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FROM THE EDITOR'S DESK

Articles for this issue were selected from the Western Decision Sciences Institute's 26th annual conference held in the big island of Hawaii on March 25-29, 1997.

Ethical issues have recently been receiving a lot of attention in both businesses and academia. **WILLIAM E. SHAFER** and **L. JANE PARK** study three groups' (accounting students, staff and public auditors) sensitivity to both ethical and technical issues. Their results indicate that while public accounting experience enhances the ability to recognize technical issues, the same cannot be said for ethical issues.

In the last couple of decades, strong emphasis on and implementation of Total Quality Management (TQM) has changed the manufacturing environment. The question is whether management accounting has kept up with these changes. **RICHARD L. JENSEN**, **CLIFFORD R. SKOUSEN** and **JAMES W. BRACKNER** study eight Shingo manufacturers and find that innovative management accounting practices are most often driven by and run parallel to innovative manufacturing practice. The results have been elimination of accounting wastes such as unnecessary transaction processing, excessive paper handling, outdated controls and procedures.

Self directed work groups have captured increasing interest in recent years. **DAVID F. ELLOY** examines the relationship between self directed work groups and superleader behaviors based on a sample of 90 employees of a government operated railway service in Australia. His findings indicate that fair, trusting and encouraging supervisors contribute to the development of self management. Suggestions include not only involving employees in decision making and problem solving but also integrating empowerment with a culture that supports and encourages this system.

The question of how much inventory to acquire is typically answered by the economic order quantity model (EOQ) under rather restrictive assumptions.

PETER M. ELLIS presents a bivalent mixed integer formulation of the EOQ model that permits both quantity discounts and varying demand. Total material and inventory costs are minimized and the optimal amount of inventory to acquire in each period of the planning horizon is determined.

An application of Data Envelopment Analysis (DEA) is utilized by **PATRICK R. MCMULLEN** to assess the desirability of several AACSB-accredited MBA programs. Of the 188 MBA programs evaluated, seventeen were found to be efficient or near efficient. The results were comparable to those made by *Business Week*, but included some surprises.

FRANKLIN STRIER

BURHAN F. YAVAS

THE EFFECTS OF AUDITING EXPERIENCE

ON SENSITIVITY TO ETHICAL

AND TECHNICAL ISSUES

William E. Shafer *
L. Jane Park **

This research examines the effects of public accounting experience on the ability to recognize ethical and technical issues presented in an audit planning context. Auditing students, staff auditors, and audit seniors completed an experimental case that required them to identify issues and rate the perceived significance of each issue identified. As hypothesized, experienced auditors identified significantly more technical issues and significantly fewer ethical issues than did auditing students. In addition, experienced auditors identified significantly more issues that were considered administrative in nature. Various individual difference variables such as ethical ideology and gender were not predictive of performance on the experimental task.

The results of this study suggest that, while public accounting experience enhances the ability to recognize technical auditing and accounting issues, it does not result in a similar improvement in ethical sensitivity. The findings also raise concerns about the ethical sensitivity of young professionals.

Ethics and morality among professional auditors have been receiving a great deal of attention in the academic literature (e.g., Ponemon, 1990; 1992; Gaa, 1992; Lampe and Finn, 1992; Shaub, 1993). However, extant empirical work in this area has primarily focused on auditors' level of moral development or ability to make moral judgments, with limited attention being given to other components of moral behavior such as the ability to recognize situations that

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require moral judgments (Shaub et al. 1993). Similarly, much research has investigated auditors' technical expertise and the effects of professional auditing experience on such expertise, but little attention has been given to auditors' ability to recognize technical auditing or accounting issues.

This study extends previous research by investigating professional auditors' and auditing students' sensitivity to ethical and technical issues in an audit planning context. The study makes two primary contributions to the auditing literature. First, it provides evidence regarding the effects of the public accounting environment on sensitivity to several significant ethical issues faced by professional auditors. Second, it extends existing knowledge of the effects of auditing experience on technical expertise to a practically significant but previously unexamined task.

The remainder of the paper proceeds as follows. The next section contains a review of the relevant literature and development of research hypotheses. The third section discusses the experimental task and subjects. The empirical results are then discussed in detail. The final section of the paper presents conclusions and implications of the research.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Sensitivity to Ethical Issues

Empirical research on auditing ethics has been heavily influenced by the psychological theory of moral judgment developed by Kohlberg (1969, 1984) and Rest (1979, 1986a). According to this theory, there are four components of moral behavior: (1) the ability to recognize situations that require moral judgments, i.e., ethical sensitivity, (2) the ability to make moral judgments regarding the appropriate course of action, (3) commitment to morally appropriate action, and (4) the ability to follow through on this commitment (Rest, 1986a). Most tests of the Kohlberg/Rest theory in auditing contexts have focused on the second component of moral behavior, the ability to make moral judgments.

The first component of moral behavior, ethical sensitivity, has received relatively little research attention. However, the ability to recognize situations that require moral judgments is a significant component of the ethical decision-making process. As observed by Jones (1991) and Shaub et al. (1993), if the ethical implications of a situation are not recognized, the appropriate rules for addressing these implications will not be activated. Thus, ethical sensitivity may be viewed as a prerequisite for making appropriate ethical judgments.

Ethical sensitivity appears to be particularly significant in the public accounting environment. As observed by the managing partners of the then Big eight firms, "Practitioners must ... be able to identify ethical issues and apply a value-based reasoning system to ethical

questions" (Arthur Andersen & Co. et al. 1989, foreword). Rules for resolving the majority of ethical issues encountered by public accounting practitioners are set forth in professional codes of conduct (Finn et al. 1988). Thus, if auditors fail to recognize situations to which these rules potentially apply, they run the risk of violating explicit provisions of their professional standards without realizing they are doing so. Because compliance with professional standards is considered the minimum acceptable level of conduct by CPAs (Lampe and Finn, 1992; Epstein and Spalding, 1993), the implications for the reputation of the profession of failing to recognize the applicability of these standards to common ethical situations are apparent.

Due to the significance of ethical sensitivity in the public accounting environment, there is a need for an understanding of its determinants. Although relatively little evidence is available on this issue, studies in the social psychology literature suggest that contextual or situational factors appear to influence ethical sensitivity to a greater degree than do personality traits.

For example, Darley and Latane (1968) found that the number of other bystanders present significantly affected the likelihood of helping in an emergency, but personality and background measures had no similar influence. Also, Darley and Batson (1973) found that subjects placed under time pressure were more likely to pass by a person in apparent need of help than subjects operating at a more leisurely pace. Various religious personality variables were not predictive of helping behavior among Darley and Batson's (1973) subjects.¹

The importance of context on ethical sensitivity is also supported by the results of a study by Volker (1984), who found no differences in the moral sensitivity of novice and experienced counselors. As observed by Shaub et al. (1993), this finding suggests that the context of clinical diagnosis encourages experienced counselors to become preoccupied with technical issues to the detriment of their ethical sensitivity.

The current study investigates whether a similar phenomenon occurs among professional auditors. The primary issue of concern is the effect of a contextual variable, the public accounting environment, on sensitivity to common ethical problems faced by auditing practitioners. During their formal university education, aspiring auditors should be sensitized to common ethical issues faced by practitioners due to the emphasis on ethics in undergraduate auditing courses. However, ethical sensitivity should be lower in an environment in which ethical issues and ethical standards are not emphasized and reinforced. It is well known that the competitive nature of the public accounting environment requires a constant focus on efficiency in conducting audits. In such an environment, it appears likely that young auditors will also become preoccupied with the technical aspects of the engagement, and may not attend to "softer" issues such as potential ethical problems. This reasoning leads to the following hypothesis:

H₁: Experienced auditors will be less sensitive to ethical issues than auditing students.

Little evidence relevant to this hypothesis has been reported in the auditing literature. Shaub et al. (1993) tested professional auditors' sensitivity to three ethical issues embedded in an auditing case. Overall, their subjects appeared to be relatively insensitive to ethical issues, with the average subject identifying less than half of the presented issues. However, the Shaub et al. study did not address the effects of experience on ethical sensitivity.

Wright et al. (1996) tested the effectiveness of an educational intervention on auditing students' ability to recognize ethical issues. These authors suggested that issue recognition is a joint function of an individual's ethical sensitivity and the moral intensity of the issues (Jones 1991), although this hypothesis was not explicitly tested. The Wright et al. (1996) student subjects appeared to be more sensitive to ethical issues than the Shaub et al. (1993) subjects, with the average student identifying approximately 66 percent of the issues included in the pretest. In contrast, the Shaub et al. (1993) subjects identified about 75 percent of the issues included in the posttest. While these findings are consistent with H_1 , it is difficult to compare the two studies because they used different experimental cases.

Sensitivity to Technical Issues

In the preceding section, it was suggested that the public accounting environment encourages auditors to focus on technical performance and efficiency rather than ethical issues. The ability to identify technical issues is obviously important to the successful conduct of an audit engagement. For example, the presence of contentious or difficult accounting issues increases audit risk at the financial statement level (AICPA, 1995). If the auditor fails to recognize such issues, significant errors or omissions in the financial statements may go undetected. To illustrate, assume that during the planning phase of an engagement the auditor learns that the client guaranteed the debt of a related company. If the auditor fails to recognize that this transaction creates a potential contingent liability, important information may be omitted from the financial statements.

Due to the importance of technical competence in auditing, it is reasonable to assume that public accounting firms will encourage and reward this type of skill. Much anecdotal evidence supports this contention; for example, the performance evaluation forms used by most CPA firms include criteria relating to technical competence and knowledge of accounting and auditing standards. If firms emphasize and reward technical proficiency we would expect experienced auditors to focus primarily on technical issues. This reasoning leads to the following hypothesis:

H_2 : Experienced auditors will be more sensitive to technical issues than auditing students.

Limited evidence supporting this hypothesis has appeared in the auditing literature. For example, Bonner and Lewis (1990) found that audit managers possessed more knowledge of

the nature of and proper accounting for hedging transactions than did audit seniors or auditing students, and that this knowledge was significantly related to performance on a related auditing task. Shafer et al. (1995) required subjects to read descriptions of complex financial accounting transactions as part of an audit planning task. Subjects then completed a surprise free recall task and also provided explanations of the perceived significance of accounting issues. The study found that experienced subjects recalled more of the important case information and made a greater number of meaningful inferences relating to financial accounting issues than did auditing students. These results indicate that the experienced subjects possessed more knowledge of generally accepted accounting principles, and were better able to apply this knowledge to facilitate the comprehension of nonroutine transactions and events.

RESEARCH METHODOLOGY

An experimental study of practicing auditors and auditing students was conducted in order to test hypotheses H_1 and H_2 . This section will discuss the research subjects, experimental materials and administration, and scoring of issues.

Subjects

Three groups of subjects participated in this study: auditing students, experienced staff auditors, and experienced senior auditors. Demographic information for each subject group is provided in Table 1. The student subjects were all senior accounting majors attending a medium-sized state university. The students completed the experiment during the last scheduled class meeting for their introductory auditing course. During the second week of the quarter, the students were exposed to the typical coverage of the AICPA Code of Professional Conduct included in undergraduate auditing texts. This information was tested on the mid-term examination, but not on the final examination. Thus, the students had not studied the Code of Professional Conduct for several weeks prior to the completion of the experiment.

It should also be noted that the student subjects in this study were actually an average of two years older than the experienced subjects. Because ethics researchers such as Kohlberg (1969) have proposed that moral development increases with age, this was a potentially confounding variable. However, as reported in the results section, we found no significant relationship between age and ethical sensitivity in our sample.

The experienced subjects were all employed by a single international accounting firm. Experienced subjects completed the experiment during scheduled in-house technical training sessions.

Table 1
Summary of Demographic Information

	<u>Auditing Students</u>	<u>Staff Auditors</u>	<u>Senior Auditors</u>	<u>All Subjects</u>
Number	65	54	44	163
Means:				
Age	28	26	26	27
Auditing Experience (mos.)	0	18	34	15
Proportion of:				
Males	52%	54%	55%	53%
Females	48%	46%	45%	47%
CPA's	0%	6%	34%	11%

Experimental Materials and Administration

The basic methodology for this study was adapted from Shaub et al. (1993), and required subjects to read an experimental case and identify issues they perceived to be important. The case developed for the current study is presented in Appendix 1, and descriptions of ethical, technical, and administrative issues raised in the case are presented in Appendix 2. The case was developed by one of the authors, who has several years of professional auditing experience. The case materials were reviewed by three CPA firm partners with extensive auditing experience, who all agreed that the case seemed realistic and the issues identified by the authors were valid issues.

The descriptions of the four technical accounting issues included in the case were adapted from actual footnote disclosures included in the annual reports of publicly-held companies. A fifth technical issue, relating to the turnover of key client personnel, was added to the list of legitimate issues because it was identified by almost half of the experienced subjects in this study and is also supported by professional auditing standards.²

The ethical issues included in the case were adapted from a variety of sources, including professional codes of conduct and previous research studies. Since the primary focus of this research is on sensitivity to ethical issues that are practically significant, an effort was made to include some of the major ethical problems encountered by professional auditors. For example, three of the six issues dealt with a potential conflict of interest/independence problem, which was cited by more practitioners than any other auditing issue as the job situation that poses the most difficult ethical or moral problem for them personally (Finn et al. 1988).³ The case also included a client proposal for the use of questionable accounting principles, which was the second most frequently cited auditing ethical problem (Finn et al. 1988). Additional justification for the inclusion of individual issues is provided in Appendix 2.

The two administrative issues in Appendix 2 were included because they were identified by a relatively large number of experienced subjects and appear to be legitimate concerns. No other issues were identified by a significant number of subjects.

All subjects completed the experiment in a classroom setting. Subjects were given an overview of the task, including time restrictions, and allowed to read the instructions. Subjects were then given a total of 30 minutes to read the case, identify the significant issues, and rate the perceived significance of each identified issue. Upon completion of the issue identification task, subjects completed the Ethics Position Questionnaire⁴ and a demographic questionnaire.

Scoring of Issues

All issues were independently categorized by both authors. The percentage of agreement based on the initial categorizations was 90 percent. All differences in categorization were resolved through discussion and mutual agreement.

EXPERIMENTAL RESULTS

Ethical Issues

The percentage of subjects identifying each of the six ethical issues is presented in Table 2. As indicated in the table, the auditing students identified an average of 2.72 ethical issues, which was significantly greater than the number identified by staff auditors (2.05) or senior auditors (2.20) based on t-tests. These results support H₁. The senior auditors identified slightly more ethical issues than the staff auditors, but the difference was not statistically significant. Similar results were obtained when the ethical issues were weighted by their significance ratings; thus, those results are not presented in detail.

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A higher percentage of the student subjects identified each of the ethical issues, with the exception of issue six. Chi-square tests indicated that the differences in percentages were statistically significant for three of the six issues.

A general linear model analysis for ethical issues is reported in Table 3.

In Panel A of the table, the dependent variable is the ethical summate, or the mean number of ethical issues identified by each subject. The univariate results indicate that the effect for experience is highly significant, which also supports H_1 . However, the percentage of total variation in ethical sensitivity explained by experience is quite low ($R^2 = .06$).

A multivariate analysis was also performed to test for relationships between ethical sensitivity and several individual difference variables, including subjects' idealism and relativism as measured by the Ethics Position Questionnaire, as well as age, sex, and CPA status. In the multivariate model, the experience variable remains highly significant, but none of the other independent variables approach significance. Thus, unlike Shaub et al. (1993), this study finds no significant relationship between ethical ideology and sensitivity to auditing issues.

In Panel B of Table 3, the dependent variable is the ethical significance summate, which is computed for each subject by summing the significance ratings for each identified issue. The results of this analysis are very similar to those based on the ethical summate. Again, the experience variable is significant in both models, and none of the other independent variables are significant at the .05 level.

Technical Issues

The percentage of each subject group identifying each of the five technical issues is reported in Table 4. The results are in sharp contrast to those obtained for ethical issues, as hypothesized. The staff (senior) auditors identified an average of 2.90 (2.72) technical issues, compared with a student average of only 1.12. Thus, the average for the experienced auditors was more than double that of the auditing students, and the differences between the means of the two auditor groups and the student group were statistically significant. These results provide strong support for H_2 . Again, the difference between the means of the staff and senior auditors was not significant. Similar results were obtained when the technical issues were weighted by their significance ratings; thus, those results are not presented in detail.

The percentage differences for each of the individual technical issues were significant based on chi-square tests, as indicated in Table 4. The general linear model results for technical issues, presented in Table 5, also strongly support H_2 .

Table 2

Percentage of Subjects Identifying Ethical Issues

		<u>Auditing Students</u>	<u>Staff Auditors</u>	<u>Senior Auditors</u>	<u>All Subjects</u>
Issue:					
1.	Eating Hours ^a	.43 (.49)	.33 (.47)	.34 (.48)	.37 (.48)
2.	Reducing Audit Scope	.83 (.38)	.83 (.37)	.77 (.42)	.81 (.39)
3.	Subordination of Judgement	.35** (.48)	.07 (.26)	.20 (.41)	.22 (.42)
4.	Accounting Services	.25* (.43)	.09 (.29)	.07 (.25)	.14 (.35)
5.	Recruiting	.26* (.44)	.05 (.23)	.07 (.25)	.14 (.35)
6.	Job Offer	.60 (.49)	.67 (.48)	.75 (.44)	.66 (.47)
Ethical Summate ^b		2.72*** (1.40)	2.05 (.890)	2.20 (1.07)	2.36 (1.19)

^a Numbers without parentheses represent the percentage of subjects who identified the issue; numbers in parentheses represent standard deviations.

^b Mean number of ethical issues (0-6) identified.

* Differences in percentages are significant at the .01 level based on Chi-square tests.

** Differences in percentages are significant at the .001 level based on Chi-square tests.

*** Difference between student mean and staff and senior auditor means is significant at the .05 level based on t-tests. Staff and senior auditor means are not significantly different.

Table 3

General Linear Model Results For Ethical Sensitivity

Panel A: Dependent Variable = Ethical Summate^a

<u>Independent Variables:</u>	<u>F-Value</u>	<u>p > F</u>	<u>Model R²</u>
Univariate Model:			0.06
Experience ^b	5.4	0.0054	
Multivariate Model:			0.09
Experience	5.4	0.0053	
Idealism	0.05	0.8175	
Relativism	0.96	0.3277	
Age	0.39	0.532	
Sex	1.06	0.3049	
CPA	1.49	0.2234	

Panel B: Dependent Variable = Ethical Significance Summate^c

<u>Independent Variables:</u>	<u>F-Value</u>	<u>p > F</u>	<u>Model R²</u>
Univariate Model:			0.05
Experience	4.58	0.0116	
Multivariate Model:			0.09
Experience	4.37	0.0143	
Idealism	0.13	0.7155	
Relativism	0.65	0.4219	
Age	1.46	0.2294	
Sex	0.39	0.5328	
CPA	2.83	0.0947	

^a Mean number of ethical issues (0-6) identified.

^b Student, staff, or senior

^c Computed for each subject by summing the significance ratings for each ethical issue identified.

Table 4
Percentage of Subjects Identifying Technical Issues

		<u>Auditing Students</u>	<u>Staff Auditors</u>	<u>Senior Auditors</u>	<u>All Subjects</u>
Issue:					
1.	Discontinued Operations ^a	.29** (.46)	.78 (.42)	.77 (.42)	.58 (.49)
2.	Contingent Liability	.27* (.45)	.52 (.50)	.43 (.50)	.40 (.49)
3.	Sale-Leaseback Accounting	.31** (.47)	.80 (.41)	.79 (.41)	.60 (.49)
4.	Related Party Transaction	.09** (.29)	.37 (.48)	.27 (.45)	.23 (.42)
5.	Turnover of Key Personnel	.15** (.36)	.44 (.50)	.45 (.50)	.33 (.47)
Technical Summate ^b		1.12*** (.99)	2.90 (1.08)	2.72 (1.19)	2.14 (1.38)

^a Numbers without parentheses represent the percentage of subjects who identified the issue; numbers in parentheses represent standard deviations.

^b Mean number of technical issues (0-5) identified.

* Differences in percentages are significant at the .05 level based on Chi-square tests.

** Differences in percentages are significant at the .001 level based on Chi-square tests.

*** Difference between student mean and staff and senior auditor means is significant at the .05 level based on t-tests. Staff and senior auditor means are not significantly different.

The univariate analysis in Panel A indicates that the experience variable is highly significant and explains almost 40 percent of the variation in the number of technical issues identified. As in the case of ethical issues, the individual difference variables tested in the multivariate model were not significant.⁵ The results in Panel B, which are based on subjects' perceived significance of the technical issues, are very similar to those in Panel A.

Administrative Issues

As previously discussed, a large number of experienced subjects identified two issues that were considered administrative in nature. These issues were not identified by the authors prior to the administration of the experiment; however, they appear to legitimate concerns and were separately analyzed. Table 6 presents the percentages of each subject group identifying each of the two issues. As shown in the table, approximately 20 percent of the experienced subjects were concerned about meeting the current year audit budget, while approximately 35 percent were concerned about engagement scheduling. The average number of administrative issues identified by the experienced subjects was significantly greater than the student average. The general linear model results presented in Table 7 also indicate that experience is significantly related to the number of administrative issues identified, as well as the perceived significance of those issues. As in the case of ethical and technical issues, individual difference variables were not significant.

LIMITATIONS AND DISCUSSION

As an initial test of the effects of auditing experience on both ethical and technical sensitivity, this study was exploratory in nature, and is subject to a number of limitations. For example, the use of subjects from a single university and a single public accounting firm limits the generalizability of the results. Furthermore, the experienced subject group contained relatively few CPAs, and no managers or partners. Future studies should test the generalizability of our findings by examining different subject groups as well as more experienced subjects. It is particularly important to test the ethical and technical sensitivity of firm partners and managers, since higher level personnel have the ultimate responsibility for the firm's work, and because they usually create an ethical atmosphere that influences all firm personnel.

However, if the findings of this study are confirmed by future research, they do have important implications for public accounting practitioners. We found that, in an audit planning context, experienced senior and staff auditors tended to focus on technical issues, and failed to recognize potentially significant ethical problems. In contrast, auditing students identified significantly more ethical issues.

Two factors suggest that these findings were primarily the result of subjects' environment rather than knowledge or skill differences. First, if the results were based on knowledge or skill differences developed through auditing experience, the senior auditors should have outperformed the staff auditors, which was not the case. Second, the technical issues included in the experimental case were all based on the type and level of knowledge tested on the CPA examination, but experienced subjects who had passed the CPA exam performed no better on technical issues than those who had not.

Table 5

General Linear Model Results For Technical Sensitivity

Panel A: Dependent Variable = Technical Summate^a

<u>Independent Variables:</u>	<u>F-Value</u>	<u>p > F</u>	<u>Model R²</u>
Univariate Model:			.39
Experience ^b	49.04	.0001	
Multivariate Model:			.39
Experience	46.86	.0001	
Idealism	.13	.7162	
Relativism	.02	.8896	
Age	.13	.7153	
Sex	2.04	.1553	
CPA	.55	.4606	

Panel B: Dependent Variable = Technical Significance Summate^c

<u>Independent Variables:</u>	<u>F-Value</u>	<u>p > F</u>	<u>Model R²</u>
Univariate Model:			.33
Experience	39.96	.0001	
Multivariate Model:			.34
Experience	38.10	.0001	
Idealism	.00	.9709	
Relativism	.57	.4515	
Age	.01	.9094	
Sex	1.17	.2812	
CPA	.33	.5693	

^a Mean number of technical issues (0-5) identified.

^b Student, staff, or senior

^c Computed for each subject by summing the significance ratings for each technical issue identified.

Table 6
Percentage of Subjects Identifying Administrative Issues

Issue:	<u>Auditing Students</u>	<u>Staff Auditors</u>	<u>Senior Auditors</u>	<u>All Subjects</u>
1. Meeting the Budget ^a	.08* (.27)	.20 (.41)	.20 (.41)	.15 (.36)
2. Engagement Scheduling	.03** (.17)	.30 (.46)	.39 (.49)	.21 (.41)
Administrative Summate ^b	.11*** (.31)	.50 (.67)	.59 (.69)	.36 (.59)

^a Numbers without parentheses represent the percentage of subjects who identified the issue; numbers in parentheses represent standard deviations.

^b Mean number of administrative issues (0-2) identified.

* Differences in percentages are significant at the .10 level based on Chi-square tests.

** Differences in percentages are significant at the .05 level based on Chi-square tests.

*** Difference between student mean and staff and senior auditor means is significant at the .05 level based on t-tests. Staff and senior auditor means are not significantly different.

An alternative explanation for the superior performance of the professional auditors in identifying technical issues is that these subjects may be more intelligent because it is likely that they were outstanding students. It is well known that large CPA firms such as the one participating in this study tend to hire graduates with high grade point averages. However, if this is the case, this makes the superior performance of the auditing students in identifying ethical issues all the more significant. If the professional auditors possessed superior intelligence, this should have enabled them to identify more of the ethical issues included in the case as well as the technical issues, and would have biased the study against our first hypothesis.

The findings of this study raise concerns about the ethical sensitivity of young professionals. Of the six ethical issues included in the experimental case, only two were identified by more than half of the subjects. Issue two, relating to the reduction of audit hours in order to maintain the profitability of the engagement, was identified by a strong majority of all subject groups. Issue six, receiving a job offer from a client, was also identified by the majority of all subjects, and is the only ethical issue identified by a higher percentage of auditors than students. The experienced subjects were relatively insensitive to the remaining issues.

Table 7

General Linear Model Results For Administrative Sensitivity*Panel A: Dependent Variable = Administrative Summate^a*

<u>Independent Variables:</u>	<u>F-Value</u>	<u>p > F</u>	<u>Model R²</u>
Univariate Model:			.12
Experience	11.24	.0001	
Multivariate Model:			.14
Experience	10.82	.0001	
Idealism	.75	.3871	
Relativism	.14	.7049	
Age	1.50	.2230	
Sex	.60	.4416	
CPA	.71	.4005	

Panel B: Dependent Variable = Administrative Significance Summate^c

<u>Independent Variables:</u>	<u>F-Value</u>	<u>p > F</u>	<u>Model R²</u>
Univariate Model:			.10
Experience	8.72	.0003	
Multivariate Model:			.12
Experience	8.26	.0004	
Idealism	.22	.6433	
Relativism	.36	.5472	
Age	1.51	.2211	
Sex	.31	.5810	
CPA	1.22	.2708	

^a Mean number of administrative issues (0-2) identified.^b Student, staff, or senior^c Computed for each subject by summing the significance ratings for each administrative issue identified.

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It is interesting to note that issue one, eating hours, was identified by only about one-third of the experienced subjects. In contrast, this issue was identified by over 80 percent of the experienced subjects in the Shaub et al. (1993) study, even though the wording of the issue in the two experimental cases was virtually identical. The difference could be attributable to the fact that the case used in the current study included substantive technical issues which had a distracting effect. This is consistent with Shaub et al.'s (1993) observation that professionals' preoccupation with technical issues may reduce their ethical sensitivity. Another possibility is that the time restriction imposed in the current study had a negative impact on ethical sensitivity. No similar restriction was imposed on the Shaub et al. (1993) subjects.

Issue three was based on the auditor's acquiescence with the client's desired accounting treatment if "any support" for the client's position existed. Only seven percent of the staff auditors and twenty percent of the senior auditors identified this issue. The need for auditors to be sensitive to this type of situation is widely recognized. For example, the Macdonald Commission of Canada noted that

...the auditor has a particular responsibility, when faced with situations for which there is no clear precedent, to be satisfied that the accounting proposed is reasonable in relation to the substance or economic reality of the thing or transaction accounted for (1988, cited in Public Oversight Board, 1993, p. 47).

It is interesting to note that auditing practitioners have recently come under criticism for failing to meet this responsibility. For example, the Public Oversight Board of the AICPA made the following observation:

The Board's review of cases of alleged audit failure studied by the QCIC in recent years indicates that in many such cases consultation on accounting matters had occurred and the matters had been extensively considered and debated. In too many cases, however, the preference of client management-influenced at least in part by objectives other than producing the most reliable financial reporting possible in the circumstances-nevertheless prevailed over the preference of the auditing or consulting partner (POB, 1993, p. 48).

In response to such criticisms, an advisory panel of the Public Oversight Board recently suggested that auditors should forthrightly communicate to corporate boards and audit committees their views on the *quality*-not just the *acceptability*-of a company's financial reporting (Kirk and Siegel, 1996).

The wording of this issue in the experimental case was designed to test if subjects would recognize the ethical problem created by the hypothetical auditor's willingness to be unduly influenced by the preferences of client management. The experienced subjects' insensitivity to

this issue is not inconsistent with criticisms currently being leveled against the auditing profession.

Finally, although issues four and five have been the subject of ethics interpretations and rulings by the AICPA, they were acknowledged by less than ten percent of both experienced subject groups. Again, this suggests inadequate ethical sensitivity on the part of the young professionals participating in this study.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The results of this study suggest that working in the professional auditing environment improves the ability to recognize technical auditing and accounting issues, but does not enhance sensitivity to ethical issues. If supported by future research, these findings appear to have important implications for public accounting firms. In particular, they suggest that auditing practitioners need to place more emphasis on the development of young professionals' ethical sensitivity. Since senior and staff auditors do the majority of the work on most engagements, they are in a position to observe many potential ethical issues that may not come to the engagement manager or partner's attention. Therefore, the failure of these lower-level personnel to recognize potential ethical problems may ultimately compromise the professionalism of the firm.

There has been a great deal of debate regarding the effectiveness of ethics education. However, Wright et al. (1996) recently found that educational interventions based on stakeholder theory improved accounting students' ability to recognize ethical issues. Perhaps public accounting firms should integrate similar educational interventions into their regular training schedules. Future research should investigate the effectiveness of such interventions when included as part of the continuing education programs of accounting firms.

There is also a need for additional research on the determinants of ethical and technical sensitivity. The experience variable in our study explained less than ten percent of the variation in ethical sensitivity, and none of the individual difference variables examined were significant. However, like studies in the social psychology literature, this study implies that contextual or situational variables may play a key role in ethical sensitivity. For example, the fact that the experienced subjects in this study were much less likely to identify the issue of eating hours than the Shaub et al. (1993) subjects suggests that the inclusion of technical issues or the time limitation imposed may have distracted subjects from ethical considerations. Future research should explore the effects of such situational variables on auditors' ethical sensitivity. Future research should also address the determinants of technical sensitivity, or the ability to identify technical auditing and accounting issues. Although this skill is obviously important to the effective and efficient conduct of an audit engagement, it has received very little attention. This

study found that experienced auditors outperformed students at issue identification, but did not outperform staff auditors. As indicated in the discussion, this suggests that the auditor/student differences in technical sensitivity may be attributable to a selection bias (i.e., CPA firms screen out less competent graduates) rather than experience effects. However, this raises an obvious question as to why experience does not enhance the ability to recognize technical issues. Research similar to that conducted by Bonner et al. (1992) in a tax planning context could help clarify the determinants of technical sensitivity in auditing.

NOTES

1. Other studies in the social psychology literature also raise doubts about the significance of personality variables as predictors of ethical sensitivity. For example, Pinto and Kanekar (1990) hypothesized that subjects scoring high on machiavellianism would be relatively insensitive to ethical characteristics in their evaluation of a hypothetical stimulus person. However, they found no consistent support for this hypothesis.
2. None of the results or conclusions of this study differ when this issue is omitted from the analysis.
3. The ethical problem most frequently cited by practitioners was client proposals for tax alteration and tax fraud, which is not within the scope of this study.
4. The Ethics Position Questionnaire is a standard psychological instrument designed to measure a person's ethical ideology. Because Shaub et al. (1993) found a significant relationship between ethical ideology and ethical sensitivity, the instrument was administered in the current study for purposes of replication.
5. There was no a priori reason to suspect any association between technical sensitivity and ethical ideology (idealism and relativism), but these variables were tested for the sake of completeness. The results of the analysis are similar when these variables are excluded from the model.

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Appendix 1

Experimental Case

Instructions

You are about to read a brief auditing case. To the extent possible, place yourself in the CPA's shoes. Different aspects of the case would vary in significance to you were you to encounter them in reality. I am interested in finding out what would be important to you.

Auditing Scenario

John Simmons is an audit manager with a national CPA firm. He was recently assigned the audit of Consolidated Stores, Inc. (CSI), a continuing audit client, for the fiscal year ending January 31, 1996. CSI, which is one of the firm's largest auditing and consulting services clients, owns and operates several national retail department store chains. Through its wholly-owned subsidiary, Holmes Co., CSI is also a wholesale distributor of premium-priced ladies clothing. CSI has been a profitable client in the past; however, the current-year audit budget was reduced significantly from prior-year levels in order to retain the engagement. John also learned from Jane Robinson, the senior on the prior-year audit, that the prior-year actual hours were understated due to the failure of some staff people to charge their wheel-spinning time to the engagement. As a result, John feels that it will be necessary to reduce the extent of auditing procedures from previous years in order to ensure that the engagement is profitable.

As part of the preliminary planning process, John met with Jim Ellis, the controller of CSI, during September 1995 to discuss general matters relating to the engagement. John planned to schedule some interim fieldwork for the first two weeks in December, and wanted to make sure the client would be prepared. After discussing preliminary matters and going over CSI's interim financial results, Ellis indicated that he was concerned about the effects of several factors on the current-year audit and financial statements.

His first concern was that CSI was considering a spin-off of Holmes Co. If approved, the spin-off would be completed during December, 1995 by distributing Holmes stock to the CSI stockholders of record at the close of business on November 15, 1995. After the spin-off, CSI would own no shares of Holmes stock, but would guarantee Holmes' debt obligations up to \$50 million until Holmes' achieved certain financial ratios. Ellis said he was not sure how the spinoff would affect the current-year financial statements.

Ellis also indicated that during August, 1995, a corporation that was partially owned by CSI purchased 37 of the company's department store properties for approximately \$400 million and leased the stores back to the company for a 10-year base term, plus renewal options. At the end

of the initial lease term CSI has an option to repurchase the stores for a cash price of approximately \$200 million. According to Ellis, the company will probably repurchase the properties, since the fair market value of the stores at the end of lease term is expected to be significantly more than \$200 million. Ellis said that the management of CSI wants the transaction to be accounted for as a sale/leaseback. Although John's initial reaction was that the deal was simply a financing arrangement, he agreed to research the reporting requirements and assured Ellis that he would agree with sale/leaseback treatment if there was any support for this position.

Finally, Ellis expressed concern about whether CSI would be ready to start the fieldwork during December, since Bob Jackson, one of the company's accounting managers, had recently resigned and a qualified replacement had not been found. John suggested that if a replacement was not found soon, his firm might be able to provide assistance in helping CSI prepare for the audit, and that he might be able to assist in the recruiting process or recommend someone for the job. He was somewhat surprised when Ellis asked if he was interested in the position himself. He thanked Ellis and told him he would consider his offer. On the way back to the office, John thought about how hard he had been working during the past few months, and remembered that his wife had recently suggested that he consider leaving public accounting.

PLEASE INDICATE BRIEFLY THE NATURE AND SIGNIFICANCE OF ANY ISSUES YOU WOULD BE CONCERNED WITH IN THIS SCENARIO. SIMPLY INDICATE:

1. THE SIGNIFICANCE OF THE ISSUE BY CIRCLING A NUMBER BETWEEN ONE AND SEVEN; AND
2. THE NATURE OF THE ISSUE ON THE LINES BELOW THE CIRCLED NUMBER. YOU DO NOT NEED TO INDICATE HOW YOU WOULD RESOLVE ANY ISSUES.

Very Insignificant Issue

Very Significant Issue

1 2 3 4 5 6 7

Issue: _____

Appendix 2

Issues Included in Auditing Case

Ethical Issues:

1. The fact that prior year actual hours were understated due to the failure of some staff members to fully charge their time raises the general ethical issue of "eating time". Although this issue is not specifically addressed in the AICPA Code of Professional Conduct, it was one of the three issues included in the Shaub et al. (1993) study, and was included here for purposes of replication.
2. John's intention to reduce the extent of auditing procedures to maintain the profitability of the engagement indicates a potential impairment of several general auditing standards, such as the requirement to exercise due care in the performance of the engagement and the requirement to obtain sufficient, competent evidential matter. Due to intense competition, this has been a major issue facing the profession for several years, and has been extensively discussed in both the practitioner and academic literature.
3. John's assurance that he would agree with sale/leaseback treatment if there was any support for this position indicates a potential subordination of judgment problem. This has been another major issue facing the profession over the past several years, and was recently addressed by the Public Oversight Board of the AICPA.
4. If John's firm provides assistance in helping CSI prepare for the audit, this may impair independence. The auditor's responsibility under AICPA rules in this case is set forth in Interpretation 101-3 of the Code of Professional Conduct, which stipulates that independence is impaired when a member provides accounting or bookkeeping services to a client, unless certain conditions are met. For example, the member must not assume the role of employee or of management. The situation described in the case involves the CPA offering assistance due to an accounting manager's resignation; thus, there is a clear implication this assistance would involve more than routine bookkeeping functions. This issue was included to test if the frequency with which CPA firms provide various types of client assistance has desensitized practitioners to their professional responsibility to carefully evaluate the nature of such services and their potential impact on independence.
5. Jacobson's participation in the recruitment of a new controller for JPW is a potential impairment of independence. The AICPA has ruled that, assisting a client in recruiting and hiring employees impairs the auditor's independence. However, an auditor may perform services such as developing a position description and candidate specifications and recommending qualified candidates for a position, provided client management is

responsible for any ultimate hiring decision. Several previous studies of auditor independence judgments have addressed this situation.

6. The fact that Ellis asked John if he was interested in the accounting position is also a potential impairment of independence. The AICPA ethical rules stipulate that, if an employee of an auditing firm receives an offer of employment from an auditing client during the course of an engagement, that employee's independence is impaired as long as the offer is outstanding.

Technical Issues:

1. Spin-off/Discontinued operations. The spin-off of Holmes Co. should be accounted for as a discontinued operation, since JPW has no continuing interests which operate the same line of business or sell to the same class of customer.
2. Contingent liability/Off-balance-sheet Risk. Assuming that a loss is at least reasonably possible, JPW's guarantee of the debt of Holmes is a contingent liability which should be disclosed in the 1995 financial statements. The amount of off-balance-sheet risk created by financial guarantees written is also required to be disclosed pursuant to SFAS 105.
3. Applicability of sale-leaseback accounting. The sale and leaseback of the 37 stores raises a question regarding the applicability of sale/leaseback accounting. Since JPW intends to repurchase the properties at the end of the lease term, this appears to be simply a financing arrangement.
4. Related party transaction. The purchase and leaseback of the department stores by a company that is partially owned by CSI is a related party transaction.
5. The turnover of key accounting personnel and resulting difficulty in being prepared for the audit on time should alert the auditor to the possibility of errors and irregularities.

Administrative Issues:

1. Reduced budget. The reduction in the current year audit budget will result in difficulty in completing the audit within the budgeted number of hours. Credit for this issue was given if subjects discussed the problem of meeting the budget without making any reference to the reduction in auditing procedures to maintain the profitability of the engagement (the second ethical issue). Most of the subjects who identified this issue separately identified the related ethical issue.

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2. The client's difficulty in preparing for the audit indicates that the start of the audit may have to be delayed. This may create scheduling problems for the firm.

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A CASE STUDY OF MANAGEMENT ACCOUNTING EVOLUTION IN THE WORLD-CLASS MANUFACTURING COMMUNITY

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Just as individual manufacturing cells strive for continuous improvement, reduced setup times, and elimination of nonvalue-added activities, the accounting organizations within the eight Shingo manufacturers examined in this study have been able to accomplish corresponding objectives by eliminating accounting wastes such as unnecessary transaction processing, excessive paper handling, unnecessary reports, outdated controls and procedures, and excessive historical analyses. Additional results from this field study suggest that reductions in manufacturing cycle times, changes to cellular manufacturing, and the implementation of JIT systems have reduced the need for much of the detailed transaction processing associated with tracking work-in-process inventories. As a result, accountants must re-evaluate the benefits of traditional costing measurements in light of modern manufacturing processes. Furthermore, accountants must be careful that the tracking of internal transactions and the measurement of resource utilization are not creating perverse incentives or perpetuating barriers to continuous improvement within the organization. Finally, the study findings suggest that accountants must develop methods to measure the prospective financial impact of employee actions.

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Although the management accounting function has historically played an important role in providing operating managers with the information needed to make decisions, severe criticism of the accounting profession has raised doubts about its long-term viability. The profession has been struggling with major changes in the industrial, economic, and technological landscapes. For example, competitive pressures in an increasingly global market have forced businesses to make continual improvements in both product quality and production efficiency. Technological advances and the emergence of new management paradigms have exerted a significant influence on the competitive structure of virtually all industries. Robotics and other computerized production technologies have eliminated the labor intensiveness of many production processes. Similarly, manufacturing philosophies such as just-in-time (JIT), total quality commitment, and zero waste have impacted significantly on manufacturing methodologies. Yet, according to some academicians and practitioners, management accountants have been deficient in providing decision-making information to managers that is relevant in light of new manufacturing and production paradigms. Johnson and Kaplan (1987) claim that "management accounting information is produced too late, too aggregated, and too distorted to be relevant for managers' planning and control decisions."

Other researchers propose various strategies for making management accounting more relevant. Boer (1991) suggests that accounting should undergo the same cost/benefit scrutiny as other functional areas. Such scrutiny should eliminate accounting activities that either promote dysfunctional behavior within the organization or fail to lead to higher quality products or more efficient production processes. McNair and Carr (1991) emphasize that management accounting should go beyond placing a value on inventory for financial reporting purposes. They suggest that the development of a system to measure the cost of quality is an example of an accounting activity with potential for adding value to the firm. Convey (1991) and Turney (1992) describe several approaches for analyzing the relevance and value-added nature of accounting activities. Opportunities also appear to exist for management accountants to improve decision support by providing managers with information across multiple dimensions such as products, distribution channels, and customers (Cooper and Kaplan, 1991; Rolfe, 1992). Similarly, supporting higher level decision making such as strategic planning offers a significant opportunity for accountants that has yet to be effectively exploited (Bromwich, 1990).

The increasing complexity and uncertainty confronting modern business operating environments has fueled the demand for increasingly sophisticated information support. While the management accounting profession scrambles to regain relevance in the modern manufacturing environment, it is clear that some innovative companies have already achieved levels of excellence in their manufacturing methodologies. For example, prestigious awards such as the Malcolm Baldrige National Quality Award and the Shingo Prize for Excellence in American Manufacturing have been bestowed upon American manufacturers who have achieved world-class status in competitiveness. Nevertheless, the role management accounting

has played in these successful organizations is not clearly understood. In order to more fully understand the contributions made by management accounting to manufacturing excellence, a study of eight Shingo Prize recipients (Appendix I) was conducted to help determine the impact of the world-class manufacturing environment on the management accounting function, and how the management accounting function contributed to the success of these world-class manufacturers. By compiling the results of these case studies, the authors sought to construct a profile of management accounting as practiced within several prize-winning organizations.

THE SHINGO PRIZE FOR EXCELLENCE IN MANUFACTURING

The Shingo Prize for Excellence in Manufacturing, named in recognition of the late Japanese industrial engineer, Dr. Shigeo Shingo, was established in 1988 to recognize North American companies that have demonstrated excellence in productivity and process improvement, quality enhancement, and customer satisfaction. The overriding philosophy of the Shingo Prize is that world-class manufacturing status is achieved by focusing on core manufacturing processes; implementing lean, flexible production systems; eliminating waste; and achieving zero defects. At the same time, the award fosters continuous product improvement and continuous cost reduction (Robson, 1991).

The Shingo Prize Model of Manufacturing

The Shingo Prize Achievement Criteria are based on the Shingo Prize Model of Manufacturing (Figure 1). The premise of the model is that the total quality and productivity management culture and infrastructure (category I) leads to the implementation of world-class manufacturing strategies, processes, and systems (category II). In turn, these strategies, processes, and systems should result in measured improvements in quality and productivity (category III). Finally, the ultimate measure of manufacturing success is viewed in this model as customer satisfaction (category IV). Applicants for the prize must therefore document their accomplishments within each of these categories in an achievement report submitted to the Shingo Prize Board of Examiners. The achievement reports are scored according to procedures outlined in the Shingo Prize Application Guidelines. Finalists emerging from this evaluation process are further evaluated on-site by a team of examiners (Shingo Prize Council, 1997).

RESEARCH METHODOLOGY

In 1993 Kaplan suggested that a field-study approach involving firms with "considerable experience with the new practices" may yield promising results for the discipline of management accounting. He cautioned, however, that because no "Japan" existed to serve as a laboratory for management accounting practices, field research studies would tend to "capture traditional

management accounting systems operating in environments radically different from the ones for which the system was designed” (Kaplan, 1993). Nevertheless, the authors of this manuscript assert that this field study offers a unique opportunity to capture a cross-section of American companies that have successfully adopted Japanese manufacturing methods and have demonstrated world-class manufacturing prowess, supported by innovative management accounting practices.

Figure 1

The Shingo Prize Model of Manufacturing

<p>I</p> <p>Total Quality and Productivity Management Culture</p> <p>•</p> <p>Leading</p> <ul style="list-style-type: none">• Empowering• Partnering	<p>II</p> <p>Manufacturing Processes and Systems</p> <p>•</p> <p>Manufacturing vision and strategy</p> <ul style="list-style-type: none">• Manufacturing process integration• Quality and productivity methods• Manufacturing and business integration	<p>III</p> <p>Measured Quality and Productivity</p> <p>•</p> <p>Quality enhancement</p> <ul style="list-style-type: none">• Productivity improvement
<p>IV. Measured Customer Satisfaction</p>		

The Advance Questionnaire

An advance survey questionnaire was sent to the eight participating Shingo Prize companies to help them prepare for the types of questions to be asked in the site interviews. The questionnaire was designed to elicit anecdotes and other documentation of the companies' experiences. Among the survey questions, key company personnel were asked to describe the role played by the management accounting function in the evolution of the organization toward world-class manufacturing. They were also asked about the changes in their management accounting function as a result of changes in the manufacturing environment, and they were asked to document any innovative management accounting applications they had developed.

Site Visits to Participating Companies

Visits to the eight participating companies were made to observe plant operations with emphasis on the supporting accounting functions and activities, and to conduct interviews with key personnel. An attempt was made to examine various perspectives both inside and outside the management accounting function. Therefore, key personnel interviewed typically included the plant manager, production foreman, procurement manager, engineering manager, chief financial officer, and cost accountants. Their responses to both the advance questionnaire and interviews were documented and transcribed.

THE RESULTS: THE SHINGO MANAGEMENT ACCOUNTING PROFILE

The experiences of the eight Shingo Prize recipients provided a basis for developing a profile of lean management accounting. In the following sections, an attempt has been made to compile a composite set of characteristics typical of the Shingo environment.

The Integration of Accounting and Manufacturing Cultures

As explained earlier, the Shingo Prize is awarded to companies demonstrating that they not only have achieved a world-class level of competitiveness within their manufacturing operations but also have integrated quality management, waste reduction, and productivity enhancement methods throughout the organization. According to Lifeline Operations Vice-President John Gugliotta:

World-class quality will only be attained when continuous improvement philosophies extend into all departments within an organization (Gugliotta, 1991).

Therefore, service units such as accounting conduct themselves in much the same spirit as their manufacturing counterparts by decreasing their reporting cycle times, improving transaction processing accuracy, and eliminating unnecessary transaction processing and financial reporting. Not only do accountants in the lean manufacturing environment measure other departments, but they also scrutinize themselves, assuring through ongoing measurement that accounting processes are producing quality output and that accounting responsibilities are being effectively discharged.

The Effects of Lean Manufacturing on Management Accounting Measures

The move from functional batch-oriented manufacturing systems toward cellular continuous-flow manufacturing has forced management accountants to re-evaluate the methods

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used to measure the efficiency of productive capital utilization. Similarly, the tenacious focus of the Shingo Prize recipients on agile production methods (such as setup reduction) continues to shorten manufacturing cycle times and diminishes the justification for in-process transactions. These concepts are more fully discussed in the following paragraphs.

Reduced Cycle Times

As manufacturing cycle times decline, the expenditure of human resources to record labor and material transactions as a product flows through its manufacturing processes would appear to make less sense. In many cases, the processing of such data lags significantly behind the physical flow of the product. A common practice in the Shingo environment is the use of back flushing in which the resource consumption of a finished product is computed *ex post* using the bill of materials to relieve raw materials inventory and standard conversion times to apply direct labor and burden to the product. United Electric Finance Vice President Brian Hallahan describes the need to simplify the accounting for work-in-process:

You take a product from the raw materials stage, you build it in a day, and then you put a transaction through at the end of the day to pull it right through work-in-process and into finished goods. Because the manufacturing process happens so fast, you don't bother following the transactions with paper. Why move the product five times on paper when the product is gone before the paper is processed? (Hallahan, 1993)

As a result, production workers spend their time adding value to the product or improving processes, not recording transactions.

In addition to being nonvalue-added activities on the production line, recording in-process transactions can actually create perverse incentives leading to local optimization. This is especially true when a functional department is measured by how much it transfers to a subsequent manufacturing process rather than by actual finished product shipments. An example of this took place at AT&T Power Systems – Dallas (now a business unit of Lucent Technologies) as explained by Power Systems Administrative Director John Archer:

The plant used to have a storeroom in the middle of the factory to store work-in-process inventory. Individual functional departments could remove raw material, perform their part of the process, then return it to the storeroom and receive recovery (credit for a sale) when the transfer transaction is processed. Another department would eventually retrieve the work-in-process item from the storeroom and perform its operations. Because each department got credit as soon as they completed their operation and returned it to inventory, their incentive was to build excess inventory. Therefore, the transfer transactions were causing three problems: (1) departments would tend to build excess inventories of selected parts because they got immediate

shipping credit upon transfer; (2) the storage and transport of the excess inventory represented additional waste; and (3) significant wasted effort was involved in entering and processing the transactions themselves (Archer, 1993).

Now, when inventory leaves the storeroom, it is not transferred back. A cell will only work on a component or assembly that is needed for a customer shipment. In addition, as Power Systems has moved to JIT, unnecessary transactions have been eliminated, particularly those involving the transfer of work-in-process between departments. Archer continues:

As you go to JIT you begin to realize that your in-process [inventory] is going down. You don't need to know where everything is because your cycle times are getting shorter and the materials are flowing through and you are doing a lot of unnecessary work [entering transfer transactions]. We eliminated all that...The only time a shop knows that they are getting "paid" for a product is when the product ships. We call that back flushing (Archer, 1993).

Cellular Manufacturing

The Shingo Prize recipients have recognized that the focus of efficiency measures should be at the manufacturing-cell level rather than at the machine or employee level. Clearly, the only meaningful utilization concern will be at each cell bottleneck; tracking the utilization of non-bottleneck resources is largely wasted effort.

Eliminating Accounting Barriers to Continuous Improvement

Traditionally, American management accounting measurements have focused on keeping labor fully utilized. As United Electric Electronic Operations Manager John Williams relates:

The former manner in which costs were viewed became barriers to the continuous improvement process. Using old modes of thinking, it would not have been considered efficient to spend time training employees when they could be spending their time building more products (Williams, 1993).

The Japanese management style allows for time periods during which the worker is not physically engaged in production. This non-production time is expected to occur occasionally as pull system demands have been met (i.e., the kanban is filled). Workers finding themselves in this situation use this time to pursue continuous improvement efforts rather than to build excess inventory. Clearly, accounting systems that penalize workers and departments for such situations must be redesigned.

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Continuous Accounting Improvement

While management accounting is no stranger to scrutinizing other functional departments, it has a relatively short history of self-evaluation. Because companies within the Shingo environment have integrated continuous improvement methodologies throughout the organization, service departments such as accounting find themselves with the same continuous improvement mandate as the production departments.

Efforts among the companies in this study show a variety of efforts aimed at continuous improvement. Some have involved the reduction in cycle times for reporting and month-end closing. Others have involved cause-and-effect analyses of credit memorandums and other transaction errors. Many of the companies were actively partnering with outside firms to reduce the complexity of transaction processing, the volume of paper document handling, and the resulting transaction costs. Most of the firms were actively pursuing mistake proofing of accounting processes. Also, metrics such as response time were used to measure and improve performance of the accounting function in returning bid quotations to customers. Lifeline Systems offers an interesting example of accounting self-measurement as explained by John Giannetto, Lifeline Corporate Manager for Materials and Purchasing:

A measure of the effectiveness of the paperless purchasing system is the number of manual checks written. This is an activity that Lifeline wants to eliminate because it costs much more to write a check manually than to process it through the system. Another non-value-added activity performed by accounting is the month-end close. Therefore, the length of the closing process is measured and reported with the intent to reduce the closing duration (Giannetto, 1993).

Giannetto further believes that accounting must focus on the operational aspects of benchmarking. He believes that a metric should indicate progress toward eliminating non-value activities. Rather than asking "how many activities are you doing," we should be asking, "how well are you doing those activities"? For example, rather than measuring the number of line-items in the inventory, an accountant should measure the number of production days lost to take physical inventory. Instead of measuring the number of employees supported by payroll services, the ratio of employees to payroll staff could be computed. Giannetto believes the key question to be asked is, "What is the measurement that helps you understand what the process is doing?" For example, he suggests that rather than measuring number of expense reports processed, measure the number or reports processed without error. Instead of measuring how many products are produced, measure the number of products produced per employee (Giannetto, 1993).

The Elimination of Accounting Waste

In the area of waste elimination, management accountants must be as aggressive as their manufacturing counterparts in identifying and removing nonvalue-added activities. Several examples of accounting waste elimination follow:

- 1) *Unnecessary Transaction Processing.* Accountants understand the costs of transaction processing and should continually seek to eliminate transactions that do not lead to better decision making and organizational efficiency. The chart of accounts can be streamlined to reduce the time spent in account lookup and selection, minimize the chances for coding errors, and minimize computer storage and processing time. According to United Electric Cost Accounting Manager Alan Waugh:

We have cut down on the number of general ledger accounts. We have cut down the number of departments we used to have. With the number of accounts we used to have, you would have thought we were General Motors. We had eighty or ninety departments, one-man bands, if you will. We don't need that kind of reporting. We are not General Motors (Waugh, 1993).

Accountants should also reduce the time spent on immaterial adjusting entries or unnecessary precision of accounting estimates--particularly if the adjustments cause delays in the closing and reporting process.

The Shingo Prize recipients have shown that travel expense transaction processing can be simplified through automation and reduced paper documentation processing. These firms have also shown that invoices can be consolidated and arrangements can be made with vendors to reduce the number of checks that need to be processed.

- 2) *Processing Paper Documents.* Clearly, the handling of paper documents results in several wasted actions and resources. These documents must be manually filed and retrieved, resulting in the waste of human effort and storage space. The documents must be physically routed, requiring additional time delays and often result in misplaced documents. Paper documents require human action and are therefore subject to wait time in the "in" basket, making them less accessible and more difficult to track.

Modern technology such as electronic data interchange (EDI) and electronic imaging should be aggressively explored as alternatives to paper handling.

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- 3) *Unnecessary Reports.* Accountants need to determine the extent to which their products are being used. Accounting resources spent producing unused reports can be redeployed in other proactive efforts.
- 4) *Unnecessary Controls and Procedures.* The accounting profession must continue to re-evaluate the appropriateness and cost effectiveness of controls and procedures. This can be done without sacrificing prudence. For example, Iomega Corporation discontinued asset tagging because the fixed asset system already tracked capital purchases and associated serial numbers. United Electric reduced the number of employees in the authorization loop with respect to resolving small account discrepancies.
- 5) *Accounting Artifacts.* The term *artifact* often refers to a tool of an earlier civilization. Although such ancient tools at one time provided practical benefits to their users, these items are only curiosities today, having been rendered obsolete long ago by advancing technology. Similarly, some accounting procedures are rapidly becoming artifacts. For example, closing a plant or business to take a complete physical inventory is an artifact of an earlier era that was considered necessary before automated perpetual inventory and cycle counting. As Gugliotta observes:

Most companies who have put in a computer system today have forgotten one major piece. They have forgotten to update the manual systems. Accountants are probably the worst ones. They still want a copy of the transaction ticket. They want a copy of the purchase order, a copy of the invoice, and a copy of the receiving ticket. You don't need most of that stuff if you have a system in place. We eliminate a lot of source documents when we do backflushing after the fact (Gugliotta, 1991).

As the reliability of modern systems becomes generally established, accountants can develop the expertise to audit and trust the systems rather than relying only on the system's outputs. The same can be said about any accounting procedure that forces the productive resources of the company to work around it. Gugliotta challenges the audit function in the following quotation:

We've made your job easier ... it should be easier for you to audit us. Therefore, you should be here fewer days and charge us less money. We want you to tell us why you have to be here to audit some of these things or why you can't come during the year to audit some of the processes we use as opposed to auditing the numbers at the end of the year (Gugliotta, 1991).

- 6) *Historical Analysis.* Not surprisingly, production management finds little relevance in most historical reporting. For example, Dana Corporation has strictly limited

backward-looking analyses. A more productive use of accounting resources may be to study the linkage of production processes to financial results, thus giving managers a forward-looking financial tool.

Toward a Proactive Management Accounting Culture

The preceding sections may seem to suggest that the management accounting role will diminish as a result of new technologies and a tenacious focus on eliminating nonvalue-added activities. While this is probably a fair assessment of traditional management accounting activities, it overlooks the great need the modern manufacturing plant has for a proactive financial consultant. Interviews by the authors, both inside and outside the accounting function, suggest that there is a significant opportunity for management accounting to satisfy this need.

- a) *Becoming Business Consultants.* Sentiments across the Shingo horizon are that manufacturing personnel would like to see less of the accountant in the role of a financial dictator, watchdog, or gatekeeper. Lucent Technologies - Power Systems Chief Financial Officer A. L. (Pete) Peterson believes that no financial officer should bear the title of "controller."

I have a personal hangup about the word 'controller'. That word to me is like saying 'gotcha.' The objective used to be to catch somebody doing something wrong and point it out, as opposed to saying, 'if you do it this way it will lessen the risk, improve the return, or shorten the cycle time.' There is a completely different flavor to the controllership function. Unfortunately, here we are trying to overcome a history where the position has *demand*ed rather than *offer*ed information (Peterson, 1993).

What manufacturing organizations do want are financial advisors to help them run their businesses. It is also clear that manufacturing would like to see increased emphasis by accountants on future-oriented support and decreased emphasis on historical analyses. Areas such as strategic planning, up-front system design, and up-front product design offer important consulting opportunities for the management accounting profession.

- b) *Management Accounting Support That Empowers.* Within the Shingo culture, it is at the level of the manufacturing cell that empowerment is taking root. Cells need to be able to develop measures for tracking their own performance. They are likely to need the assistance of the management accounting function in developing these measures. Management accounting is also in an excellent position to show the manufacturing cells how to access relevant data from the database.
- c) *Knowing the Core Business.* The proactive involvement of the management accountant will require that he or she fully understand the core business and the

production processes that drive it. United Electric General Ledger Manager Kelly Tonner expects her staff to become involved in UE team projects outside the accounting area. Tonner's admonition to her staff is "you work in Finance, but you work for United Electric -- go find out what's going on in this company." She has also brought in sales representatives to give presentations to her staff on the types of products being produced at UE (Tonner, 1993).

As the Shingo companies have shown, this knowledge of the core business require more direct involvement with the production floor. This will take several forms, such as cross-training, physical placement within production, job enrichment, and team participation. Clearly, the credibility of management accounting products will hinge directly on the degree to which management accountants are perceived as understanding the business and its operating processes. As Lucent Technologies - Power Systems Senior Financial Planner Kevin Mortazavi observes:

When I approach those financial people [those with operational experience] I always come away with a complete understanding of the process. When I go to a purely financial person who hasn't been out there, I can tell the difference. They know their job but they don't have a clear picture of the overall situation. Broadening financial personnel will give finance more credibility. It's a lot easier for me to meet with a Business Unit Head and talk about productivity when they know I have been out there and that I know what they are talking about (Mortazavi, 1993).

Management Accountants as Educators

This study of eight Shingo Prize manufacturers reveals that management accounting must develop its role as the financial educator to the organization. Management accounting should strive to raise the level of financial understanding and sophistication of their constituents. Gugliotta (1993) emphasizes that the primary job of the finance function is not merely to report what happened, but rather:

One of the functions of any finance organization is to educate the world around them. Finance helps people understand how their activities affect the profits of the organization.

Management accounting is in the best position to study and articulate the linkages between operational measures and their corresponding financial results. These linkages will allow decision makers to evaluate prospective decisions and take them beyond postmortem analyses. Engineers will better understand the financial consequences of their design decisions. Finally, workers will better understand the financial consequences of their work patterns.

CONCLUSION

The results of a study of eight Shingo Prize recipients reveal that innovative management accounting practices are most often driven by and run parallel to innovative manufacturing practice. Like their manufacturing counterparts, management accountants within these recognized organizations have sought aggressively to eliminate accounting wastes, reduce accounting cycle times, and support the empowerment of the manufacturing cell. These accountants have also re-examined the motivational impact of accounting measurements in the context of modern manufacturing practice, being careful not to contribute to perverse behavioral incentives or inhibit continuous improvement within the plant. Finally, the Shingo management accounting culture encourages a proactive, future-oriented accounting stance.

Appendix

Brief Descriptions of Participating Shingo Prize Recipients

Dana Mobile Fluid Products Division, Minneapolis, Minnesota (1991 Shingo Prize)

The Minneapolis Plant of Dana Corporation - Mobile Fluid Products Division was founded under the name of Gresen Manufacturing in 1945. A manufacturer of hydraulic control valves for heavy off-highway equipment, Gresen was eventually acquired by Dana Corporation in 1981.

Gates Rubber Company, Siloam Springs, Arkansas (1993 Shingo Prize)

The Gates Rubber Company is the Gates Corporation's largest subsidiary. It manufactures and markets hose and connector products, V-belts, synchronous belts, conveyor belts, flat belts, and molded rubber products for automotive and industrial customers and boots and carpet underlay. Operations include 16 manufacturing plants in the U.S., 20 plants in eight other countries, and three international joint ventures.

Glacier Vandervell, Inc., Atlantic, Iowa (1991 Shingo Prize)

Glacier Vandervell, Inc., formerly JPI Transportation Products, Inc., manufactures heavy-duty engine bearings in its Atlantic, Iowa production facility. JPI was purchased in 1990 by T&N Plc of Great Britain. This merger has positioned Glacier Vandervell as part of the world's leading engine producers.

Iomega Corporation, Roy, Utah (1992 Shingo Prize)

Iomega Corporation is a leading manufacturer of removable computer storage and backup devices. Founded in 1980, the company went public in 1983, and presently employs 3,000 people in its worldwide operations.

Lifeline Systems, Inc., Watertown, Massachusetts (1991 Shingo Prize)

Lifeline Systems, Inc., founded in 1974, is a manufacturer of personal emergency response systems. The company also provides real-time monitoring services to elderly subscribers.

Lucent Technologies - Power Systems, Dallas, Texas (1992 Shingo Prize; 1994 Deming Prize)

Lucent Technologies – Power Systems (formerly AT&T Microelectronics Power Systems), located in Dallas, Texas, is one of eleven strategic business units within Lucent Technologies, and is a world-class manufacturer of energy systems, electronic power supplies, and components for the data processing and telecommunications industries. Power Systems was the first U.S. manufacturer to receive the Deming Prize (Japan).

United Electric Controls Company, Watertown, Massachusetts (1990 Shingo Prize)

Founded in 1931, United Electric Controls, Inc. (UE), located in Watertown, Massachusetts, is a manufacturer of electronic and electromechanical temperature and pressure controls and sensors.

Wilson Sporting Goods Company, Humboldt, Tennessee (1993 Shingo Prize)

Wilson Sporting Goods Company has been manufacturing and marketing golf, baseball, basketball, football, and other sporting goods for well over three-quarters of a century.

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THE RELATIONSHIP BETWEEN SUPERLEADER BEHAVIORS AND SITUATIONAL AND JOB CHARACTERISTICS VARIABLES: AN EXPLORATORY STUDY

David F. Elloy

This study examined the relationships between superleader behaviors (as described by Manz & Sims, 1990) and selected situational and job characteristics variables in self-managed work groups in a government-operated railway service. Based on a sample of 90 employees, the results indicated that in general, supervisors who are seen as trusting, encouraging innovative behaviors, fair, and who positively reinforce group members when they have performed their job well, contribute to the development of self-management leader behaviors of rehearsal, self-goal-setting, self-criticism, self-reinforcement, self-expectation and self-observation. In addition, fostering communication within the group, and allowing the group members to make work-related decisions, also enhances the movement toward self-management.

In recent years, the concept of autonomous work groups has gained increasing interest (Stewart & Manz, 1995; Cohen & Ledford, 1994; Mohrman, Cohen & Ledford, 1995; Lawler, 1992; Hackman, 1986; Manz, 1986; 1990; 1992; Manz & Sims, 1980; 1990). Stemming from the concept of socio-technical systems developed by Emery & Trist (1969), autonomous work groups have been most recently utilized as a form of work system, particularly as pressures are being exerted on organizations to become more responsive to the competitive environment (Writon, 1991). Several hundred plants in the United States adopted a self-managing work design (Lawler, 1986; Walton, 1985) and more than a thousand moved towards a more participative design (Walton, 1985).

Autonomous work groups have a number of key characteristics. They consist of a small group of individuals (8-15) who (Jessup, 1990; Wall et. al., 1986) are generally responsible for

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completing a whole unit of work (Jonsson & Zank, 1985), performing a variety of tasks, and utilizing a number of skills which the group as a whole possesses. (Wall & Clegg, 1986). Job feedback is important to the work group so that variance from goal attainment can be controlled by group members within a defined work area boundary.

Although strong empirical evidence supporting the benefits of team structures is still evolving, several case studies, both within the United States and Europe, have proved that the implementation of autonomous work groups produces outcomes such as increased employee satisfaction, the opportunity for increased socialization in the workplace, increased autonomy, opportunity to learn new skills, and other benefits such as reduced absenteeism and turnover and increased performance and motivation (Cohen & Ledford, 1994; Verespej, 1990; Pearson, 1991; Pearce & Ravlin, 1987; Wall, Kemp, Jackson & Clegg, 1986). However, much of the research about the actual processes at work within autonomous work groups and their effects upon these outcomes have not provided answers as to why such phenomena occur. It may even be legitimate to say that in some cases proposed outcomes may not be linked to autonomous work groups, but to some other unacknowledged processes, suggesting the need for further research. The dearth of good research into this area has made it particularly difficult to evaluate the worth of such new systems. Although the concept of highly participative work designs that offer high levels of autonomy for individuals is intuitively attractive, the ultimate worth of these designs in terms of organizational outcomes requires further investigation.

Autonomous Work Groups and the External Leader

An important role in the autonomous work group concept that has received little attention in past research is the leader in the group. Little research exists on the external leader and its effect on the functioning of the group. The basic idea behind autonomous work groups portrays group members in total control over their work environment and responsibility for all tasks within their group. Researchers in the past often presumed that the role of external leader is redundant and, therefore, to be of little interest.

Some recent research (Manz & Sims, 1984, 1986, 1987, 1990; and Manz, 1992) looks at the role of external leaders as it impacts on the effectiveness of autonomous work groups and the changing nature of their own positions under autonomous work group settings. Far from becoming redundant, the research suggests that the external leader has moved away from the traditional roles of supervision and control to a highly facilitative style of management, much less direct but still essential for the effectiveness of the group.

Initially the term "external leader" might seem a misnomer since the basis of autonomous work groups is self-management -- this represents the ideal autonomous work group situation. In fact, the formal supervisor or manager continues to play a role in the functioning of almost all autonomous work groups. Leadership, when applied to autonomous work groups, describes

the idea of "a person who leads others to lead themselves" (Whitsett & Yorks, 1983). Termed the "Superleader" by Manz and Sims (1986), the idea of the formal leader in the autonomous work group system implies that the leader works towards making his or her own position eventually redundant through guiding the group towards total self-management. In contrast, transformational leadership focuses on the leader's ability to create a highly motivating and inspiring vision (Bass, 1990). The focus is on the leader's vision, and the leader represents the source of direction. Individuals are expected to commit to the vision and the leader. With the superleader, however, the focus is largely on the individuals in the team who become self leaders and in essence share power with the leader. The leader's job in this environment changes to one that helps followers to develop the necessary skills for work, especially self leadership (Manz & Sims, 1990).

Later work by Manz and Sims (1991) provides a basis upon which to evaluate leadership in the autonomous work setting. The recommended style of leadership, namely a "Superleader," reflects the basic requirements of autonomous work groups. According to Manz and Sims (1991), the Superleader engages in behaviors that help team members learn to lead themselves. Instead of inspiring workers by generating an attractive vision, Superleaders help members to recognize their own capacity for effective decision-making without the need for direct involvement by the leader. This research has revealed basic behaviors that Superleaders perform, which directly affect the level of self-management displayed by the team.

For example, Superleader behavior encourages self-reinforcement by team members. Through reinforcement of high levels of group performance, the Superleader encourages the group to recognize and appreciate actions that lead to effective performance. The Superleader supplies the group with sufficient information to allow the group to evaluate its own performance. Most of the behaviors enacted by Superleaders concern the internalization of the concepts of task responsibility and influence over organizational outcomes. In other words, the Superleader, through a subtle process of boundary control, helps the team feel responsible for its own outcomes and recognize intrinsic rewards in its own work setting. The Superleader supplies information and feedback as needed to permit the continuance of self-leadership behaviors. Through the selective use of legitimate criticism and rewards, the Superleader enforces self-leadership outcomes.

Team members are encouraged to be critical of their own performance. By learning to recognize faults in their work practice, members can gain increased knowledge of their work and recognize appropriate behaviors for group success. Not mentioned in the literature, although implicitly implied, is the need for the external leader to promote norms of behavior based on group aspects.

Since the primary goal of the Superleader is to improve the performance of group members through the development of their own self leadership capabilities, employee self- goal setting

is an important ingredient. The Superleader through coaching and modeling helps assist members to engage in the behavior of self-goal setting within the group, and helps them to effectively set specific challenging goals for themselves. Table 1 outlines a description of these behaviors.

Table 1
Superleader Behaviors

<u>Variables</u>	<u>Description</u>
Encourages self-reinforcement	Leader encourages work group to be self-reinforcing of high work group performance.
Encourages self-criticism	Leader encourages work group to be self-critical of low group performance.
Encourages self-goal-setting	Leader encourages work group to set performance goals.
Encourages self-coordination	Leader encourages work group to monitor, be aware of and to evaluate performance level.
Encourages self-expectation	Leader encourages work group to have high expectations for work performance.
Encourage rehearsal	Leader encourages work group to over an activity and "think through" before actually performing the activity.

Source: Manz and Sims (1987).

While the Superleader position is described as a leader who leads others to lead themselves (Manz & Sims, 1986), the inference is that the leader is moving toward becoming redundant or at least only influential in a minor way. It would be more suitable to express the role of the Superleader as a leader who teaches others to appreciate the effectiveness of self-leadership for both organizational and individual benefits, and who encourages group members to look at management in a different, though not necessarily less influential, way. The group's relationship with the Superleader changes from one of basic reliance for the designation of tasks, rewards and direction, to a subtler, though just as important, role of maintenance and facilitation. The group may not rely on him/her in terms of having to ask for desired input once self-leadership is established, but the Superleader evolves into a facilitator of group behaviors and acts as a

buffer between the group and the external environment by supplying information and resources to the team.

The concept of Superleadership is still a relatively unexplored one. While theories relating to the type of behaviors required of the Superleader are available, (Stewart & Manz, 1995; Manz & Sims, 1990; Cordery & Wall, 1985) there is very little research on the actual effects of a variety of situational and organizational variables on the various dimensions of Superleader behaviors. The purpose of this research study then, is to examine the relationship between Superleader behaviors and selected situational and job characteristics variables. Based upon the above discussion, various hypotheses are examined. However, due to the lack of research in these areas, literature support for the propositions is limited. Nevertheless, the exploratory nature of the research is designed to look at these untested hypotheses, and endeavors to discover the relationships between Superleader behaviors and those variables that are important for the effective functioning of autonomous work groups.

H₁: Trust, innovation training and recognition will be positively related to self- rehearsal.

A Superleader encourages group members to think about how they are going to undertake an assignment. In order for employees to be successful in doing this there must be trust between the Superleader and the group. The Superleader should also foster an environment where individuals are encouraged to find new ways to perform their work duties, and receive recognition for a job well done. In addition, in order for them to effectively perform their jobs they should also have the proper training.

H₂: Self-goal setting will be positively related to communication, team goal setting, team communication and innovation.

Since a main focus of the Superleader is to improve the performance of individuals within a team through the development of their own self-leadership capabilities, employee self-goal setting is a key element. The Superleader encourages group members to effectively set specific challenging goals for themselves. For this to happen, group members should be encouraged to find new ways to perform their jobs. Also there should be good communications between the Superleader and the group members and within the group itself so that team goals are effectively formulated.

H₃: Self-criticism will be positively related to innovation, decision making and autonomy.

One objective of Superleadership is to encourage constructive self-criticism as an important part of the transition to self-leadership (Manz & Sims, 1986). The major focus is to treat mistakes as learning opportunities. In order for group members to effectively undertake this function they require autonomy, and the authority and responsibility to take corrective action to

rectify mistakes or variations from set standards. They should also be encouraged to be innovative in the generation of solutions to correct work related problems.

H₄: Innovation, team training and trust will be positively related to self-reinforcement.

The purpose of self-leadership is to lead others to self-leadership. An essential ingredient is to teach group members how to reward themselves and to build natural rewards into their own work (Manz & Sims, 1986). This means that individuals need to have the freedom to perform their jobs as they see fit and in ways that they find most rewarding. In order for this to happen members need to be trained to perform their jobs and trust needs to exist between the leader and group members.

H₅: Self-Expectation will be positively related to trust, fairness, autonomy, job feedback, team participation and goal setting.

Facilitating positive expectations in group members is an important role of a Superleader. The role of a Superleader is to guide, excite and engage (Manz & Sims, 1984). Trust, fairness, providing autonomy, expressing confidence in the group members' abilities to extend their present level of competence, and providing support, encouragement and feedback are necessary to foster self-expectations among group members.

H₆: Innovation, communication and trust will be positively related to self-observation.

In the process of helping group members to lead themselves, the Superleader encourages them to be aware of and evaluate their own level of performance. For this to occur, there should be an environment where group members are encouraged to find creative ways to solve work related problems, and have the autonomy to make decisions regarding the performance of their job. It is also important that the leader provides information to solve problems and facilitates communication within the group.

METHOD

Site and Research Participants

The research was based upon data gathered from 18 maintenance groups from two divisions of Westrail, a government operated railway service that controls much of the railway system across the entirety of Western Australia. Maintenance along its extremely extensive system is undertaken by maintenance gangs who operate individually within different geographical divisions. Each group is assigned a particular portion of the system which they must maintain. Maintenance here, refers to a variety of scheduled duties ranging from laying

new tracks and upkeep of old sections, to unscheduled emergency work, such as derailments and repairs stemming from environmentally related damage. Each of these groups was engaged in similar tasks and in similar settings. Numbers of individuals within the teams varied from a low of 6 to a high of 15.

A total of 139 surveys were distributed in person by the author to the employees over a three-day period. They were instructed to return the completed surveys in a stamped sealed envelope to the central office where they were collected by the author. Ninety surveys were returned for a response rate of approximately 68%. All the respondents were male. Forty percent graduated from high school, 46% did not finish high school and two percent had taken some university courses.

Measures

Supervision. A slightly modified version of Decotiis and Koy's (1981) scales were used to measure various perceptions of the leader, including trust, recognition, fairness and innovation. Items were rated on a 7-point scale.

Self-Leadership. Self-leadership scores were obtained using the Self-Management Leadership Questionnaire developed by Manz and Sims (1987). The 22-item questionnaire is designed to test the extent to which leaders of autonomous work groups display typical Superleader behaviors. Items were rated on a 7-point scale.

Communication and Decision-Making. Communication was measured with an expectation scale developed by House and Rizzo (1972). Items were rated on a 7-point scale. Decision-making was measured by House and Rizzo (1972). Items were rated on a 7-point scale.

Job Characteristics. Modifications of the scale developed by Sims, Szilyagi and Keller (1976) to measure perceptions of specific job characteristics were used to measure autonomy. Items were rated on a 7-point scale.

Team Functions. Perceptions of team functions were assessed with scales developed by the Center for Effective Organizations. The scales measured team participation, training and goal setting. Items were rated on a 7-point scale.

Analysis

In order to test these hypotheses, a series of hierarchical regressions were carried out separately for each of the various dimensions of Superleader behaviors. Selected situational and job characteristics variables were separately regressed on each of the dimensions of Superleader behaviors.

RESULTS

Table 2 presents the alpha values, means , standard deviations of the major variables in the study.

Table 2

Alpha Values, Means and Standard Deviation of Wages Study Variables

	<u>Alpha</u>	<u>M</u>	<u>S.D.</u>
Sel/Self-Examination	0.88	3.8	0.9
Self-Reinforcement	0.79	4.5	1.0
Self-Criticism	0.88	4.1	1.2
Self-Goal Setting	0.87	4.3	1.6
Self-Expectation	0.91	3.9	1.1
Rehearsal	0.92	3.8	1.4
Decision Making	0.71	4.5	1.0
Autonomy	0.83	4.1	1.6
Recognition	0.86	4.2	1.2
Trust	0.79	4.4	1.1
Training	0.86	4.7	1.7
Team Communication	0.75	4.7	1.5
Fairness	0.81	5.0	1.2
Feedback	0.82	4.2	1.5
Team Participation	0.82	4.5	1.7

The results of the hierarchical regression are presented in Table 3. Self-rehearsal was significantly predicted by recognition ($\beta = .32, p < .00$), trust ($\beta = .29, p < .00$), innovation ($\beta = .24, p < .01$), and training ($\beta = .15, p < .02$). Seventy-six per cent (adjusted R^2) of the variance was explained. Self-goal setting was significantly predicted by communication ($\beta = .18, p < .00$), innovation ($\beta = .56, p < .00$), team goal setting ($\beta = .33, p < .04$). Sixty-eight per cent (adjusted R^2) of the variance in self-goal setting was explained. Decision making ($\beta = .23, p < .00$), autonomy ($\beta = .22, p < .02$), and innovation ($\beta = .68, p < .00$) significantly predicted self-criticism. Thirty-five per cent (adjusted R^2) of the variance was explained. Self-reinforcement was significantly predicted by innovation ($\beta = .53, p < .00$), trust ($\beta = .20, p < .03$), and team training ($\beta = .20, p < .00$). Sixty-three per cent (adjusted R^2) of the variance in self-reinforcement was explained. Supervisory fairness ($\beta = -.33, p <$

.00), trust ($\beta = .65, p < .00$) and team participation ($\beta = .50, p < .00$) significantly predicted self-expectation. Fifty-six per cent (adjusted R^2) of the variance was explained. However, autonomy, feedback and team goal setting failed to enter the equation. Self-observation was significantly predicted by communication ($\beta = .21, p < .00$), autonomy ($\beta = .15, p < .00$) and innovation ($\beta = .74, p < .00$). Fifty-eight per cent (adjusted R^2) of the variance in self-observation was explained.

DISCUSSION

In this study, the relationship between the various dimensions of Superleader behaviors and selected situational and job characteristics variables were explored. The results indicated that in general, supervisors who are seen as trusting, innovative, fair, and who positively reinforce group members when they have performed their job well will contribute to the development of self-management leader behaviors of rehearsal, self-goal setting, self-criticism, self-reinforcement, self-expectations and self-observation. Enhanced feelings of trust result when group members feel that they are receiving a greater degree of responsibility and there is consequently a reduced need for the group to be controlled by the external leader. In addition, fostering communication within the group, and allowing group members to make work related decisions also enhances the movement towards self-management.

All the hypotheses were supported except for hypothesis five, (H_5) which was only partially supported. The results indicated that team participation, supervisory trust and fairness were all positively related to self-expectation (H_5); however autonomy and feedback did not enter the equation. With respect to feedback, it is possible that the job itself provided feedback and hence it was not required from the supervisor. It is also possible that the nature of the tasks did not offer significant variation to allow group members to exercise autonomy. The general tasks performed by the maintenance gangs, though diverse, are generally predictable and of reasonably low complexity. Hence, the perceived level of autonomy may not have had an influence on self-expectation, as group members are bounded by work constraints that cannot be altered by the supervisor.

MANAGEMENT IMPLICATIONS

It is obvious that the Superleader style of management of autonomous work groups results in some positive beneficial outcomes. The overall theme of management in autonomous work groups would seem to be learning to use facilitating skills as opposed to controlling skills, and as such is fundamentally different from traditional views of leadership (Manyard & Sims, 1990). In fact, if organizations really want employees to develop into top performers, providing them with the autonomy and responsibility to be more in charge of themselves and their work is

essential. As Lawler (1986, 1992) indicates, this high involvement approach provides the most extensive involvement and ability for self-influence. It entails passing power, information, knowledge and rewards to the lowest levels of the organization. The logic is that if workers are going to care about the organization they need to know about, be able to influence, be rewarded for and have the knowledge and skills to contribute to the performance of the organization.

In work situations where self-managed work groups are used, it would be appropriate for management to develop an employment strategy that recognizes Superleader behaviors, and recruit individuals displaying these characteristics as external leaders for such groups. Westrail employs its trackmasters from within the ranks of gang members. Once hired, the trackmaster is placed in a probationary position for a period of six months. During this period of time it would be very advantageous for management to evaluate the new trackmaster's behavior for typical Superleader behaviors. By endeavoring to employ individuals displaying Superleader behaviors the organization is aided in its efforts to develop a culture that is conducive for the effective functioning of self-managed work groups.

Although there are several benefits accruing from this type of management system, the environment in Australia is not particularly encouraging, and some of the necessary conditions for success are not currently present nor widespread. One of the required elements for the success of autonomous work groups is management support for the system (Lawler, 1992). If organizations want to obtain the maximum benefits that accrue from empowering workers, the focus should be not only in involving employees at all levels in decision making and problem solving, but it should also be integrated with a culture that supports and encourages this new system. Personnel policies should also be developed which support and reinforce this system.

While there is some tepid support for this type of structure from top management, the strong unions and the centralized wage systems are likely to have many constraining effects on the implementation of innovative structures such as self-managed work groups in both the private and public sectors. Under the present industrial system it is difficult to implement work structures that encourage informal task acquisition at work. Job classifications are such that there are limits to the extent workers may share or alternate tasks. Designation of tasks by the group are restricted by job boundaries. Union resistance to change in many industries acts as a major hindrance to the adoption of any major change for many companies (including Westrail) even though the benefits are self evident. Workplace reform in traditional fields requires active union support. Lack of this support is quite often due to the fact that unions lack knowledge about less traditional forms of work practices. This may, however, be overcome through comprehensive training and education of unions. Awareness of programs which promote the effectiveness of self-managed work groups, and the benefits of improved quality of work life that are purported to result from this system are essential if organizational structures that cut across organization boundaries to enhance co-ordination, communication and cooperation are to become part of new work cultures.

Table 3

Hierarchal Regression Results

<u>Self - Referral</u>			<u>Self - Goal Setting</u>		
<u>Prediction/ Variables</u>	<u>Beta</u>	<u>P</u>	<u>Prediction/ Variables</u>	<u>Beta</u>	<u>P</u>
Recognition	0.32	.00	Communication	0.18	.00
Trust	0.29	.00	Innovation	0.56	.00
Innovation	0.25	.01	T. Goal Setting	0.33	.00
T. Training	0.15	.02	T. Communication	-0.16	.04
Adjusted R ² = .76			Adjusted R ² = .68		
<u>Self-Criticism</u>			<u>Self-Reinforcement</u>		
<u>Prediction/ Variables</u>	<u>Beta</u>	<u>P</u>	<u>Prediction/ Variables</u>	<u>Beta</u>	<u>P</u>
Decision Making	0.23	.00	Innovation	0.53	.00
Autonomy	-0.2	.02	Trust	0.2	.03
Innovation	0.68	.00	T. Training	0.21	.00
Adjusted R ² = .40			Adjusted R ² = .63		
<u>Self - Expectation</u>			<u>Self - Observation</u>		
<u>Prediction/ Variables</u>	<u>Beta</u>	<u>P</u>	<u>Prediction/ Variables</u>	<u>Beta</u>	<u>P</u>
T. Participation	0.5	.00	Communication	0.21	.00
Trust	-.033	.00	Innovation	-0.15	.03
Innovation	0.65	.00	T. Goal Setting	0.74	.00
Adjusted R ² = .56			Adjusted R ² = .58		

In conclusion, implementation of effective self-leadership within teams is not an instantaneous process, but adopting a Superleader style may lead to effective work groups over

time. Therefore, continual study of this particular type of application will contribute greatly to the understanding and application of Superleadership principles in modern organizations. Further research is also needed to provide additional insights into those behaviors needed to effectively lead those who are supposed to lead themselves, as well as for badly needed guidelines for training external leaders of self-managed teams.

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THE OPTIMAL ORDER QUANTITY PROBLEM WITH QUANTITY DISCOUNTS: A MIXED BIVALENT INTEGER FORMULATION

Peter M. Ellis *

A bivalent mixed integer formulation of the economic order quantity problem is presented here. This model accommodates varying demand over the several periods of a planning horizon. It seeks to minimize the total of cost of goods, fixed ordering costs and inventory carrying costs over the horizon. The model incorporates quantity discounts that are made possible if a purchase amount is large enough. The model determines the amount of inventory to acquire in each period of the time horizon. It establishes the cost of goods by determining the purchase quantity in each period to match the corresponding unit price.

The lot size problem has been very notable in operations management literature for years. The familiar square root formula appears in every traditional operations management text. It is well known that this formula arises from some very restrictive conditions. One of those is the assumption of constant demand over time. Another is that the cost of the goods is constant, and thus can be ignored.

An extension permits inclusion of quantity discounts. Here, several different total cost functions are nested vertically and the true total cost will jump from one cost curve to the next at the price breaks. The optimal order quantity is easily seen to occur either at the minimum point of one of the cost functions or at a price break.

When demand is not constant over time the problem gets much more challenging. It is common in this situation to divide the time continuum into consecutive periods, such as months. A separate inventory acquisition decision arises in each time period. The objective is to minimize the total of cost of goods, fixed costs of placing orders and inventory carrying costs. The cost of goods will remain constant and immaterial if the unit cost is always fixed. Wagner and Whitin formulated this problem in 1958 and demonstrated a convergent search routine that

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yields an optimal ordering schedule. A similar construct was also presented by Manne in 1958. Dynamic programming has been used extensively to analyze extended versions of this problem. The work by Denardo (1982) is an excellent source for illustrating the dynamic programming approach. A very recent work using dynamic programming is that of Aggarwal and Park (1993), who use Monge arrays to bring about dramatic computational efficiencies. The problem is similar to that of economic lot sizing and production scheduling. Zangwill demonstrated the network nature of the production/inventory scheduling problem as early as 1966, 1968 and 1969.

The quantity discount problem for a single item was considered by Widrick (1985). His focus was on the determination of the pricing of the goods. Extensions to the problem of multiple items have recently been analyzed by Katz, Sadrian and Tendick (1994), Pirkul and Aras (1985) and by Sadrian and Yoon (1994). As pointed out by Rosenthal, Zydiak and Chaudry (1995), these formulations are quite intractable. The goal programming approach was presented by Weber and Current (1993). They also considered the case of multiple vendors. This approach was further extended by Rosenthal, Zydiak and Chaudry (1995) to bundling of purchases from multiple vendors when the vendors offer price breaks on one item when quantities of other items are sufficiently large.

The problem considered here is one of determining the optimal order lot size of a single good under conditions of variable demand, discrete time periods and the availability of quantity discounts. A mixed integer programming model of the problem will be formulated and the analysis will permit consideration of limits upon order quantities.

THE MODEL

This problem arose from an inquiry made to the author by a small manufacturer. They produce a frozen dairy product that has a highly seasonal demand pattern. Summer sales are quite high and December - January holiday season sales are strong. Demand is relatively low in the spring and fall. Raw materials are costly to store. Quantity discounts on raw material purchases are available. They seek to determine an optimal ordering schedule for raw material acquisitions. The cost function to minimize includes cost of goods, fixed costs of placing orders and inventory carrying costs. They desire to make monthly purchase decisions over a limited planning horizon. While this manufacturer desired to establish monthly decision points, it is generally necessary that the duration of a single decision period should be so short that product demand can be taken to be constant and deterministic over the course of the period.

The variables and parameters of the problem are:

- N = number of time periods in the planning horizon
 J = number of price levels available through discounting
 D_i = demand in time period I
 INV_i = inventory at end of time period I
 X_{ji} = number of units to purchase at price level j in period I
 h = unit inventory holding cost per time period
 I_{ji} = $\{0,1\}$ is a bivalent variable and equals 1 if price level j is used for purchases
 C_j = upper limit on quantity available at price j
 F = fixed cost of placing an order
 C_{ji} = cost per unit at price level j in period I
 J_i = $\{0,1\}$ and equals 1 if a purchase is made in time period I , equals 0 otherwise
 M = maximum allowable purchase quantity in any period
 Z_1 = total cost of purchasing goods
 Z_2 = total ordering cost
 Z_3 = total inventory carrying cost

The mixed integer model is given as:

$$\text{minimize: } Z = Z_1 + Z_2 + Z_3 \quad (1)$$

subject to:

$$\sum_{j=1}^J \sum_{I=1}^N C_{ji} X_{ji} = Z_1 \quad (2)$$

$$F \sum_{j=1}^J \sum_{I=1}^N I_{ji} = Z_2 \quad (3)$$

$$\sum_{i=1}^N \text{INV}_i = Z_3 \quad (4)$$

$$\text{INV}_{i-1} + X_{1i} + X_{2i} + \dots + X_{ji} - \text{INV}_i = D_i \quad (5)$$

$I = 1, 2, \dots, N$

$$X_{1i} \leq C_1 I_{1i}$$

$$(C_1 + 1) I_{2i} \leq X_{2i} \leq C_2 I_{2i}$$

.

.

.

$$(C_{j-2} + 1) I_{(j-1)i} \leq X_{(j-1)i} \leq C_{(j-1)} I_{(j-1)i}$$

$$(C_{j-1} + 1) I_{ji} \leq X_{ji} \quad (6)$$

$I = 1, 2, \dots, N-1$

$$X_{ji} \leq I_{ji} M \quad (7)$$

$$I_{1i} + I_{2i} + \dots + I_{ji} = J_i \quad I = 1, 2, \dots, N \quad (8)$$

$$\begin{aligned} &\text{all } X_{ji}, \text{INV}_i, Z_1, Z_2, Z_3 \geq 0 \\ &\text{all } I_{ji} = \{0, 1\} \\ &\text{all } J_i = \{0, 1\} \end{aligned}$$

The objective function in (1) seeks the minimization of the sum of cost of goods plus ordering costs plus inventory carrying cost. Constraints of (2), (3) and (4) establish these three parts as Z_1 , Z_2 and Z_3 . The constraints of (5) declare that ending inventory in any time period I is obtained as the sum of beginning inventory plus new acquisitions minus demand. The quantity intervals for the price breaks are established with constraint set (6). The purchase amount X_j is forced to be either zero or in the interval from $C_{j-1} + 1$ to C_j . Note that if I_{ji} is zero, then the purchase amount X_{ji} must be zero as well. However, if $I_{ji} = 1$ then the constraints require that X_{ji} be between $C_{j-1} + 1$ and C_j . The maximum allowable acquisition in any period is set by the constraints of (7).

The constraints of (8) permit the use of at most one price level j in any time period I . The model will thereby force the selection of the time periods during which purchases will be made, the number of units to purchase and the appropriate corresponding unit price level. There will be JN of the X_{ji} and I_{ji} variables and J of the J_i and INV_i variables, for a total of $2JN + 2J$ operational variables in the formulation.

AN EXAMPLE

The parameter values here are totally unrelated to the operating environment of the above manufacturer. They are artificial and used only to illustrate the structure of the model. Let the time periods be eight consecutive months. Note that the standard time unit used in the model must be sufficiently small so that there do not exist any significant fluctuations in demand over the course of a single interval. For the purpose of this illustration the requirement means that there should be no significant intra month demand fluctuations. This condition would be easily satisfied if, for example, there were just a single product delivery to be made at the end of the month.

Take the inventory carrying cost to be $h = \$1.20$ per unit per month and the fixed ordering cost to be $F = \$30$. Further, let there be three price levels available in any month. If the purchase quantity is 50 units or less the unit price will be \$3. If the order quantity is between 51 and 75 units the purchase price will be \$2.80. If the purchase quantity is at least 76 units, then the unit price is \$2.50.

Let the 8 monthly demands be for 63, 46, 36, 32, 37, 54, 67 and 78 units. The formulation of this problem is presented in Table 1. For convenience, the three components of the objective function were established as constraints equal to Z_1 , Z_2 and Z_3 , respectively. The objective function is thereby simply given as the minimization of $Z_1 + Z_2 + Z_3$. Inventory at the beginning of the eight months is taken to be zero. Maximum permitted inventory purchases in any month are limited to the amount $M = 1000$.

The optimal solution to this formulation is seen in Table 2. The minimum total cost is \$1374.80. It is composed of the three parts $Z_1 + Z_2 + Z_3$. The total cost of goods, Z_1 , is \$1085.60. The total ordering cost is $Z_2 = \$180.00$. The total inventory carrying cost is $Z_3 = \$109.20$. The purchase month variables J_1 , J_2 , J_4 branches there will also be linear programming optimization for the set values of the bivalent variables. As an illustration, this example problem required 12,684 iterations.

Table 1

The Mixed Integer Formulation

MIN $Z1 + Z2 + Z3$

SUBJECT TO

- 2) $-Z1 + 3 X0101 + 2.8 X0201 + 2.5 X0301 + 3 X0102 + 2.8 X0202 + 2.5 X0302 + 3 X0103 + 2.8 X0203 + 2.5 X0303 + 3 X0104 + 2.8 X0204 + 2.5 X0304 + 3 X0105 + 2.8 X0205 + 2.5 X0305 + 3 X0106 + 2.8 X0206 + 2.5 X0306 + 3 X0107 + 2.8 X0207 + 2.5 X0307 + 3 X0108 + 2.8 X0208 + 2.5 X0308 = 0$
- 3) $J1 + J2 + J3 + J4 + J5 + J6 + J7 + J8 - JZ = 0$
- 4) $-Z2 + 30 JZ = 0$
- 5) $-Z3 + 1.2 INV1 + 1.2 INV2 + 1.2 INV3 + 1.2 INV4 + 1.2 INV5 + 1.2 INV6 + 1.2 INV7 + 1.2 INV8 = 0$
- 6) $X0101 + X0201 + X0301 - INV1 = 63$
- 7) $X0102 + X0202 + X0302 + INV1 - INV2 = 46$
- 8) $X0103 + X0203 + X0303 + INV2 - INV3 = 36$
- 9) $X0104 + X0204 + X0304 + INV3 - INV4 = 32$
- 10) $X0105 + X0205 + X0305 + INV4 - INV5 = 37$
- 11) $X0106 + X0206 + X0306 + INV5 - INV6 = 54$
- 12) $X0107 + X0207 + X0307 + INV6 - INV7 = 67$
- 13) $X0108 + X0208 + X0308 + INV7 - INV8 = 78$
- 14) $-50 I0101 + X0101 \leq 0$
- 15) $-51 I0201 + X0201 \geq 0$
- 16) $-75 I0201 + X0201 \leq 0$
- 17) $-76 I0301 + X0301 \geq 0$
- 18) $-1000 I0301 + X0301 \leq 0$
- 19) $-50 I0102 + X0102 \leq 0$
- 20) $-51 I0202 + X0202 \geq 0$
- 21) $-75 I0202 + X0202 \leq 0$
- 22) $-76 I0302 + X0302 \geq 0$
- 23) $-1000 I0302 + X0302 \leq 0$
- 24) $-50 I0103 + X0103 \leq 0$
- 25) $-51 I0203 + X0203 \geq 0$
- 26) $-75 I0203 + X0203 \leq 0$
- 27) $-76 I0303 + X0303 \geq 0$
- 28) $-1000 I0303 + X0303 \leq 0$
- 29) $-50 I0104 + X0104 \leq 0$
- 30) $-51 I0204 + X0204 \geq 0$
- 31) $-75 I0204 + X0204 \leq 0$
- 32) $-76 I0304 + X0304 \geq 0$
- 33) $-1000 I0304 + X0304 \leq 0$
- 34) $-50 I0105 + X0105 \leq 0$
- 35) $-51 I0205 + X0205 \geq 0$
- 36) $-75 I0205 + X0205 \leq 0$
- 37) $-76 I0305 + X0305 \geq 0$
- 38) $-1000 I0305 + X0305 \leq 0$
- 39) $-50 I0106 + X0106 \leq 0$
- 40) $-51 I0206 + X0206 \geq 0$
- 41) $-75 I0206 + X0206 \leq 0$

- 42) - 76 I0306 + X0306 >= 0
- 43) - 1000 I0306 + X0306 <= 0
- 44) - 50 I0107 + X0107 <= 0
- 45) - 51 I0207 + X0207 >= 0
- 46) - 75 I0207 + X0207 <= 0
- 47) - 76 I0307 + X0307 >= 0
- 48) - 1000 I0307 + X0307 <= 0
- 49) - 50 I0108 + X0108 <= 0
- 50) - 51 I0208 + X0208 >= 0
- 51) - 75 I0208 + X0208 <= 0
- 52) - 76 I0308 + X0308 >= 0
- 53) - 1000 I0308 + X0308 <= 0
- 54) - J1 + I0101 + I0201 + I0301 = 0
- 55) - J2 + I0102 + I0202 + I0302 = 0
- 56) - J3 + I0103 + I0203 + I0303 = 0
- 57) - J4 + I0104 + I0204 + I0304 = 0
- 58) - J5 + I0105 + I0205 + I0305 = 0
- 59) - J6 + I0106 + I0206 + I0306 = 0
- 60) - J7 + I0107 + I0207 + I0307 = 0
- 61) - J8 + I0108 + I0208 + I0308 = 0

END

Also, J1, J2, ..., J8, I0101, I0201, ..., I0308 = {0,1}

Table 2
The Optimal Solution to the Example Problem

OBJECTIVE FUNCTION VALUE

1) 1374.8000

<u>VARIABLE</u>	<u>VALUE</u>	<u>REDUCED COST</u>
J1	1.000000	30.000000
J2	1.000000	30.000000
J3	.000000	30.000000
J4	1.000000	30.000000
J5	.000000	30.000000
J6	1.000000	30.000000
J7	1.000000	30.000000
J8	1.000000	30.000000
I0101	.000000	.000000
I0201	1.000000	.000000
I0301	.000000	-299.999900
I0102	.000000	.000000
I0202	.000000	15.300000
I0302	1.000000	.000000
I0103	.000000	-35.000000
I0203	.000000	-67.500010
I0303	.000000	-1200.000000
I0104	.000000	.000000
I0204	.000000	.000000
I0304	1.000000	250.800000
I0105	.000000	.000000
I0205	.000000	.000000
I0305	.000000	.000000
I0106	.000000	.000000
I0206	1.000000	61.200000
I0306	.000000	.000000
I0107	.000000	.000000
I0207	1.000000	.000000
I0307	.000000	-299.999900
I0108	.000000	.000000
I0208	.000000	.000000
I0308	1.000000	.000000
Z1	1085.600000	.000000
Z2	180.000000	.000000
Z3	109.200000	.000000
X0101	.000000	.200000
X0201	63.000000	.000000
X0301	.000000	.000000
X0102	.000000	.500000
X0202	.000000	.000000
X0302	82.000000	.000000
X0103	.000000	.000000
X0203	.000000	.000000
X0303	.000000	.000000
X0104	.000000	3.800000

X0204	.000000	3.600000
X0304	76.000000	.000000
X0105	.000000	2.600000
X0205	.000000	2.400000
X0305	.000000	2.100000
X0106	.000000	1.400000
X0206	51.000000	.000000
X0306	.000000	.900000
X0107	.000000	.200000
X0207	63.000000	.000000
X0307	.000000	.000000
X0108	.000000	.500000
X0208	.000000	.300000
X0308	78.000000	.000000
JZ	6.000000	.000000
INV1	.000000	1.500000
INV2	36.000000	.000000
INV3	.000000	5.700000
INV4	44.000000	.000000
INV5	7.000000	.000000
INV6	4.000000	.000000
INV7	.000000	1.500000
INV8	.000000	3.700000

NO. ITERATIONS = 12684

BRANCHES = 1079 DETERM. = 1.000E 0

CONCLUSION

A mixed integer formulation of the lot size problem has been presented here. It determines the optimal inventory purchase decision when there are both uneven demands over time and price breaks available from making large orders. The objective function seeks to minimize the sum of cost of goods plus fixed ordering cost plus inventory carrying cost. One set of constraints guarantees that demand will be met through carrying and replenishing inventory. Another set forces new purchase amounts to conform to the intervals that fit the price breaks. An example problem was worked to a successful conclusion. It is noted that computer solution of this problem may require a large amount of numerical calculations because of the presence of the bivalent variables. However, the example problem presented here was solved in just a few minutes on a desktop microcomputer with a commercially available software package.

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ASSESSMENT OF MBA PROGRAMS VIA DATA ENVELOPMENT ANALYSIS

Patrick R. McMullen *

This research presents a technique to assess the relative desirability of AACSB-accredited MBA programs via an Operations Research based tool called Data Envelopment Analysis (DEA). Several attributes of these MBA programs are incorporated into a set of linear programming problems, ultimately determining which programs are most desirable in terms of these attributes. The research finds that of 188 AACSB-accredited MBA programs studied, several possess characteristics that are dominant over others.

Which considering MBA programs, several issues usually come to mind: tuition, reputation of the school, and placement issues (i.e., starting salary upon graduation) are some of the more common evaluation criteria. Deciding upon which MBA programs are "best" is usually treated as a subjective issue. *Business Week* and other publications have annual issues dedicated to assessing the "best" MBA programs. These assessments are usually quite subjective, based upon surveys (and interviews) of graduates and companies hiring the graduates. *Barron's* also has an annual issue dedicated to determining the schools which are the "best buys." Again, their models are quite subjective, usually based upon surveys of stakeholders. The fact is, with so many criteria involved, the assessment process is far from trivial.

Data Envelopment Analysis (DEA) is an Operations Research based tool that can assist in this assessment process by jointly considering several appropriate attributes and presenting a single composite score for each MBA program under consideration. This composite score, referred to as *efficiency*, is essentially the objective function of a linear programming model. Doyle and Green (1991) offer a fundamental, yet informative, description of Data Envelopment Analysis. A more detailed description of DEA is offered by Charnes et al. (1994), which concentrates more on the mathematical aspects of DEA.

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The intent of this research is twofold. Primarily, it is intended to shed some light on which AACSB-accredited MBA programs are found to be most desirable through the use of DEA—desirable, that is, within the context of a DEA model. The results of this analysis will then be compared with *Business Week's* (October 21, 1996) "Top 25 MBA Programs." Secondly, it is intended to show, in general, how DEA can be used to perform a relatively objective analysis on a subject typically receiving subjective treatment.

This research will show which of the 188 schools analyzed are found to be efficient in terms of Data Envelopment Analysis (referred to as DEA-efficient). Additionally, it will be shown why certain schools not found to be DEA-efficient (referred to as DEA-inefficient) are in fact inefficient, and what can be done to improve their efficiency score.

The following sections of the paper discuss the general methodology of DEA, present the criteria used for the analysis, present the results, and offer conclusions regarding the desirability of the schools as well as describe the benefits of using DEA for such an evaluation.

ASSESSMENT CRITERIA AND DATA

This research examines 188 AACSB-accredited MBA Programs using the following criteria: starting salary upon graduation, difficulty in gaining admission to the school of interest, annual tuition, and average class size. The first two criteria are considered outputs—benefits associated with the school of interest, while the latter two criteria are considered inputs—necessary sacrifices associated with attending the school of interest.

The output of starting salary upon graduation is a straightforward measure—the average salary of graduates as reported by the schools. The level of the school's relative difficulty in gaining admission is measured by two attributes—the average GMAT score of students in the program and the percentage of students denied admission to the program of interest. High levels of starting salary and difficulty in gaining admission indicate a high level of output (benefits) associated with the school of interest.

The annual tuition is also a relatively straightforward measure—the annual tuition required for the school of interest. For state-funded institutions, a weighted-average is used for analysis—the sum of resident tuition multiplied by the percentage of resident students and non-resident tuition multiplied by the percentage of non-resident students.¹ This weighted average can be thought of as the average amount of annual tuition paid per student for the school of interest. The average class size is simply the average size of core (required) classes as reported by the schools. Here, large classes are treated as a cost—a lack of individual interaction between student and faculty. High levels of tuition and large classes represent a high level of input (sacrifices) required to attend the program of interest.

The data for this analysis was primarily attained from *Peterson's Guide to MBA Programs* (1997). For some schools, this source did not disclose complete information. In this event, one of two courses of action was taken. The first course of action was for schools appearing on *Business Week's* (October 21, 1996) list of "Top 25 MBA Programs." Here, necessary follow-up was performed to complete the data set for these schools. In several instances, schools appearing on this list were missing information regarding average GMAT scores. To obtain this information, school web pages were searched in addition to consulting the *Princeton Review* (Gilbert, 1997). The second course of action was for the schools that were not on *Business Week's* (October 21, 1996) list of Top 25 MBA programs. Here, follow-up was performed as much as realistically possible so that "gaps" in the data could be filled. Some of these gaps were filled by consulting the MBA Database (Schatz, 1997). There were situations, however, where certain schools had data that could just not be found—despite the efforts previously described. These schools were ultimately excluded from this analysis. The most frequent reason for omitting these schools from the analysis was the fact that there was no disclosure regarding salary upon graduation. The majority of schools omitted from the analysis for this reason were typically smaller programs with a large percentage of part-time students (presumably working full-time), where the placement attributes of the school is perhaps not a major concern. Obtaining complete data for larger programs with a majority of part-time students (presumably working full time) was typically not a problem.

As a result of the specification of the input and output attributes, a data set of 188 AACSB-accredited MBA programs was constructed. It should be noted that the inputs and outputs are in differing units. For example, average GMAT scores are in points, while average starting salary is in US dollars—this complicates the interpretation. To compensate for this, all attributes were standardized and then re-scaled from zero, so that the lowest possible output and input values would be zero.

DATA ENVELOPMENT ANALYSIS METHODOLOGY

DEA is employed to determine the relative efficiency of each of the 188 schools analyzed. This efficiency is a composite ratio of the outputs to the inputs. An efficiency of unity is the highest possible score, and represents a program that is DEA-efficient, while an efficiency of anything less than unity is referred to as DEA-inefficient. Within the context of the analysis, DEA-efficient programs are considered most desirable, and possess a set of attributes that the DEA-inefficient schools do not possess, but strive for.

Consider the output attributes: average starting salary upon graduation, average GMAT scores for students in the program and percentage of students rejected admission for MBA program k , where $i=1, 2, \dots, k, \dots, 188$. These outputs are represented by the variables O_{1k} , O_{2k} , and O_{3k} respectively ($s=3$ outputs). These outputs have weights of u_{1k} , u_{2k} , and u_{3k} . The inputs of

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annual tuition and class size are represented by the variables I_{1k} and I_{2k} respectively, with weights of v_{1k} and v_{2k} ($r=2$ inputs). The general linear programming model used for this Data Envelopment Analysis is as follows:

$$\begin{aligned} \text{Max:} \quad & h_k = \sum_{y=1}^s (O_{yk} u_{yk}) + \mu_{yk} \\ & \text{for school } k \end{aligned} \quad (1)$$

$$\begin{aligned} \text{Subject to:} \quad & \sum_{x=1}^r (I_{xk} v_{xk}) + \rho_{xk} = 1 \\ & \text{for school } k \end{aligned} \quad (2)$$

$$\begin{aligned} \text{and} \quad & O_{yk} u_{yk} - \left(\sum_{x=1}^r I_{xk} v_{xk} \right) + \mu \\ & \text{for all } i = 1, 2, \dots, k, \dots, n \\ & \mu_{yk}, \rho_{xk} \text{ unrestricted, } u_{yk}, v_{xk} \\ & \geq 0 \end{aligned} \quad (3)$$

As noted in equation (1), the objective is to maximize the value h_k subject to the constraints given in equations (2) and (3). The h_k value is the relative efficiency of school k . It should be noted that μ_{yk} and ρ_{xk} are slack variables designed to quantify the inefficiency in school k . In basic terms, the DEA model finds the "best value" of each h_k by varying the weights u_{yk} and v_{xk} subject to the "rules" specified in equations (2) and (3). These "rules" in (2) and (3) prohibit any values of h_k from exceeding unity. In short, the above model maximizes the efficiency for each school—showing each school in its best possible light with respect to the rules that efficiency cannot exceed unity.

When attempting to show a school in its best possible light with respect to the DEA model and the other schools being studied, there is a specific occurrence which can produce dubious results. Consider, for example, a school that is difficult in gaining acceptance. In addition, the starting salary of graduates is formidable. Furthermore, the class-sizes are small—students receive a high level of attention from faculty. The only negative is that the annual tuition for this particular school is very high. In short, all attributes associated with this school are favorable with the exception of the tuition. The DEA model defined above, however, would probably show this particular school to be DEA-efficient because the weight associated with tuition, v_{1k} , would be allowed to take on a value of zero, thereby ignoring the fact that tuition for this school is high. This type of situation permits schools to be classified as DEA-efficient when perhaps they should not be.

To prevent this from happening in the analysis, restrictions must be placed on the weights such that they are not permitted to take on negligible (or zero) values. These weight restrictions should reflect the decision-maker's view of the relative importance of the attributes. For this research the following weighting restrictions were applied to the outputs:

The weight of salary was not permitted to be less than, or more than five times that of GMAT score or rejection rate:

$$1 < \frac{u_{1k}}{u_{2k}}, \frac{u_{1k}}{u_{3k}} < 5 \quad (4)$$

This restriction obviously articulates the relative importance placed upon salary, but at the same time, GMAT score and rejection rate are considered as well.

The weight of GMAT score was not allowed to be more than twice that of rejection rate and visa versa:

$$.5 < \frac{u_{2k}}{u_{3k}} < 2 \quad (5)$$

Here, GMAT score and rejection rate are given approximately equal treatment, but some weighting freedom is permitted in attempt to find high levels of efficiency.

The weight of annual tuition was not permitted to be less than, or more than six times that of student to faculty ratio:

$$1 < \frac{v_{1k}}{v_{2k}} < 6 \quad (6)$$

As is the case with the weight restrictions for involving salary, the restriction here treats tuition as the primary input, but considers class size as well.

A DEA model can be analyzed two different ways—an input orientation and an output orientation. An input orientation informs the decision-maker as to how much reduction is needed from the current levels of input for a DEA-inefficient MBA program to become DEA-efficient. An output orientation presents information regarding how much augmentation is needed to the current levels of output for a DEA-inefficient MBA program to become DEA-efficient. DEA-efficient MBA programs, which have an efficiency of unity, require neither input reduction nor output augmentation. Both input and output oriented DEA models are used here to interpret changes necessary for DEA-inefficient programs to become DEA-efficient (Ali, 1995).

RESULTS

General Results

Of the 188 MBA programs analyzed, thirteen were found to be DEA-efficient—they have combinations of inputs and outputs that the remaining 175 MBA programs do not possess. These 13 programs make up what is referred to as the Efficiency Frontier, which is analogous to the Production Possibilities Frontier in Economics. Within the context of the analysis, these programs require neither input reduction nor output augmentation. The x-axis of the Efficiency Frontier is the level of virtual input—the weighted sum of inputs. The virtual input for program k is:

$$(\text{Virtual Input})_k = \sum_{x=1}^r I_{xk} v_{xk} \quad (7)$$

The y-axis of the Efficiency Frontier is the level of virtual output—the weighted sum of outputs. The virtual output for program k is:

$$(\text{Virtual Output})_k = \sum_{y=1}^s O_{yk} u_{yk} \quad (8)$$

The thirteen MBA programs found to be DEA-efficient were: Nebraska, Indiana University/Purdue University at Fort Wayne (IUPUI), Texas/Pan Am, McNeese St., San Jose State (SJSU), Oklahoma, Texas, Florida, Harvard, Massachusetts Institute of Technology (MIT), University California at Berkeley (Berkeley), University of Pennsylvania (Penn), and the University of Chicago (Chicago). In addition to these thirteen programs, five more exhibited virtual inputs and outputs that put them closer to the Efficiency Frontier than the other DEA-inefficient programs. While they were not found to be DEA-efficient, they would require relatively little input reduction or output augmentation to become DEA-efficient. The criteria used for determining whether-or-not a program is DEA "near-efficient" was based on both input reduction and output augmentations being less than 20%. Table 1 details these five programs along with the amounts of input reduction and output augmentation needed to make them DEA-efficient.

Table 1

Near Efficient MBA Programs

School	Input	Output
	Reduction	Augmentation
Lamar University	3.31%	1.38%
Northern Illinois University	17.68%	9.21%
Stanford University	15.79%	4.89%
University of California at Irvine	13.43%	7.73%
University of Massachusetts at Lowell	16.09%	8.62%

Interpretation of the input reduction and output augmentation values is straightforward. Consider, for example, Lamar University. For this program to become DEA-efficient, a linear combination of the inputs of tuition and class size would have to be reduced 3.31% below their current levels. This program could also become DEA-efficient by having a linear combination of the outputs of average starting salary upon graduation, average GMAT score and percentage of students rejected for admission increased to 1.38% above their current levels.

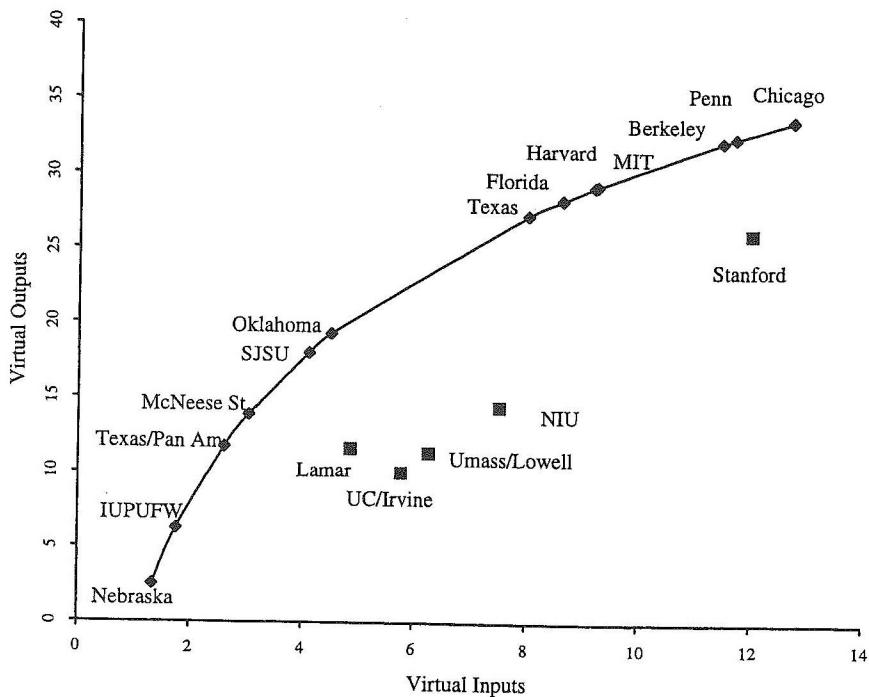
Figure 1 shows where the DEA-efficient and near-efficient schools exist with respect to the Efficiency Frontier. A distinctive characteristic of the Efficiency Frontier is its convex shape (Banker, et al., 1984 and Charnes, et al., 1978). The DEA-efficient programs are actually on the frontier (noted above the line), while the near-efficient programs are just "southeast" of the frontier (noted below the line).

The frontier provides some interesting information. The "northeast" end of the frontier includes schools like Harvard, MIT, Penn, and Stanford—programs frequently regarded as formidable. These schools are relatively expensive, but their benefits can be sizable (salaries, etc.). At the "southwest" end of the frontier are schools like IUPUI, Texas/Pan-American and McNeese St. These schools typically do not provide the same magnitude of benefits (salaries, etc.) as the schools at the other end of the frontier, but the benefits offered do offset the sacrifices necessary to attend (i.e., tuition). Regardless of what end of the frontier these schools reside, they share the common attribute of having their input requirements offset by their outputs. It is interesting to note that several schools on or near the frontier are state-funded programs which have generally favorable reputations. These schools would be especially attractive to prospective in-state students who could avoid paying the more expensive out-of-state tuition—this analysis used a weighted average for tuition (as previously described) as the input tuition attribute.

Figure 1 provides some perspective regarding the efficiency frontier.

Figure 1

Efficiency Frontier with Near-Efficient Programs



Sensitivity Analysis

Both inputs and outputs used for this DEA model can be considered stochastic—they will vary slightly over time. For example, tuition for some schools will change at different rates than at other schools. To address the stochastic nature of the inputs and outputs involved here, a sensitivity analysis was performed to determine which of the DEA-efficient programs were the most robust—least sensitive to unfavorable changes in their levels of inputs and outputs. In this context, an unfavorable change means a decrease of x percent in all outputs of a DEA-efficient program and a simultaneous increase of x percent in all inputs of a DEA-efficient program. Additionally, all DEA-inefficient programs have their outputs increased by x percent and their inputs decreased by x percent. In short, this change basically means that DEA-efficient programs are forced to appear less desirable and DEA-inefficient programs are forced to appear more desirable (Thompson et al, 1994, Thrall, 1996). After this change of x percent is made for all schools, the model is re-run and the set of DEA-efficient programs are interpreted. If an MBA program initially found to be DEA-efficient continues to exist in the efficient set of programs after a change has been made, the program can be considered robust—insensitive to unfavorable changes. For this research, four different levels of change were explored: 2.5%, 5%, 7.5% and 10%.

In addition to performing a sensitivity analysis with respect to the input and output values for each school as previously described, another sensitivity analysis was performed to examine the robustness of the thirteen schools originally found to be DEA-efficient when weighting constraints were made more restrictive. Consider the weighting restrictions as presented in equations (4), (5) and (6). To make these weighting constraints more restrictive, an adjustment factor (AF—which is a percentage) was chosen to “tighten” the range to which the ratios were permitted to take. Generically this can be expressed as follows:

$$\text{Lower Bound} * (1 + \text{AF}) < \text{Ratio} < \sum_{y=1}^s (O_{yk} u_{yk}) + \mu_{yk} \quad (7)$$

This “tightening” of the multiplier bounds essentially reduces the amount of freedom that the DEA model weights have when attempting to maximize the efficiency of the school of interest (refer to equations [1] through [3]).²

MBA programs originally found to be DEA-efficient that also show DEA-efficiency when the weighting constraints were made more restrictive can be thought of as robust, or insensitive to weighting restrictions. For this research, three adjustment factors were used: 5%, 10% and 15%.

The results of the two sensitivity analyses are shown in Table 2.

Table 2

Results of Sensitivity Analyses							
DEA Efficient School	2.5% (SA-1)	5.0% (SA-1)	7.5% (SA-1)	10.0% (SA-1)	5% (SA-2)	10% (SA-2)	15% (SA-2)
Nebraska	X	X			X	X	X
IUPUI	X	X	X	X	X	X	X
Texas/Pan Am	X				X		
McNeese St	X	X	X		X	X	X
SJSU	X				X	X	X
Oklahoma					X	X	X
Texas					X	X	X
Florida					X	X	X
Harvard	X	X	X		X	X	X
MIT	X	X			X	X	X
UC/Berkeley	X	X			X	X	X
Penn	X	X			X	X	X
Chicago	X	X			X	X	X

The table is straightforward. The first column is the name of the school initially found to be DEA-efficient. Columns 2-5 show the results from the first sensitivity analysis while columns 6-8 show the results from the second sensitivity analysis. An "X" indicates that a school of interest remains in the efficiency set despite the applicable change.

The first sensitivity analysis shows that most schools remain robust up through a 5% unfavorable change in output and input values (Florida, Oklahoma and Texas leave the efficiency set with a 2.5% change and SJSU and Texas/Pan Am leave the set with a 5% change). A 7.5% change results in only three schools remaining in the efficiency set (Harvard, IUPUI and McNeese St.), while only IUPUI remains in the efficiency set when subjected to a 10% unfavorable change in terms of outputs and inputs.

The second sensitivity analysis shows that the set of DEA-efficient schools remains completely intact when subjected to a 5% tightening of the multiplier bounds. When the multiplier bounds are tightened 10%, only Texas/Pan Am leaves the efficiency set, and only Penn leaves the efficiency set when the multiplier bounds are tightened 15%.

It is appropriate to note that when a program initially found to be DEA-efficient leaves the efficiency set due to a restriction imposed by sensitivity analysis, it will not return to the efficiency set provided the restrictions continue to become more "binding." This reasoning applies to both sensitivity analyses performed here. For example, once SJSU leaves the

efficiency set when the unfavorable change is 5% (SA-1), it will not return to the efficiency set when the unfavorable change is 7.5% or 10%.

DEA Results Compared to *Business Week*

Table 3 shows the efficiency measures of the *Business Week* "Top 25 MBA Programs" in terms of input reduction and output augmentation:

Table 3

<i>Business Week</i> "Top 25 MBA Programs"—DEA Results				
Rank	School	Input Reduction	Output Augmentation	Comment
1	Pennsylvania	N/A	N/A	DEA Efficient
2	Michigan	54.4%	36.12%	DEA-Inefficient
3	Northwestern	46.24%	19.43%	High Inputs
4	Harvard	N/A	N/A	DEA Efficient
5	Virginia	46.01%	25.97%	DEA-Inefficient
6	Columbia	60.21%	32.93%	DEA-Inefficient
7	Stanford	15.79%	4.89%	Near Efficient
8	Chicago	N/A	N/A	DEA Efficient
9	MIT	N/A	N/A	DEA Efficient
10	Dartmouth	51.73%	20.72%	DEA-Inefficient
11	Duke	58.06%	32.89%	DEA-Inefficient
12	UCLA	33.58%	17.16%	High Inputs
13	California	N/A	N/A	DEA Efficient
14	NYU	55.34%	32.99%	DEA-Inefficient
15	Indiana	35.05%	26.09%	DEA-Inefficient
16	Washington Univ.	73.59%	71.89%	DEA-Inefficient
17	Carnegie-Mellon	64.01%	45.46%	DEA-Inefficient
18	Cornell	57.93%	40.91%	DEA-Inefficient
19	North Carolina	52.75%	24.05%	DEA-Inefficient
20	Texas	N/A	N/A	DEA Efficient
21	Rochester	61.33%	51.11%	DEA-Inefficient
22	Yale	58.03%	33.36%	DEA-Inefficient
23	SMU	75.36%	73.31%	DEA-Inefficient
24	Vanderbilt	62.62%	54.79%	DEA-Inefficient
25	American (Thunderbird)	76.19%	88.22%	DEA-Inefficient

From inspection of Table 3, it is clear that while there is some agreement between the *Business Week* assessments and this research, there are also some conflicting results. Of the 25 programs cited by *Business Week*, this research classifies seven of them as DEA-efficient or near-efficient. In two instances a classification or "high inputs" was made if the required output augmentation

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was discovered to be less than 20%. The remaining sixteen MBA programs classified as DEA-inefficient receive that classification due to the fact that they are both input-excessive and output-deficient—they need large amounts of input reduction and/or output augmentation to improve their DEA-efficiency status.

SUMMARY

This research has presented a technique known as Data Envelopment Analysis to assess the desirability of several AACSB-accredited MBA programs. An attractive feature of this tool is that it can be used to make assessments of several alternatives (in this case MBA programs) when there are several attributes to be considered (in this case salary, tuition, etc.). The technique uses concepts of Linear Programming to optimize an objective function subject to a set of rules, or constraints. For this research, the objective function optimized was the efficiency score for each MBA program, and the constraints were various restrictions on the virtual inputs and outputs in addition to weighting restrictions. The DEA model finds a solution that maximizes the efficiency for each school subject to all relevant constraints, essentially showing each school in its best possible light while subjected to the constraints.

Specifically, 188 programs were evaluated and thirteen were found to be DEA-efficient, while five others were found to be near-efficient. Of these seventeen schools generally found to be most desirable, some are perhaps not surprising (i.e., Harvard, MIT), while others are perhaps surprising (i.e., McNeese State, Texas/Pan-American). Regardless of the reputations possessed by these eighteen schools, they share a common characteristic with regard to this research—the benefits reaped from attending and graduating from these programs generally justify the sacrifices necessary to attend them. The results also show some similarities and differences with an assessment of programs made by *Business Week*. Sensitivity analyses were also performed examining the robustness of the schools found to be DEA-efficient. The first analysis shows that most schools in the original DEA-efficiency set remain insensitive to unfavorable changes in outputs and inputs through a 5% level of change. Very few schools in the original efficiency set are robust to unfavorable changes beyond 5%. The second sensitivity analysis shows that most all schools remain insensitive to the “tightening” of the weighting restrictions through 15%.

CONCLUSIONS

When considering this analysis as a whole, one must also give consideration to the variables selected as outputs and inputs. When salary, rate of rejection and average GMAT scores were selected as outputs and average tuition and average class size were selected as inputs, they were selected in an attempt to show the most important attributes pertinent to the

problem at hand. Other possible inputs and outputs were not considered for this study. Consider, for example, part-time MBA programs. Here, students are presumably working full-time which means it will probably take them longer to complete the program. In this instance, these part-time students incur an opportunity cost of lost benefits due to their being in the program longer than their full-time counterparts. At the same time, however, these part-time students (many of whom *are* presumably working full time) are earning income while simultaneously working on their MBA, which could be considered as an alleviating measure to some of this opportunity cost.

Another issue to consider is that of financial aid. The information sources used for this research typically report a statistic of the percentage of students receiving financial aid, but do not report an average amount of financial aid received per student—which for this study, is considered more informative. Because of this, the financial aid issue is not incorporated as a variable here and the basic assumption made pertaining to tuition is that whatever financial aid is awarded by the schools is proportional to their tuition level.

One of the primary motivations for performing this research was to provide some objective treatment of assessing MBA programs since this topic typically receives only subjective treatment. This subjective treatment has typically involved surveying students and alumni, in addition to employers of the program's graduates. Here, the exploration of the desirable programs is made via a mathematical model, where selection of attributes (and their weighting) is the only subjective component. In addition to the somewhat objective nature of this analysis, one of its advantages is that not only can DEA inform the decision-makers of the most DEA-efficient MBA programs, but it can also inform them of the ones that are not efficient and the necessary measures to make them efficient. This information could be useful to prospective students who are considering MBA programs, in addition to faculty and administrators of MBA programs exploring means of self-study and improvement.

While this technique has value in its objective approach to assessment of MBA programs, it should not be viewed as a vehicle that always results in an optimum decision—finding the “best” school. Information needed to find the “best” school comes from many sources, some of which are not quantitative. Rather than using DEA as an unconditional tool to determine the very best schools, it should be thought of as a device to assist in finding schools which are generally favorable due to the fact that the benefits associated with these schools justify the sacrifices necessary to attend them.

NOTES

1. The tuition figure used is tuition and fees for a single academic year, based upon 24 semester hours or 36 quarter hours.
2. It is appropriate to note that "widening" of the multiplier bounds was also performed and the set of DEA-efficient programs remained intact, which shouldn't be surprising considering that "narrower," more restrictive multiplier bounds resulted in the same DEA-efficiency set.

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