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Measuring the Impact of Manufacturing Extension

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Abstract[1]

In this paper, I measure the impact of manufacturing extension on productivity and sales growth at manufacturing plants. To do this, I match manufacturing extension client data to the Census Bureau's Longitudinal Research Database (LRD). The LRD contains data for all manufacturing establishments in the U.S. and provides a number of measures of plant performance and characteristics that are measured consistently across plants and time. This facilitates valid comparisons between both client and non-client plants and among clients served by different manufacturing extension centers.

The goal of the paper is to see if measures of plant performance (e.g., productivity and sales growth) are systematically related to participation in manufacturing extension, while controlling for other factors that are known or thought to influence performance. Selection bias is often a problem in evaluation studies, so I specify an econometric model that controls for selection.

I estimate the model with data from 8 manufacturing extension centers in 2 states. The control group includes all plants from each state in the LRD. Results indicate that participation in manufacturing extension is systematically related to productivity growth but not to sales growth.

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Introduction

This paper uses plant level census data to evaluate the effectiveness of manufacturing extension programs. To do this, data from 8 manufacturing extension centers in 2 states are matched to the Longitudinal Research Database (LRD). The LRD is useful for evaluating manufacturing extension for two reasons. First, it provides a control group against which to compare the performance of extension clients. Second, the LRD contains a number of variables useful for evaluation that are measured consistently across clients and non-clients, across different extension centers and over time.

The National Institute of Standards and Technology's (NIST) Manufacturing Extension Partnership (MEP), as part of a national effort to improve the competitiveness of U.S. manufacturing industries, supports several manufacturing extension centers around the country. These centers provide technical and business assistance to small and medium sized manufacturers, much as county extension agents do for farmers[2]. This assistance often consists of providing "off the shelf" solutions to technical problems. However, manufacturing extension centers can also channel more recent innovations generated in government and university laboratories to smaller U.S. manufacturing concerns that may not have access to such information. The idea is that extension services will help these firms become more productive and compete more effectively in the international marketplace.

In order to maximize the effectiveness of extension programs, it is crucial that program stakeholders (e.g., extension clients, extension centers, NIST, state and local governments and Congress) have detailed information about current program performance and that a reliable evaluation framework be in place to analyze its future performance. Ideally, one would want to evaluate programs such as manufacturing extension by collecting experimental data[3]. Namely, firms would be randomly assigned to treatment and control groups. Evaluation would then consist of a simple comparison of the performance of treatment and control firms. Unfortunately, this has not been done, nor is it likely to be done, for manufacturing extension.

Therefore, evaluation must be carried out with non-experimental data. As a result, the NIST/MEP evaluation staff asked the Center for Economic Studies (CES) of the U.S. Census Bureau about exploiting the LRD for evaluation purposes. This paper provides some early results from this effort.

Note that, in this paper, I am only trying to measure the direct gross benefits of extension services to client plants. I do not attempt to measure indirect benefits that may accrue to client suppliers or spillover from clients to non-client plants. Further, I have no information on the costs of manufacturing extension. Therefore, I can not make any statements about the net social returns to manufacturing extension.

In addition to the obvious task of measuring the impact of extension services on client performance, this paper seeks to determine whether the LRD is an effective tool for program evaluation. An important part of this is to see if credible evaluation studies can be done while maintaining confidentiallity standards[4].

The rest of the paper is organized as follows. First, in section II, I briefly review previous attempts to evaluate agricultural extension programs. Many of the problems encountered in these studies also need to be addressed in an evaluation of manufacturing

[2] While all eight of the extension centers used in the analysis below are presently part of the MEP, only 1 of the 8 was during the period for which the data apply.

[3] See Heckman, Hotz and Dobs (1987), LaLonde (1986), LaLonde and Maynard (1987) and Moffitt (1991) for discussions of program evaluation methodology.

[4] The Census Bureau collects data from business establishments under Title 13 that stipulates that individual respondent's data cannot be disclosed.

extension. In section III, I discuss the evaluation data set constructed by linking extension client records to plant level census data. In section IV, I outline the empirical models used to estimate the impact of extension services on client performance. Estimation results are discussed in section V. Conclusions are given in section VI.

Background

Only limited work has been done to rigorously measure the impact of manufacturing extension programs[5]. It is, therefore, instructive to first review the methods used in studies to assess the effectiveness of agricultural extension programs. Although significant differences exist between agricultural and manufacturing extension[6], both programs have generically similar objectives (i.e., improve farm/manufacturing performance through outreach and education), and share many of the same evaluation issues[7].

In evaluating either agricultural or manufacturing extension, the goal is to assess whether extension services have any impact on client performance. The agricultural economics and economic development literatures contain many studies which seek to measure the impact of agricultural extension.

Birkhaeuser, Evenson and Feder (1991, hereafter BEF) review this literature and find that researchers typically employ regression analysis to examine the relationship between farm performance and the receipt of extension services. Most such studies find that extension has significant and positive impacts on knowledge diffusion, technology adoption, productivity and profits. BEF note that, although most authors stop short of claiming that agricultural extension has positive net social benefits, several suggest that the rates of return to agricultural extension can be very large.

However, BEF point out that the existing studies of agricultural extension are subject to a number of qualifications concerning data and methodology. First, most studies lacked a proper control group of similar farmers that did not receive extension services against which to compare the performance of those that did. Use of a control group is important because it permits an estimate of what might have occurred in the absence of a program.

The members of a good control group should be as similar to those receiving services as possible. In the agricultural extension context, an evaluator might first consider how closely selected characteristics of farms operated by those not receiving services corresponded to those of farms operated by service recipients. The most important characteristics would be those which most directly influence farm performance, such as crop types, soil quality, farm size and location.

Second, evaluation studies often fail to take into account the type of services received (e.g., training in silage storage techniques or in the choice of seed varieties) and the intensity with which these services are provided (e.g., number of field agent days of service or cost). This makes it impossible to know the extent to which individual extension services vary in their effect.

Third, these studies also fail to account for the influence of other non-extension programs and secondary information flows. If clients and non-clients differ systematically in their access to non-extension services (these could be offered, for example, by seed companies and other farm vendors), then estimates of the impact of extension may be biased. Also, these studies do not allow for the benefits of extension services to "spillover" from clients to non-clients. For example, it is likely that the knowledge of a new cultivation method flows easily from a client farmer to his non-client neighbors.

[5] This is changing, however, see Martin (1994) and Oldsman (1996) for examples.

[6] See Feller (1993) and Shapira (1990) for discussions about the differences between agricultural and manufacturing extension. See True (1969) for a history of agricultural extension in the U.S.

[7] Much of the discussion in this section is based on Jarmin (1995).

Finally and perhaps most importantly, many studies may have biased estimates of the impact of extension services due to selection bias. This can occur if farmers with some characteristic (e.g., ability) that is not observable by the evaluator, self select themselves into the group of farmers receiving extension. It could very well be the case that farmers with more ability are the ones most likely to seek out additional information through extension. Biased estimation may also occur if extension agents select high ability farmers to receive the bulk of their services. In either case, an evaluator might mistakenly credit extension with the superior performance of the high ability farmers. This is because the evaluator can't control for the unobserved characteristics that determine whether farmers receive extension services. To get unbiased estimates of the impact of extension services, the evaluator must account for the selection bias. To do so requires the evaluator model the process by which individual farmers become extension clients. Given this information, alternative estimation procedures can be constructed to correct for the selection bias.[8]

In summary, in most studies of agricultural extension there is evidence that these programs provide substantial benefits. However, these studies suffer from four major methodological problems: 1) lack of a control group 2), failure to control for the influence of non-extension services and secondary information flows 3) failure to incorporate information about the characteristics of the services provided and 4) selection bias.

The data and methodology I employ below to evaluate manufacturing extension allow me to address all but one of these concerns. First, the LRD provides an excellent control group. Namely, I use all plants in the two states in which the 8 extension centers are located. Second, a subset of manufacturing extension centers studied here included some information on the type and intensity of the services provided to each client. Although I do not pursue this approach in the present paper, this type of information allows evaluators to see if the effect of extension services varies by the resources devoted to them or by the type of service provided. Finally, I attempt to control for selection bias by estimating a Heckman style two stage model. Unfortunately, I do not have any data on other non-extension services that clients and/or non-clients may have received during the period in which extension services were provided.

Data

This study uses data from two primary sources: 1) plant level Census data contained in the LRD and 2) a small number of data items from extension client records. For this study, NIST/MEP asked 8 centers in 2 states if they would make client information available to CES on a confidential basis. These data are from older centers and cover services that were delivered between 1987 and 1992. Only one of these centers received support from NIST/MEP during this period, though all later became part of the MEP system.

To carry out the analysis, records from these two sources must first be linked together. The General Accounting Office (GAO) requires a 70% match rate for studies such as this. NIST/MEP adopts this standard for the linked client/LRD data to be used for evaluating the impact of manufacturing extension.

To link the data from the two sources, I employ information contained in the Standard Statistical Establishment List (SSEL)[9]. The SSEL contains name, address and other fields that can be used to match establishments to client records, whereas the LRD does not. The LRD

[8] LaLonde (1986) shows that the use of longitudinal data and/or a two step estimation procedure can reduce the potential for misspecification. These methods do not, however, alleviate the potential for misspecification. He also shows that econometric models which pass standard specification tests often fail to replicate experimental results.

[9] See Doms and Peck (1994) for a more detailed description of the SSEL.

and SSEL share establishment identifiers so that once client records are matched to the SSEL they can easily be linked to the LRD.

Linking the client and SSEL records is done by creating matching variables from one or more of fields that are common between them. For example, a useful matching variable consists of the concatenation of elements of the establishment's name and its zip code. The matching variable is then used to flag potential matches between the two data sets. These matches are then verified by hand.

In order to obtain a match rate in excess of 70%, I repeated this procedure four times. A different matching variable was employed in each round. The result of the matching process was that 8,516 of 11,343 client records from the 8 extension centers were successfully linked to the SSEL and thus to the LRD. This yields a 75.1% match rate. However, this match rate is misleading since each client record refers to a project and individual clients often have multiple projects. There are 3,972 clients in the extension client data, 2,807 of which were successfully matched to the SSEL[10]. Thus, the true match rate is 70.7%, just over the 70% level desired by OMB.

All of the client records used in this study included a measure of employment. The matched clients account for 78% of the total employment contained in the client records. The matched establishments also account for 20.7% of total 1992 LRD employment in the two states where the client plants reside.

[10] Note that the definition of a "client" does not necessarily correspond to an establishment. For instance, it was often the case that more than one "client" was found to match to a single establishment. These were often just different parts of the same plant. Also, there were cases where a client record matched to more than one plant. If the plants were all in the same zip code, I allowed the match.

Methodology

The goal of evaluation is to determine whether the performance of client plants is systematically related to the receipt of extension services. Based on the evaluation literature reviewed earlier, an evaluation of manufacturing extension should incorporate an appropriate control group and address the issue of selection bias.

The first step is to identify measures of plant performance that are of interest to project stakeholders, that can be measured reliably, and will provide credible results. For this paper I examine the impact of extension services on sales and labor productivity growth. Both of these variables, as well as all the control variables used, are taken from the LRD so that they are measured consistently across both clients and non-clients and over time.

For this study, I employ two econometric specifications to estimate the relationship between these variables and participation in extension. The first is a simple OLS regression with an extension dummy (Ext). This model is written as

Model 1 (OLS):

$$y_{it} = X_{it}\beta + \alpha Ext_{it} + u_{it} \qquad (1)$$

where X_{it} is a vector of characteristics for each plant i and $Ext_{it} = 1$ if plant i is a client in period t and 0 otherwise. The parameter measures the mean difference in y between clients and non clients controlling for the characteristics in X.

This model is appealing because it is easy to estimate and interpret. The vector X contains control variables that are known or thought to influence the dependent variable. If these variables control for all other factors that influence y, then the parameter measures the impact of participation in manufacturing extension.

However, there are several reasons to believe that this might not be the case. First, the vector of control variables is unlikely to include all of the other factors that influence the dependent variable. In this particular study, one important "missing variable" is a measure on non-extension services that either clients and/or non-clients may have received.

Second, plants were not randomly assigned to be in either the client or non-client groups. As a result, estimates of the and parameters in (1) are likely to suffer from selection bias. This is a well known problem in the applied econometrics literature, in general, and the program evaluation literature, in particular[11].

If one has panel data, selection bias can be controlled for by estimating a fixed effects model. This, however, assumes that the omitted variable that is correlated with program participation is fixed over time. A more general way to control for selection bias, in an evaluation framework, is given by Maddala (1983) who suggests the following model.

Model 2 (Two Stage Model):

$$y_{ci} = X_{ci}\, \beta_c + u_{ci} \qquad (2)$$

$$y_{nci} = X_{nci}\, \beta_{nc} + u_{nci} \qquad (3)$$

$$Ext_i = Z_i\, \gamma + \varepsilon_i,$$
$$Ext_i = 1 \text{ iff } Ext_i > 0 \text{ and}$$
$$Ext_i = 0 \text{ iff } Ext_i \quad 0. \qquad (4)$$

Subscript c denotes client observations and nc denotes non-client observations. We observe a client observation for plant i if $Ext_i = 1$ and a non-client observation if $Ext_i = 0$. The variable Ext_i measures the propensity of plant i to become a client. However, we only observe the binary variable, Ext, which tells us whether a given plant is client or not. The variables (Z) used in the probit regression include all those in X. In order to identify the model, I also include a dummy, in Z, for whether the plant is in a SMSA that contains a manufacturing extension center. It seems likely that being near a center would affect the likelihood of becoming a client, but not necessarily measures of plant performance such as sales and productivity growth.

[11] See Maddala (1983) for a large number of cites in the general applied econometrics literature. Stromsdorfer (1987) and Moffitt (1991) provide reviews of the evaluation literature.

This model is more general than (1) in two important ways. First, it allows the coefficients in β to differ for clients and non-clients. Second, it accounts for the covariance between the errors in the two performance equations (u_c and u_{nc} in (2) and (3), respectively) and the errors in the client selection equation (ε in (4)). OLS estimates of (1) are biased when these covariance terms are non zero.

The first step in estimating this model is to estimate (4) using probit maximum likelihood. From this, I obtain estimates of the inverse Mill's ratio for each plant.[12] The Mill's ratio is then used as an additional instrument to correct for selection bias in second stage OLS regressions of (3) on client observations and (4) on non-client observations or of an augmented version of (1) on the pooled sample. The coefficients on these instruments estimate $\mathrm{cov}(u_c\, \varepsilon)$ and $\mathrm{cov}(u_{nc}\, \varepsilon)$ for the client and non-client regressions, respectively. If they are non-zero, then selection bias exists.

I use the model given in equations (2) through (4) to estimate the impact of manufacturing extension on client performance in two ways. First, I include the Mill's ratio in second stage OLS regressions on the pooled client and non client sample. Like the single stage OLS model in equation (1), these regressions employ an extension dummy variable to measure program impact by comparing client and non client performance.

For evaluation, however, I want to measure the difference between how clients perform after involvement in extension and how they would have performed had they not received any services. That is, I would like to measure $E(y_{ci}|\ Ext_i{=}1) - E(y_{nci}|\ Ext_i{=}1)$. Unfortunately, I can not observe the $E(y_{nci}|Ext_i{=}1)$ term. However, the model given in equations (2) through (4) does allow one to estimate this expression with non experimental data. Thus, the second way I measure program impact using the 2 stage model is to compute the following expression

[12] The inverse Mill's ratio is given by $-\phi\,(Z_i\, \gamma)/\Phi(Z_i\, \gamma)$ for client plants and by $\phi\,(Z_i\, \gamma)/(1-\Phi(Z_i\, \gamma))$ for non-clients ϕ and Φ are the normal density and cumulative distribution functions, respectively.

$$E(y_{ci}| Ext_i=1) - E(y_{nci}| Ext_i=1) = (X_c \beta_c - \sigma_{c\varepsilon} (\phi (Z\gamma)/\Phi(Z\gamma))) - (X_c \beta_{nc} - \sigma_{nc} (\phi (Z\gamma)/\Phi(Z\gamma))) \quad (5)$$

where ϕ and Φ are the normal density and cumulative distribution functions, respectively, and β_{nc} and σ_{nc} are estimates from the second stage non-client regression. This expression computes the predicted difference in performance between how client plants perform having received services and how they would have performed in the absence of manufacturing extension. To compute (5), separate second stage regressions must be run on the client and non client subsamples.

Results

For the analysis below, I restrict attention to plants that were in the LRD for the three most recent Censuses of Manufactures (i.e., 1982, 1987 and 1992). This is required in order to estimate the impact of extension services on sales and productivity growth between 1987 and 1992, while controlling for growth in these variables over the previous 5 year period. I look at 5 year changes, since many of the client plants are small and, therefore, are not likely to be included in the LRD during non-census years.

Because of this restriction, the number of client plants included in the analysis drops from 2482 to 1559 and the number of non-client plants drops from 34,889 to 15,982. Table 1 provides some summary statistics for this reduced sample. These show that client plants are, on average, larger than non-client plants. They also show that extension clients enjoyed more sales and labor productivity growth over the 1987 to 1992 period (the period in which clients received services) than did non-clients. However, clients also grew faster during the previous 5 year period from 1982 to 1987.

The Impact of Manufacturing Extension on Sales Growth

To determine whether or not participation in manufacturing extension is systematically associated with improved sales performance, I first estimate several alternative specifications of the simple OLS model given by (1), where y_{it} is the natural log of sales (in 1987 dollars). These regressions simply compare the performance of client and non-client plants. To mitigate the effects of selection bias, I estimate the model in growth rates (this is one method of estimating a "fixed effects" model). That is, I transform the model so that the dependent variable becomes the log difference of sales between 1987, before any plants received extension services, and 1992, after clients had been served. This transformation sweeps out the effects of any omitted variables that remain fixed over time but still influence performance[13]. An important example of such a variable is managerial ability.

Estimates from this model are given in Table 2. The basic specification, in column 1, shows that extension clients enjoyed 11.3% more sales growth than non-clients between 1987 and 1992, after controlling for sales growth in the previous five year period and the growth in the capital labor ratio and in the share of production workers at the plant. Column 2 substitutes the growth in sales between 1977 and 1982 for that between 1982 and 1987, since the latter is likely to be endogenous[14]. While the coefficient on previous sales growth changes considerably, the impact on the extension coefficient is only marginal.

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[13] This transformation removes all variables that remain fixed over time, such as dummy variables. The extension dummy does not drop out, however, since its value changes (for clients) between 1987 and 1992.

[14] Namely, the 1982-1987 sales growth term, $\log(sales_{87}) - \log(sales_{82})$ shares a term with the dependent variable, $\log(sales_{92}) - \log(sales_{87})$. Thus, the negative coefficient on the sales growth rate term in the first and third columns in not surprising. The specification in the second fourth columns, while it reduces the number of observations available, avoids the endogeniety problem encountered in the first and third columns.

The regressions in columns 3 and 4 are the same as in the first two columns except that they refer only to plants with 500 or fewer workers. This is the target population for extension services. The results indicate that the difference between client and non-client performance is slightly larger for the small and medium sized plants for which the program is intended to serve.

Even though the growth rate specification may mitigate the effects of selection bias, the most rigorous way to control for the bias, in the current setting, is to estimate the Heckman style two stage model described above. The first step is to obtain estimates of the inverse Mill's ratio from probit model that explains the propensity of plants to become clients.

Table 3 contains the first stage probit estimates for the four basic specifications of the model. The probit model should include all the variables to be used in the second stage OLS regressions. I also include a number of dummy variables that are differenced out of the growth rate model, such as whether plants are located in an URBAN or rural area, are single unit enterprises or are owned by MULTI plant firms and 2-digit SIC and size class dummies. As mentioned above, I also include a dummy that measures whether plants are located within an SMSA that contains an extension center to ensure the model is identified.

The results indicate that plants that grew faster prior to 1987 and single unit plants were more likely to become clients. Plants located near an extension center are also more likely become clients. Thus, it appears that CENTER is a good instrument for program participation.

In Table 4, I re-estimate the regressions from Table 2 but include the inverse Mill's ratio obtained from the probit model to correct for selection bias. The results show that, in each case, the estimated Mill's ratio coefficient is significantly different from zero which indicates that selection bias is a problem in the OLS estimates[15]. Indeed, the bias corrected estimates suggest that manufacturing extension had no significant impact on sales growth.

The Ext coefficients in Tables 2 and 4 estimate the difference between the mean sales growth rates for clients and non-clients controlling for several factors. Recall, however, that for evaluation we want to know how much better clients perform after receiving services than they would have had they not received any services. That is, we want to estimate the complete unrestricted model given in equations (2) - (4) and evaluate equation (5).

Tables 5 and 6 provide the second stage OLS estimates for clients and non-clients, respectively. The coefficient on the Mill's ratio term is significantly different from 0, at the 5% level, in all of the client only regressions and in 1 of the non-client regressions (where it was significant at the 10% level).

To get a measure of the difference between the sales growth that clients actually experienced and what they would have experienced had they not received any services, I use the non-client estimates, in Table 6, to compute the expression in equation (5) for each client plant. Recall that this expression measures the predicted gross change in sales growth for client plants conditional on them having client characteristics.

The estimated program impacts from the fully unrestricted two stage model are given in Table 7. Like in Table 4, these results show that controlling for selection bias reduces the estimates of the program impact on sales growth compared to the simple OLS estimates. Further, none of the estimates in Table 7 are statistically significant at the 5% level and only one case is significant at the 10% level.

The main result to take from Tables 4 and 7 is that simple OLS estimates of the impact of extension services on sales growth are biased upwards due to selection bias. All of the estimates of program impact on sales growth are summarized in figure 1. The OLS estimates range between 10.0 and 12.3% and the two stage

[15] While OLS yields consistent parameter estimates in the second stage regression, it gives inconsistent estimates of the covariance matrix. To correct for this I use the covariance estimator in Lee (1982).

estimates range between -1.5 and 9.3%. Also, the two stage estimates are statistically insignificant except in one case. Thus, the case for a significant impact of extension services on sales growth is weak.

The Impact of Manufacturing Extension on Productivity Growth

To estimate the impact of extension services on client productivity I specify the following standard value added production function

$$Y_{it} = Ae^{\alpha EXT_{it}} L_{it}^{\beta} K_{it}^{\eta} e^{\varepsilon it} \quad (6)$$

where Y_{it} is value added, L_{it} is employment and K_{it} is the book value of the capital stock of plant i in period t. This equation can be rewritten as

$$(y_{it}-l_{it})=a+\alpha EXT_{it}+\eta(k_{it}-l_{it})+(\mu-1)l_{it}+\varepsilon_{it} \quad (7)$$

where small letters denote logs, the parameter μ measures deviations from constant returns to scale and the dependent variable is the log of labor productivity. Again to mitigate the impact of omitted variables, such as managerial ability, I transform (7) into a growth rate specification by taking differences and I add a measure of previous productivity growth.

Table 8 lists the simple single stage OLS estimates. The format of this table is the same as that used in the sales growth regressions above. The estimated Ext coefficients suggest that extension clients enjoyed around 4.7% more growth in value added per worker between 1987 and 1992 than did non clients.

The probit equations for the productivity models are the same as those used above, except that the change in employment is added. The results are nearly identical, so I do not list then in a separate table. Second stage estimates for the productivity growth regressions are provided in Tables 9 through 12. The regressions in Table 9 are the same as in Table 8 but control for selection bias. The results show that including the Mill's ratio increases the magnitude of the Ext coefficient in all but one case. Thus, unlike the sales growth estimates, OLS estimates of the impact of extension services on productivity growth are biased downward. Note, however, that the Ext coefficients in Table 9 are significant in only two cases (columns 2 and 4) and the Mill's ratio coefficients are never significant.

Tables 10 and 11 contain the second stage estimates for the unrestricted model. Taking both the client and non client regressions together, the results indicate that selection bias is a significant problem in 3 of the 4 specifications of the completely unrestricted model. The estimated gross impact of manufacturing extension on client productivity are given in Table 12. These are all statistically significant and much larger than the OLS estimates in Table 8.

All of the estimates of the impact of participation in manufacturing extension on productivity growth are summarized in figure 2. The main finding is that these estimates are consistently positive, ranging between 4.4% and 14.4%. While selection bias is a problem in estimates of the impact of manufacturing extension on productivity growth, the bias appears to be downward. Given this and the fact that significant positive estimates of program impact were computed for 10 of the 12 cases, it appears that manufacturing extension participation is related to improved productivity growth for this sample of client plants[16].

Conclusions

The goal of this paper was to see if measures of plant performance (e.g., productivity and sales growth) are systematically related to participation in manufacturing extension, while controlling for other factors that are known or thought to influence performance. To do this, I

[16] The two cases where the result was not statistically significant, in columns 1 and 3 of table 9, is where the 1982-1987 growth rate in sales is used as a control variable. As discussed above, this variable likely leads to endogeniety bias. Thus, the results in columns 2 and 4 in all of the regression tables including table 9 are probably more reliable.

matched extension client data to the Census Bureau's Longitudinal Research Database (LRD). The LRD offers two useful things for evaluation studies such as this one. First, because it includes plant level data for all manufacturing plants in the U.S., it is the best available database for constructing control groups. Second, it contains a number of both performance and control variables that are measured consistently across client and non-client plants and over time.

Because selection bias is often a problem in evaluation studies using non-experimental data, I specified an econonmetric model that controls for selection. I estimated the model with data from 8 manufacturing extension centers in 2 states. The control group includes all plants, in the LRD from each state.

The results indicate that participation in manufacturing extension is systematically related to productivity growth but not to sales growth. These findings are consistent with those from other studies, such as Oldsman (1996). These results alone are not enough to evaluate the usefulness of manufacturing extension. The analysis in this paper looks only at the direct impacts of extension services on only two measures of client performance. Data on secondary program benefits and program costs are needed to ascertain whether manufacturing extension provides positive net social benefits.

Finally, I believe that the paper demonstrates that the LRD can be utilized in evaluation studies. It is possible to match a sufficient number program records to the LRD in order to perform a credible analysis. Further, this can be done in a manner that does not violate Census Bureau data disclosure rules.

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Table 1
Summary Statistics

Variable	Client Mean	Non-Client Mean
N	1559	15,982
Age, 1992	15.97	16.04
Employment, 1992	170.21	71.70
Employment Growth Rate, 1987-1992	0.013	-0.088
Sales, 1992	30,797,199	13,418,587
Sales Growth Rate, 1987-1992	0.052	-0.085
Sales Growth Rate, 1982-1987	0.427	0.338
Annual wage, 1992	28,072	25,013
Production Worker Share, 1992	0.699	0.724
Value Added Per Worker, 1987	53,042	50,853
Value Added Per Worker, 1992	56,709	52,797
Labor Productivity Growth Rate, 1987-1992	0.215	0.203
Labor Productivity Growth Rate, 1982-1992	0.052	0.010
# of Extension Projects	3.82	NA
Total Project Costs	63,787	NA

Notes: Employment is the total number of employees from the LRD. Sales is the total value of shipments from the LRD. Wages is payroll ÷ employment from the LRD. Production worker share is the # of production workers ÷ employment from the LRD. Labor productivity is measured as value added per worker from the LRD. The # of Extension Projects is the number of distinct project records per client from the extension client data. Total project costs in the total client investment as a result of its engagements with manufacturing extension. Real values for shipments obtained using the NBER's 4-digit deflators.

Table 2
OLS Estimates: Sales Growth
(absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	-0.021* (3.962)	-0.066* (12.265)	-0.020* (3.679)	-0.066* (11.867)
EXT	0.113* (7.112)	0.100* (5.993)	0.123* (7.462)	0.108* (6.217)
Growth Rate in K/L	0.034* (6.461)	0.035* (5.887)	0.037* (6.824)	0.037* (6.306)
Growth Rate in PW share	-0.090* (5.394)	-0.031*** (1.686)	-0.097* (5.719)	-0.039** (2.075)
Sales Growth Rate, 1982-1987	-0.053* (7.977)		-0.052* (7.823)	
Sales Growth Rate, 1977-1982		0.044* (5.748)		0.044* (5.634)
N	15143	11556	14737	11162
R^2	0.012	0.009	0.013	0.034

Notes: The dependent variable is the Sales Growth Rate for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 3
Probit Estimates: Sales Growth Model
(Absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
CONSTANT	-1.103*** (1.772)	-1.573*** (1.770)	-0.941** (2.095)	-1.413*** (1.779)
Sales Growth Rate, 1982-1987	0.076* (3.128)		0.076* (3.077)	
Sales Growth Rate, 1977-1982		0.053*** (0.026)		0.054** (1.907)
Growth Rate in K/L	-0.136 (0.954)	-0.132 (0.553)	-0.137 (0.957)	-0.143 (0.598)
Growth Rate in PW share	-0.132 (0.319)	0.872 (1.277)	-0.192 (0.455)	0.791 (1.119)
URBAN	-0.615 (1.563)	0.064 (0.087)	-0.662*** (1.673)	0.055 (0.073)
MULTI	-0.701** (2.322)	-0.897** (2.132)	-0.762** (2.457)	-1.005** (2.320)
AGE	-0.234 (1.524)	-0.025 (0.087)	-0.239 (1.547)	-0.020 (0.069)
CENTER	1.246* (3.832)	1.014** (1.952)	1.241* (3.793)	0.987*** (1.884)
2-Digit SIC Dummies	yes	yes	yes	yes
Size Dummies	yes	yes	yes	yes
Interaction Terms	yes	yes	yes	yes
N	15057	11509	14652	11116
logL	-3780	-3088	-3578	-2888

Notes: The dependent variable is Ext. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. URBAN=1 if inside an SMSA. MULTI=1 if owned by a multi plant firm. CENTER=1 if located inside an SMSA that contains an extension center. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 4

Second Stage OLS Estimates: Sales Growth

Clients and Non-Clients

(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	-0.011*** (1.663)	-0.058* (8.4217	-0.012*** (1.752)	-0.059* (8.355)
EXT	-0.015 (0.399)	0.022 (0.538)	0.010 (0.245)	0.037 (0.877)
Mills Ratio	-0.082* (0.023)	-0.051** (2.069)	-0.072* (2.978)	-0.047*** (0.025)
Growth in K/L	0.034* (5.799)	0.033* (5.037)	0.036* (6.446)	0.036* (5.414)
Growth in PW share	-0.088* (4.520)	-0.032 (1.509)	-0.095* (4.860)	-0.040*** (1.889)
Sales Growth, 1982-1987	-0.048* (5.896)		-0.048* (5.820)	
Sales Growth, 1977-1982		0.033* (5.025)		0.044* (4.896)
N	15057	11509	14652	11116
R^2	0.012	0.010	0.013	0.033

Notes: The dependent variable is the Sales Growth Rate for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 5
Second Stage Estimates: Sales Growth
Clients Only
(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	-0.117* (2.147)	-0.112** (1.982)	-0.093 (1.635)	-0.093 (1.555)
Growth in K/L	-0.009 (0.396)	0.012 (0.521)	-0.005 (0.222)	0.019 (0.779)
Growth in PW share	-0.172** (2.039)	-0.121 (1.428)	-0.167** (1.974)	-0.110 (1.346)
Sales Growth, 1982-1987	0.004 (0.130)		0.003 (0.111)	
Sales Growth, 1977-1982		0.050** (2.010)		0.047*** (1.812)
Mills	-0.129* (3.367)	-0.104** (2.529)	-0.118* (2.983)	-0.095** (2.221)
N	1442	1209	1344	1112
R^2	0.017	0.016	0.037	0.014

Notes: The dependent variable is the Sales Growth Rate for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 6

Second Stage Estimates: Sales Growth

Non-Client Plants

(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	-0.013*** (1.905)	-0.065* (8.463)	-0.014*** (1.916)	-0.064* (7.078)
Growth in K/L	0.038* (6.228)	0.035* (5.097)	0.040* (6.471)	0.038* (4.751)
Growth in PW share	-0.080* (4.081)	-0.025 (1.150)	-0.089* (4.474)	-0.035 (1.410)
Sales Growth, 1982-1987	-0.054* (6.324)		-0.054* (6.226)	
Sales Growth, 1977-1982		0.042* (4.539)		0.043* (4.010)
Mills	-0.050*** (1.715)	-0.012 (0.389)	-0.043 (1.406)	-0.011 (0.233)
N	13615	10300	13308	10004
R^2	0.010	0.029	0.010	0.020

Notes: The dependent variable is the Sales Growth Rate for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 7

Second Stage Estimates of Gross Impact of Manufacturing Extension
on Client Sales Growth
(Absolute asymptotic t statistics in parentheses)

Model	$E(y_{ci} \mid Ext_i=1) - E(y_{nci} \mid Ext_i=1)$
1	0.037 (0.755)
2	0.083 (1.636)
3	0.058 (1.127)
4	0.093*** (1.746)

Notes: $E(y_{ci} \mid Ext_i=1) - E(y_{nci} \mid Ext_i=1) = X^*_c{}' \beta_c - X^*_c \beta_{nc} = \lambda$, where X^*_c is a vector containing the means of the variables used in the regressions in tables 5 and 6 computed for client plants only. $Var(\lambda) = X^*_c var(\beta_c - \beta_{nc}) X^*_c{}' = X^*_c (var(\beta_c) + var(\beta_{nc})) X^*_c{}'$, where $var(\beta_c)$ and $var(\beta_{nc})$ are the asymptotic covariance matrices from the second stage client and non client regressions, respectively. *** denotes significant at the 10% level.

Table 8
OLS Estimates: Productivity Growth
(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	0.065* (13.850)	-0.008 (1.460)	0.064* (13.533)	-0.009 (1.644)
EXT	0.047* (3.255)	0.046* (2.771)	0.048* (3.204)	0.047* (2.706)
Growth Rate in K/L	0.130* (26.940)	0.136* (23.290)	0.131* (26.942)	0.137* (23.289)
Growth Rate in L	-0.165* (21.819)	-0. 195* (20.516)	-0.165* (21.626)	-0.195* (20.344)
Labor Productivity Growth Rate, 1982-1987	-0.265* (39.955)		-0.264* (39.472)	
Labor Productivity Growth Rate, 1977-1982		-0.024* (3.099)		-0.025* (3.266)
N	15248	11609	14848	11220
R^2	0.195	0.096	0.197	0.099

Notes: The dependent variable is the growth rate in labor productivity for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 9
Second Stage Estimates: Productivity Growth
Clients and Non Clients
(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	0.065* (10.837)	- 0.012*** (1.777)	0.065* (10.710)	- 0.012*** (1.762)
Mills Ratio	0.002 (0.080)	0.032 (1.303)	-0.003 (0.123)	0.027 (1.068)
EXT	(1.411)	0.095** (2.310)	0.044 (1.200)	0.087** (2.071)
Growth Rate in K/L	0.127* (20.338)	0.131* (16.987)	0.128* (20.383)	0.132* (17.070)
Growth Rate in L	-0.170* (17.970)	-0. 202* (16.672)	-0.170* (17.818)	-0.202* (16.534)
Labor Productivity Growth Rate, 1982-1987	-0.265* (26.471)		-0.264* (26.103)	
Labor Productivity Growth Rate, 1977-1982		-0.025* (3.121)		-0.027* (3.251)
N	14940	11412	14544	11027
R^2	0.193	0.095	0.195	0.097

Notes: The dependent variable is the growth rate in labor productivity for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 10
Second Stage Estimates: Productivity Growth
Clients Only
(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	0.051 (1.005)	0.016 (0.290)	0.034 (0.629)	0.008 (0.133)
Mills Ratio	-0.051 (1.449)	-0.017 (0.446)	-0.061*** (1.666)	-0.021 (0.526)
Growth Rate in K/L	0.108* (4.874)	0.115* (4.571)	0.102* (4.518)	0.108* (4.177)
Growth Rate in L	-0.114* (3.046)	-0. 149* (3.244)	-0.109* (2.877)	-0.151* (3.132)
Labor Productivity Growth Rate, 1982-1987	-0.317* (9.080)		-0.316* (8.780)	
Labor Productivity Growth Rate, 1977-1982		-0.001 (0.046)		-0.009 (0.349)
N	1418	1191	1326	1100
R^2	0.180	0.056	0.179	0.053

Notes: The dependent variable is the growth rate in labor productivity for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 11
Second Stage Estimates: Productivity
Non Clients Only
(Asymptotic absolute t statistics in parentheses)

	All Plants		L<500	
Variable	1	2	3	4
Constant	0.059* (8.911)	-0.018** (2.326)	0.059* (8.840)	-0.017** (2.236)
Mills Ratio	0.035 (1.299)	0.064** (1.964)	0.033 (1.209)	0.056*** (1.730)
Growth Rate in K/L	0.128* (19.693)	0.132* (16.257)	0.130* (19.828)	0.134* (16.451)
Growth Rate in L	-0.175* (17.915)	-0. 208* (16.473)	-0.175* (17.791)	-0.207* (16.347)
Labor Productivity Growth Rate, 1982-1987	-0.260* (24.962)		-0.259* (24.692)	
Labor Productivity Growth Rate, 1977-1982		-0.028* (3.242)		-0.028* (3.288)
N	13522	10221	13218	9927
R^2	0.195	0.100	0.197	0.102

Notes: The dependent variable is the growth rate in labor productivity for 1987 to 1992. K/L is the capital labor ratio. Capital is the book value of machinery and structures assets from the LRD deflated by 2-digit BEA capital stock deflators. * denotes significant at the 1% level. ** denotes significant at the 5% level. *** denotes significant at the 10% level.

Table 12
Second Stage Estimates of the Gross Impact of Manufacturing Extension
on Client Productivity Growth
(Absolute asymptotic statistics in parentheses)

Model	$E(y_{ci} \mid Ext_i=1) - E(y_{nci} \mid Ext_i=1)$
1	0.103** (2.290)
2	0.144* (2.722)
3	0.101** (2.200)
4	0.134** (2.488)

Notes: $E(y_{ci} \mid Ext_i=1) - E(y_{nci} \mid Ext_i=1) = X^*_c \beta_c - X^* \beta_{nc} = \lambda$, where X^* is a vector containing the means of the variables used in the regressions in tables 10 and 11 computed for client plants only. $Var(\lambda) = X^*_c var(\beta_c - \beta_{nc}) X^{*\prime}_c = X^*_c var(\beta_c) + var(\beta_{nc})) X^{*\prime}_c$, where $var(\beta_c)$ and $var(\beta_{nc})$ are the asymptotic covariance matrices from the second stage client and non client regressions, respectively. * denotes significant at the 1% level. ** denotes significant at the 5% level.

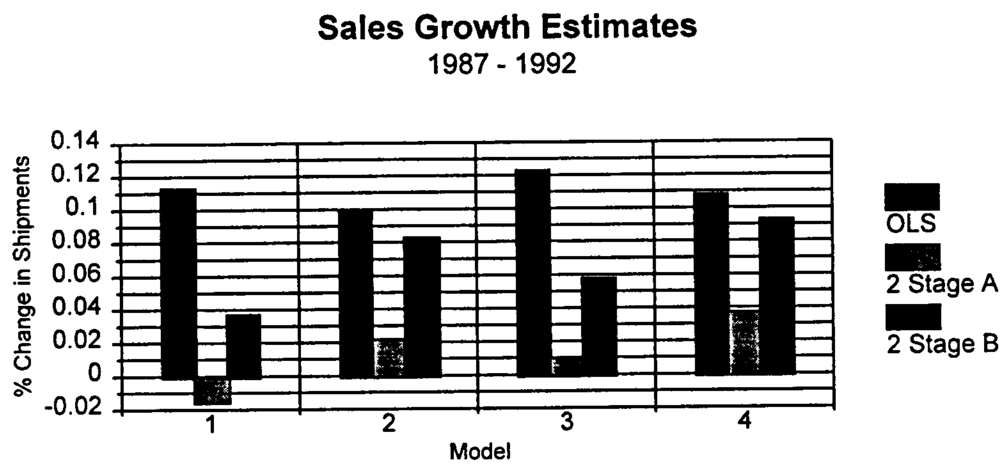

Figure 1

OLS: Average difference in % change in shipments between clients and non clients controlling for the characteristics in the regression.

2 Stage A: Average difference in % change in shipments between clients and non clients controlling for the characteristics in the regression plus the bias correction term.

2 Stage B: Predicted difference between client performance after extension services are provided and how they would have performed had they not been clients.

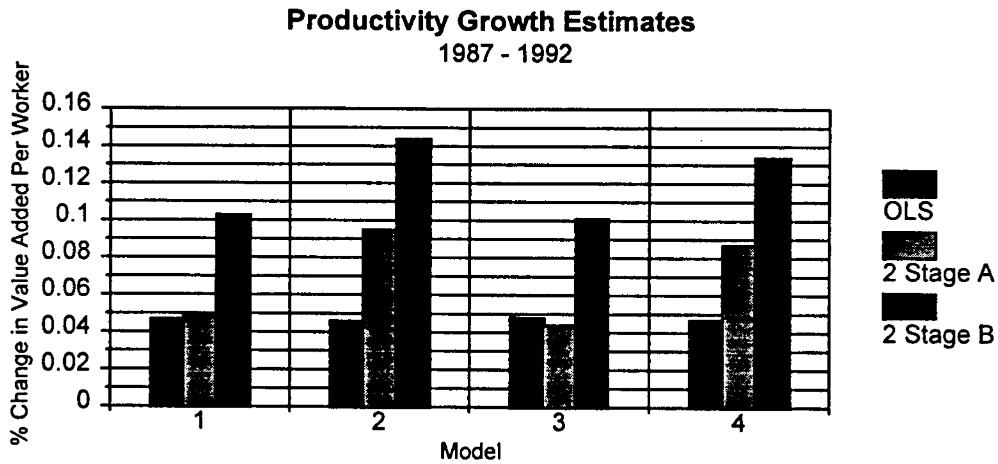

Figure 2

OLS: Average difference in % change in productivity between clients and non clients controlling for the characteristics in the regression.

2 Stage A: Average difference in % change in productivity between clients and non clients controlling for the characteristics in the regression plus the bias correction term.

2 Stage B: Predicted difference between client performance after extension services are provided and how they would have performed had they not been clients.