized experiments are not a feasible option for evaluating programs, such as manufacturing extension. Therefore, we must evaluate these programs with nonexperimental data. Given this constraint, a researcher wants to specify and estimate an empirical model that mimics a controlled experiment as closely as possible. This requires that we control, to the greatest extent possible, for the unobserved influences that may bias estimates of program impact. The best empirical methodology for accomplishing this is to use panel data to estimate a fixed effects model. Adequately controlling for these unobserved effects requires several time series observations per plant. However, no study of manufacturing extension, to date, has had more the two observations per plant.

This raises two issues concerning the robustness of the results of these studies, which generally find a positive association between manufacturing extension and improved plant performance. Namely, fixed effects estimators are most effective in controlling for unobserved heterogeneity when there are several time series observation per plant. Second, the current studies do not deal adequately with the issue of the timing of performance improvement relative to the receipt of services. For example, Jarmin (forthcoming) finds evidence that manufacturing extension clients exhibited more productivity growth between 1987 and 1992 than did non-clients controlling for a number of factors including selection bias. What is not known is when the performance improvements occurred. If they happened towards the beginning of the period, before most client plants received assistance, then it is likely that the estimated impact of manufacturing extension services is spurious.

In this paper, I construct a panel data set with annual data for 815 client and 5739 nonclient plants from 1987 to 1993. I use this data set to compare the productivity dynamics of clients and nonclients. The longer panel allows me to more fully control for unobserved differences (e.g., managerial ability) between client and nonclient plants that may bias estimates of program impact. The panel data set also permits a more careful analysis of the relative timing of service provision and performance improvements. The results indicate positive program impacts with estimates that lie within the range of those from previous studies.

Data

As in Jarmin (forthcoming), the data used here are from 2 sources. First plant level production data are taken from the Census Bureau's Longitudinal Research Database (LRD). The LRD is constructed by linking plant level data from the Censuses and Annual Surveys of Manufactures.[3] Due to its comprehensive and

[3]The LRD and other micro data sets are housed at the Census Bureau's Center for Economic

longitudinal nature, the LRD is, perhaps, the best data set available for evaluating the impact of government programs on manufacturing establishments. Second, manufacturing extension client data come from nine manufacturing extension centers in three states. NIST/MEP arranged to have these centers provide client records on a confidential basis.

All the primary data items used in the analysis below are taken from the LRD. The client records are used to identify which plants in the LRD received extension services and when. To identify extension clients in the LRD, I match client records to the Standard Statistical Establishment List (SSEL) using names, addresses and other information shared across the two data sets[4]. The nine extension centers provided just under 12,000 project level records from 4,185 establishments. I was able to match 2,977 (or 71.1%) of these establishments to the LRD (via the SSEL).

In order to compare the productivity dynamics of extension clients to nonclients, I examine a panel of plants that were in the LRD in 1987 and each year of the 1989 to 1993 ASM panel.[5] In the three states, in which the nine extension centers operate, there are 5739 nonclient plants that meet this requirement. There are 815 client plants that meet this and the additional requirement that they had completed at least one project before the end of 1993. Approximately 65% of client and 62% of nonclient plants also appear in the LRD in 1988,

Restricting attention to plants in the LRD with annual data yields a sample that is not representative of either the client or nonclient establishment populations. The plants examined in this paper are considerably larger and more productive the average plant. Thus, one should be careful to note that estimates of program impact obtained from this sample may differ from what would be obtained if we had similar data for the entire manufacturing establishment universe.

Empirical Model and Results

The general empirical framework for examining the impact of extension services on the productivity dynamics of client plants is the following Cobb-Douglas production function

$$Y_{it}=Ae^{\lambda t}e^{\delta Ext_{it}} K_{it}^{\beta i} L_{it}^{\eta i} M_{it}^{\gamma i}e^{\varepsilon_{it}} \quad (1)$$

where Y is total value of shipments adjusted for changes in inventories and deflated using 4 digit Gray-Bartelsman deflators, M is material and energy inputs (also deflated by 4 digit deflators), K is the capital stock constructed using the perpetual inventory method, L is the total number of employees and Ext is a measure of extension services. Within this framework, I estimate the impact of extension services on both labor and total factor productivity (TFP). Labor pro-

Studies (CES). These data are confidential and can be accessed only by special sworn employees (not necessarily Census Bureau employees) at CES or at regional data centers in Boston or Pittsburgh.

[4]For more details on the matching process see Jarmin (forthcoming). The SSEL is used since the LRD does not contain names and addresses for matching. The LRD and the SSEL share common establishment identifiers that facilitate linking the matched client records to the LRD.

[5]The ASM is a rotating five year panel. All plants with more the 250 employees are included in the ASM with certainty. A probability sample of smaller establishments is also included. However, noncertainty plants can not be selected in to consecutive ASM panels.

ductivity is defined as real value added[6] per worker. TFP is defined in the conventional way as

$$TFP_{it} = \frac{Y_{it}}{K_{it}^{\beta i}\ L_{it}^{\eta i}\ M_{it}^{\gamma i}} \qquad (2)$$

The weights in the TFP calculation are computed using average cost shares for each plant.[7]

Table 1 provides summary statistics for the main variables used in the analysis below. The plants identified as clients are, on average, larger and more productive than nonclient plants. Simple level comparisons, however, say little about the effectiveness of manufacturing extension programs. To evaluate manufacturing extension we want to follow and compare the performance of client and nonclient plants over time.

Figure 1 shows the timing of the services received by the extension clients examined in this paper. Just over half of the clients received services before 1990 and 90% had been served by 1992 (by definition, all had been served by 1993). Given figure 1, if we were to observe most of the performance improvement at client plants occurring towards the beginning of this period, we would seriously question whether extension services had any role.

Figures 2 and 3 show how the productivity performance of client plants relative to 4 digit SIC industry averages evolved over the period from 1987 to 1993. Figure 2 depicts the relative level and the one and three year growth rates of labor productivity and figure 3 provides the same information for TFP. In both cases we see that client plants move up their industry productivity distributions over this time period. Further, the bulk of this movement occurs after 1990 and, thus, is at least consistent with a positive impact of manufacturing extension services. It also appears that productivity growth rates increase relative to industry averages over this period especially for labor productivity.[8]

To more rigorously test whether extension services had any impact on the improved relative performance of client plants, I estimate several regressions, all of which are variants of the following two models:

$$\Delta\log(VA/L)_i=\alpha+\delta Ext_I+\beta\Delta\log(K/L)_i+(\mu-1)\Delta\log(L)_i+\varepsilon_i \qquad (3)$$

$$\log(TFP)_{it}=a+\delta Ext_{it}+\varepsilon_{it} \qquad (4)$$

In several cases, dummies for 4 digit industry, year and state are also included. The parameter, δ, on the extension variable (Ext) measures the impact of extension services on productivity. One of the main concerns in trying estimate the program impact parameter, is that unobserved variables that influence produc-

[6]Real value added is measured as shipments adjusted for changes in inventories and deflated minus deflated materials and energy costs.

[7] Namely

$$\eta_i = \frac{1}{7}\sum_{t=87}^{93}\frac{SW_{it}}{TVS_{it}},\quad \gamma_i = \frac{1}{7}\sum_{t=87}^{93}\frac{M_{it}}{TVS_{it}},\quad and\ \beta_i=1-\eta_i-\gamma_i$$

where SW is total salaries and wages and TVS is total shipments.

[8]Note that, since a large number of plants are missing from the panel in 1988, the peaks in the one year growth rates (1st differences) and the troughs in the one and three year growth rates at 1989 and 1990, respectively, are outliers.

tivity, such as managerial quality, may be correlated with client status. In this case, estimates of program impact may be biased upwards.

If these unmeasured influences are relatively fixed over time, using difference or within estimators of (3) and (4) will yield unbiased estimates of program impact. Alternatively, if there are instruments available that are correlated with client status but not with the unobserved variables that influence productivity (and are captured in the error term), two stage estimation methods can be employed to obtain unbiased estimates. Luria and Wiarda (1996), Nexus Associates (1996) and Shapira and Youtie (1997) have employed difference estimators, and Jarmin (forthcoming) has used both of these approaches to estimate the impact of manufacturing extension services on client productivity.

However, none of these studies have more than two time series observations per plant. Difference and within estimators are more reliable with longer panels. Further, with only two observations per plant it is not possible to tell if productivity growth rates improve after clients receive services. Rather, its only possible to determine whether client productivity growth is faster or slower than that for nonclients.

With the longer panel used in this study it is possible to test both whether client growth rates are greater than those for nonclients and whether client growth rates increase after receiving services. To do this I use two measures of client status in the regressions below. First, I define the dummy variable $(\text{Ext A})_i$ to equal 1 if plant i was ever a client and 0 otherwise. This variable measures the mean difference in the dependent variable between client and nonclient plants and does not vary over time. This is the same measure used in Jarmin (forthcoming) and Shapira and Youtie (1997). Second, I define the dummy variable $(\text{Ext B})_{it}$ to equal 1 if plant i is or was a client in period t or before, and 0 otherwise. That is (Ext B) is 0 before plants receive extension services and 1 afterwards and, thus, measures the mean difference between plant year observations for plants that have not yet received extension services and plant year observations for plants that have.

Tables 2 through 7 provide the results of several regressions based on the models given in equations (3) and (4). Tables 2 and 3 contain estimates of the impact of extension services on labor productivity using the client - nonclient (Ext A) and before - after (Ext B) extension measures, respectively. In both cases, the 3rd difference and within estimates suggest positive and significant program impacts. The level regressions show that, once other factors are controlled for, the clients in this sample are less productive than nonclients (this is also evident in figure 2).

The first difference results suggest that the program has a negative but insignificant effect. However, taking differences tends to increase the noise in the data. Griliches and Hausman, (1986) discuss this and point out that this problem is most severe with 1st differences and can be alleviated somewhat by taking longer differences. The increased noise can be seen in the small and insignificant capital coefficients in the 1st difference regressions in table 2. Notice the capital coefficients improve somewhat when taking longer differences. Thus, the weak 1st difference estimates of program impact are not surprising.

The magnitudes of the 3rd difference and within impact estimates are smaller than those in Jarmin (forthcoming) but larger than those in Shapira and Youtie (1997). However, the plants here are larger than in the other studies and its likely that extension projects simply do not have as large of an impact (on a percentage basis) at large plants as they might at smaller plants. This might be due to both the fact that at larger plants the projects are smaller relative to the scale of the plant's operations, and that large plants pursue more productivity enhancing activities besides participating in manufacturing extension than do smaller plants.

Many policymakers might be concerned if it was the case that the improvements in labor productivity observed at manufacturing extension client plants were due primarily to reductions in employment. Table 8 provides some descriptive statistics that suggest that this is not the case. In the table, plants are divided into 4 quadrants as in Baily, Bartelsman and Haltiwanger (1994). These are defined by determining whether plants had productivity and employment increases or decreases between 1987 and 1993. The table shows that a larger proportion of client plants were in Quadrant 1, the so-called successful upsizers, and smaller proportions of clients were in the other three Quadrants. Clients also had a larger proportion in the first two Quadrants (i.e., those that were "successful" by increasing productivity).

Tables 4 and 5 look at the impact of manufacturing extension services on total factor productivity. The results are quite similar to those for labor productivity. Larger and more significant estimates of program impact are obtained from the 3rd difference and within estimators. The estimated impacts on TFP are also smaller than for labor productivity which we might expect after comparing figures 2 and 3 which also suggest that clients experienced more growth in value added per worker than in TFP.

Tables 6 and 7 contain before - after regressions that are estimated using client plants only. Thus, the extension coefficients in these regressions strictly measure changes in client plant performance after receiving extension services. The estimated program impacts on labor productivity in table 7, while following a similar pattern to those in table 3, are smaller and insignificant when dummy controls are included. In table 8, the estimates of impact of TFP show no significant impact.

Conclusions

This paper presents preliminary results from an investigation of the effects of manufacturing extension on the productivity dynamics of client plants. These results suggest that the timing of observed productivity improvements at client plants is consistent with a positive impact of manufacturing extension. Estimated program impacts are within the range of those found in previous studies. However, more still needs to be done before we can convincingly argue that manufacturing either does or does not have a significant impact on the performance of client plants. In particular, by examining the timing of extension projects, plant level investment behavior and productivity, we may be able to get closer to a causal story. Work on this is underway.

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Table 1
Descriptive Statistics

	Clients	Nonclients
Number of Plants	815	5729
Number of Obs	5448	37999
Shipments	$59,758,000	$45,076,000
Total Employment (L)	357.5	255.2
log(L)	5.297	4.755
Capital Stock (K)	$24,104,000	$18,123,000
log(K/L)	3.609	3.588
Materials and Energy (M)	$30,094,000	$24,324,000
log(M/L)	3.841	3.942
log(VA/L)	4.005	3.984
log(TFP)	1.788	1.664

Table 2
All Plants / Client - Nonclient Comparison
Dependent Variable: log(VA/L)

Variable	Levels		First Differences		Third Differences	
Ext. A	0.014	0.019***	0.011	0.017***	0.022***	0.041*
	(0.010)	(0.010)	(0.008)	(0.009)	(0.013)	(0.013)
log(K/L)	0.368*	0.263*	-0.013	-0.010	0.037**	0.025***
	(0.003)	(0.004)	(0.019)	(0.019)	(0.013)	(0.013)
log(L)	-0.003	0.010*	-0.335*	-0.338*	-0.199*	-0.209*
	(0.003)	(0.001)	(0.021)	(0.022)	(0.016)	(0.011)
Dummies	No	Yes[1]	No	Yes[1]	No	Yes[1]
N	42600	42600	33580	33580	23084	23084
R^2	0.241	0.098	0.023	0.028	0.020	0.025

[1] Includes 4 digit industry, state and year dummies.
***Significant at the .01 level; **significant at the .05 level; *significant at the .1 level.

Table 3
All Plants / Before - After Comparison
Dependent Variable: log(VA/L)

Variable	Levels		First Differences		Third Differences		Within	
Ext. B	-0.001	-0.011	-0.010	-0.011	0.030***	0.047*	0.026**	0.025**
	(0.099)	(0.014)	(0.020)	(0.020)	(0.017)	(0.018)	(0.013)	(0.013)
log(K/L)	0.368*	0.263*	-0.006	-0.009	0.039**	0.025***	0.053*	0.053*
	(0.003)	(0.004)	(0.019)	(0.019)	(0.013)	(0.014)	(0.009)	(0.010)
log(L)	-0.002	-0.010*	-0.329*	-0.336*	-0.199*	-0.208*	-0.180*	-0.176*
	(0.003)	(0.003)	(0.021)	(0.022)	(0.016)	(0.016)	(0.011)	(0.011)
Dummies	No	Yes[1]	No	Yes[1]	No	Yes[1]	No	Yes[2]
N	42600	42600	33580	33580	23084	23084	42600	42600
R^2	0.241	0.098	0.023	0.028	0.020	0.025	0.020	0.024

[1] Includes 4 digit industry, state and year dummies.
[2] Includes year dummies.
***Significant at the .01 level; **significant at the .05 level; *significant at the .1 level.

Table 4
All Plants / Client - Nonclient Comparison
Dependent Variable: log(TFP)

Variable	Levels		First Differences		Third Differences	
Ext. A	0.125* (0.011)	0.017 (0.010)	0.005 (0.003)	0.006 (0.004)	0.009 (0.007)	0.015** (0.007)
Dummies	No	Yes[1]	No	Yes[1]	No	Yes[1]
N	43060	43060	34081	34081	23505	23505
R^2	0.003	0.003	0.0001	0.005	0.0001	0.004

[1]Includes 4 digit industry, state and year dummies.
**Significant at the .05 level; *significant at the .1 level.

Table 5
All Plants / Before - After Comparison
Dependent Variable: log(TFP)

Variable	Levels		First Differences		Third Differences		Within	
Ext. B	0.108* (0.016)	0.005* (0.015)	0.004 (0.005)	0.004 (0.005)	0.012 (0.008)	0.017** (0.008)	-0.011 (0.007)	0.016** (0.008)
Dummies	No	Yes[1]	No	Yes[1]	No	Yes[1]	No	Yes[2]
N	43060	43060	34081	34081	23505	23505	43060	43060
R^2	0.001	0.003	0.0002	0.005	0.0001	0.004	0.0001	0.006

[1] Includes 4 digit industry, state and year dummies.
[2] Includes year dummies.
***Significant at the .01 level; **significant at the .05 level; *significant at the .1 level.

Table 6
Clients Only / Before - After Comparison
Dependent Variable: log(VA/L)

Variable	Levels		First Differences		Third Differences		Within	
Ext. B	-0.010 (0.017)	-0.015 (0.021)	-0.012 (0.018)	-0.012 (0.019)	0.035** (0.015)	0.029 (0.020)	0.029** (0.012)	0.007 (0.017)
log(K/L)	0.279* (0.009)	0.214* (0.011)	0.050 (0.047)	0.051 (0.048)	0.011 (0.032)	0.008 (0.033)	0.053** (0.025)	0.042*** (0.025)
log(L)	0.035* (0.008)	0.016*** (0.009)	-0.207* (0.054)	-0.216* (0.055)	-0.177* (0.038)	-0.188* (0.039)	-0.127* (0.029)	-0.130* (0.029)
Dummies	No	Yes[1]	No	Yes[1]	No	Yes[1]	No	Yes[2]
N	5373	5373	4302	4302	2938	2938	5373	5373
R^2	0.146	0.077	0.017	0.028	0.015	0.029	0.017	0.024

[1] Includes 4 digit industry, state and year dummies.
[2] Includes year dummies.
***Significant at the .01 level; **significant at the .05 level; *significant at the .1 level.

Table 7
Client Plants / Before - After Comparison
Dependent Variable: log(TFP)

Variable	Levels		First Differences		Third Differences		Within	
Ext. B	-0.013 (0.020)	-0.066* (0.025)	-0.001 (0.006)	-0.001 (0.008)	0.019 (0.009)	0.003 (0.011)	-0.011 (0.007)	0.005 (0.010)
Dummies	No	Yes[1]	No	Yes[1]	No	Yes[1]	No	Yes[2]
N	5420	5420	4345	4345	2980	2980	5420	5420
R^2	0.0001	0.005	0.00001	0.011	0.0002	0.008	0.0001	0.006

[1] Includes 4 digit industry, state and year dummies.
[2] Includes year dummies.
*Significant at the .1 level.

Table 8
BBH Quadrants by Client Status

	Clients	Nonclients
Quadrant 1 (LP↑ , TE↓)	27.2%	21.8%
Quadrant 2 (LP↑ , TE↓)	30.1%	32.4%
Quadrant 3 (LP↓ , TE↑)	21.6%	22.9%
Quadrant 4 (LP↓ , TE↓)	21.1%	22.9%
N	815	5739

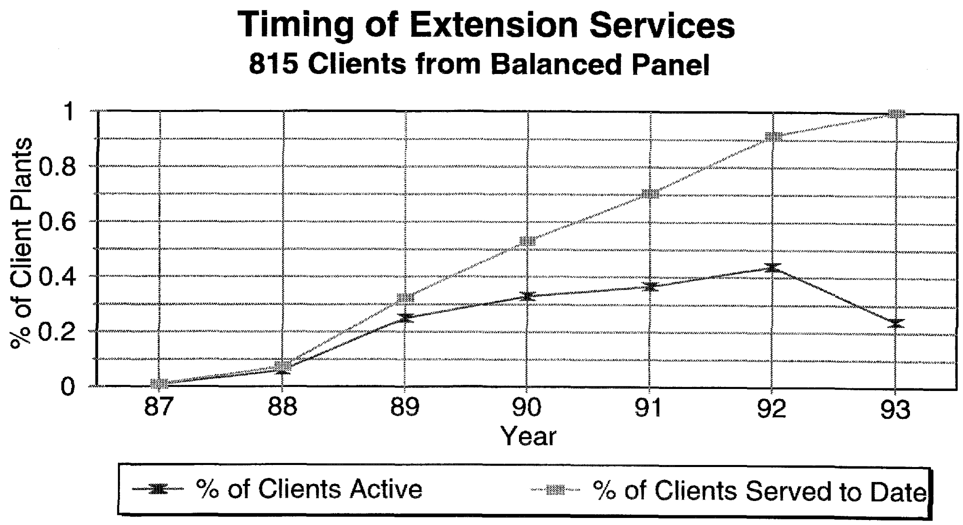


Figure 1

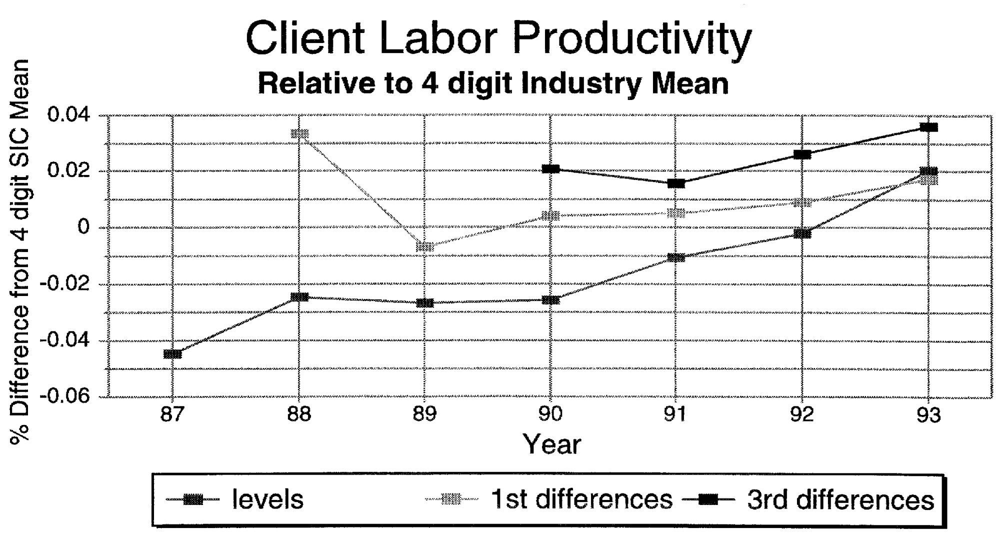
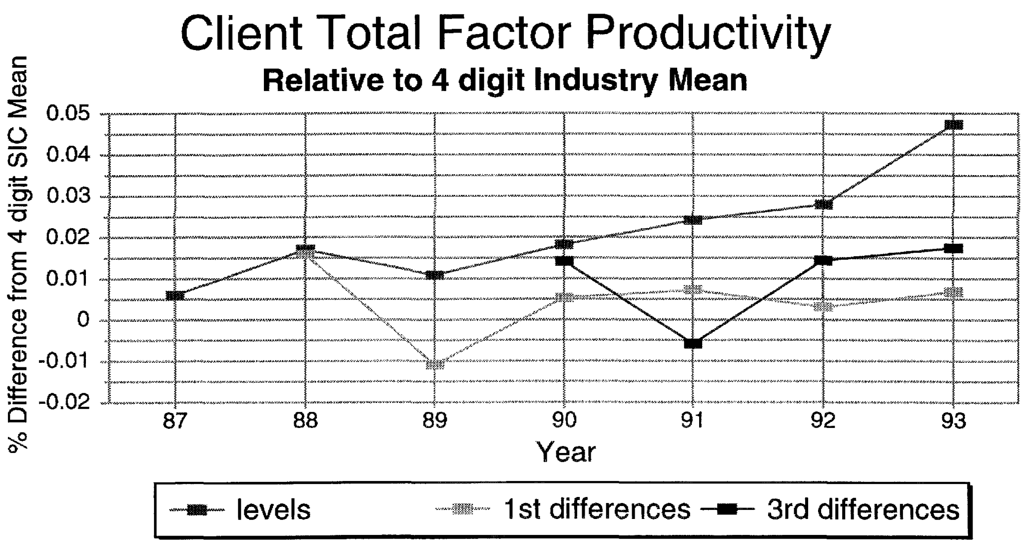


Figure 2



Client Total Factor Productivity
Relative to 4 digit Industry Mean
% Difference from 4 digit SIC Mean
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
87
88
89
90
91
92
93
Year
levels
1st differences
3rd differences

Figure 3