

International Quality Control Certification: Signal or Heuristic?

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Timothy R. Wojan and Thomas Bailey

University of Kentucky
Department of Agricultural Economics
400 Charles E. Barnhart Bldg.
Lexington, KY 40546-0276

Phone: 859-257-5762

Fax: 859-323-1913

<http://www.uky.edu/Ag/AgEcon/>

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ABSTRACT: The objectives of this paper are to: 1) understand the characteristics of manufacturing firms associated with ISO 9000 quality control certification and to assess the support these relationships provide for different explanations of the phenomenon; and 2) use these empirical relationships to identify firms most likely to benefit from technical assistance regarding quality control: i.e., firms with a strong need for quality control certification but with limited capabilities to acquire it. Thus, the policy interest of the analysis is to identify the possible role for industrial extension to facilitate quality control certification of disadvantaged firms.

* Wojan is a Post-Doctoral Research Associate, TVA Rural Studies and Department of Agricultural Economics, University of Kentucky. Bailey is a Ph.D. Candidate, Department of Agricultural Economics, and Economist, Cabinet for Economic Development, Commonwealth of Kentucky. Financial support for this research was provided by TVA Rural Studies.

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I. Introduction

Deming's 'Quality Revolution' is now being taken very seriously by Western management after a long gestation across the Pacific. Market outcomes speak louder than management paradigms and consumer demand for quality became thunderous in the 1980s. However, any 'necessity' for quality in consumer markets is still contentious and it is difficult to argue that lower price is not a substitute for higher quality in the decision calculus of consumers. If there is anywhere that quality and price defines a lexicographical ordering it is in intermediate markets. Vertical disintegration of many industries along with new management practices such as Just-in-Time inventory has pushed quality to the top of the ordering for logistical reasons. It is no longer the case that defects can merely be remedied at the end of the production line. Neither can an assembler go back to inventory to replace a defective lot. Rather, defects in components often require the shutdown of an entire production line until the source of the defect is found so that it can be permanently remedied. (Sabel 1994). The cost of defective goods is now tangible and significant in the form of idle machinery and workers.

The implications of the 'Quality Revolution' for rural manufacturing are potentially dire. The most obvious implication is that the lower labor and land costs enjoyed by rural manufacturers may cease to be a source of comparative advantage. If these manufacturers cannot meet the quality requirements of industrial customers they will not win contracts no matter how significant the nominal cost savings. However, it is the change in the contracting structure of production that may pose the most substantial threat to rural manufacturers. The coordination problems generated by quality concerns are not resolved in the conventional arms-length contracting arrangements used in traditional mass production practice. To better deal with these coordination problems customers have drastically reduced the number of component suppliers and have moved toward medium- to long-term relationships with their suppliers that may include quality audits on a periodic basis (Sabel 1994, Wojan 1996). The spread of just-in-time inventory management¹ is perhaps the clearest manifestation of much greater interdependency between manufacturing customers and their suppliers (Sabel 1994).

An institutional innovation to address the increasing importance of quality in the marketplace is the introduction of the Series 9000 Quality Control Standards by the International Organization of Standardization (ISO 9000). The absence of "hard" standards related to outcome or process in the series has helped to fuel the debate in the business literature over the value and function of certification. The standards can be described most simply as codification of all firm functions that may affect product quality so that these processes are transparent to a customer. The seemingly vacuous requirements of the standards may also explain the disinterest of the applied economics community on a topic that may be central to understanding the competitiveness of industry.

However, both survey and case study analysis of ISO 9000 certification suggest that the standards satisfy one or more essential economic prerequisites of the 'New Economy.' With

¹ Forty-eight percent of manufacturing firms either used just-in-time practices or supplied just-in-time customers in a survey of firms in the U.S. (Unpublished data from the 1996 USDA/ERS Manufacturing Survey)

respect to external relations of the firm, ISO 9000 standards are seen as an effective way to **signal** higher quality control ability to prospective industrial customers. The 'New Economy' construct suggests that this will become increasingly important as the trend for outsourcing increases the complexity of intermediate markets. Empirical studies also suggest that ISO 9000 may improve the internal coordination of business practice. The standards provide a consistent framework for "programming" purchasing, design or contract decisions. The move from unprogrammed to programmed decisions is a central tenet from the behavioral theory of the firm (Simon 1979) in which agents with bounded rationality develop **heuristics** to aid good decision-making in complex environments.

The objectives of this paper are to: 1) understand the characteristics of manufacturing firms associated with certification and to assess the support these relationships provide for different explanations of the phenomenon; and 2) use these empirical relationships to identify firms most likely to benefit from technical assistance regarding quality control: i.e., firms with a strong need for quality control certification but with limited capabilities to acquire it. Thus, the policy interest of the analysis is to identify the possible role for industrial extension to facilitate quality control certification of disadvantaged firms.

The paper begins with a brief summary of the ISO 9000 standard. A theoretical section discusses the ways in which ISO 9000 certification may address external (signaling) or internal (heuristics) coordination problems of firms. This discussion is used to motivate the specification of an empirical model to predict the probability that a manufacturing firm is certified. The analysis is limited to all firms in the Kentucky Manufacturers Directory. Results from the first analysis are used in the specification of a policy model with the central interest of identifying firms with high need but low capability to pass a certification audit. The characteristics of these 'target' firms are compared with 'nontarget' firms before concluding with a discussion of ways to implement the research in a manufacturing modernization program.

II. The ISO 9000 Standard

ISO 9000 certification is most simply described as verification that a firm can back-up claims it makes regarding the quality control requirements of a customer. And further, that it can systematically evaluate its quality control performance and promptly correct identified shortcomings. The criterion, of itself, appears indefinite if not vacuous (Hancke & Casper 1996). It is in the context of complex purchasing and selling relationships that the value of a transparent code of quality control practice is more flexible, and thus ultimately more useful, than a 'hard' set of quality thresholds.

The popular assumption that ISO 9000 establishes an international product quality standard is incorrect. It is important to understand that certification is **not** granted on meeting a predetermined product quality threshold. The standards are silent on stipulating outcome criteria such as acceptable defect rates or acceptable product impurities. The standards do however stipulate the various organizational capacities that must be in place. ISO 9000 certification requires demonstrated capability to systematically analyze, implement and evaluate all firm functions bearing on product quality. The chapter titles from ***The Manager's Guide to ISO 9000*** are illustrative of the range of activities that are thought to bear on product quality:

Contract Review...Design Control...Document Control...Purchasing...Purchaser-Supplied Product...Product Identification and Traceability...Process Control...Inspection and Testing...Inspection, Measuring and Test Equipment...Inspection and Test Status...Control of Nonconforming Product...Corrective Action...Handling, Storage, Packaging and Delivery...Quality Records...Internal Quality Audits...Training...Servicing...Statistical Techniques...Economics: Quality-Related Cost Considerations (Arnold 1994, pp. v-vi).

The principal objective of certification is to verify that a firm can back-up claims it makes regarding the quality control requirements of a customer. It is in a volatile environment in which the description of ISO 9000 as an interactive standard of competence is most useful.² With increasing volatility in the parameters of design, production technology and marketing organizational capability to redesign the system quickly when quality control is important is essential. In a stable environment it would be appropriate to describe certification as the product of demonstration of appropriate organizational or institutional capabilities to address product quality concerns. However, in an environment where any of these parameters may be volatile, a given organizational structure designed to ensure product quality might soon become obsolete. A frequent re-certification process would soon mire down the standard and decrease its value to both registrants and customers. ***It is clear that the standard does not certify an outcome***, but it also does not merely certify the existence of appropriate organizational structures to address quality concerns. Rather, the standard certifies that ***the firm is capable of responding systematically to novel challenges of the firm's competence***-- "certification qualifies a firm as a reliable interlocutor in the eventual discussion of its performance capacities" (Sabel 1994, p. 9).

III. Two Nonexclusive Explanations for Certification

A concise description of the standards can be used to support either the external signaling or the internal coordination rationale for a firm investing significant time and money in passing a certification audit.³ These same explanations are corroborated in survey and case study research. However, the most important contribution of the empirical research is the insight it provides as to how real world problems interact with ISO 9000 certification to accord value to these alternative explanations.

Survey research undertaken shortly after the introduction of the standards suggest that external factors are dominant in deciding whether or not to apply for certification. Investigations by

² The term is borrowed from Sabel's (1994 p. 9) description of ISO 9000 as a 'discursive standard of competence'.

³ See Davis (1997) for a description of the types of documents and records needed to pass a certification audit. Rural firms examined by Wojan (1996) needed from 1 to 2 years to codify firm procedures and successfully pass the certification audit. Most firms do not pass the audit on their first attempt. Statistics on the failure rate are hard to come by but one commentator claims that only 15% of firms pass on their first try (Thayer). Estimates of the cost of preparing for and soliciting an audit by an accredited registrar varies from \$30,000 to \$500,000 depending on the size of the firm, the processes to be certified, and whether series 9001 (design, production and installation), 9002 (production and installation) or 9003 (installation) certification is sought (Voehl). There are also recurrent costs as the registrar is required to periodically re-audit the firm in order to maintain its certification.

Rayner and Porter (1990), Fynes and Ennis (1993) and Deloitte & Touche (1993) all identify the main motive as customer demands or expected customer demands. Other marketing advantages of some sort were also mentioned by a large number of respondents either in the form of entry into markets or as a way to increase market share. For firms doing business in the EU it was seen as a 'license to compete,' at least within the chemical industry (Thayer 1993).

Case study analysis provides support for the dominant role of external factors in compelling firms to seek certification. Rural firms in the Upper Midwest sought certification in anticipation of existing customer demands (Wojan 1996). While these expectations were often not realized the firms identified a concrete benefit in expanding their customer base. Given that many customer firms were drastically reducing the number of suppliers, ISO 9000 certification served as an effective signal of potentially higher competence of these firms. Thus, in contract bidding certified firms were fairly confident of making the short list of prospective suppliers. However, before winning a contract the customer would usually perform its own quality audit. The fact that customers were expending additional resources to assess the specific quality control capabilities of already certified firms is highly suggestive of a signaling function of the ISO 9000 standards.

It is interesting that in later surveys—presumably after firms had become more familiar with certification—improved internal coordination emerges as the primary benefit. Mullins (1995) survey of U.S. chemical companies along with a survey of Belgian companies (Vloeberghs and Bellens 1996) find that improved internal work processes is the primary motivation ahead of improved market image or honoring a customer's request. The case study of rural firms in the Upper Midwest corroborates this finding (Wojan 1996). Although external factors were decisive in pursuing certification, it was only after the certification process began that several firms realized that real benefits would accrue from thinking systematically about their production process. The comprehensiveness of the standards forced them to think about all aspects of the production process and how the seemingly separable processes within the plant fit together. For example, before certification purchasing and production may have had disagreements about the selection of suppliers. This might spillover to quarrelsome committee meetings but was unlikely to resolve the underlying problems of either party. After certification, both parties knew the operating procedures of the other so they could start from a common understanding to meet the goals of the firm—not merely pursue the goals of their respective departments.⁴

The fact that there are divergent opinions on the true value of ISO 9000 certification is a strong argument for economic analysis of the phenomenon to test whether either or both theoretical explanations are consistent with the data. Indeed, external factors consistent with the signaling hypothesis may be the primary reason to begin the process of seeking ISO 9000 certification. However, if the firm discovers that the real economic benefits of signaling higher quality control capability are not greater than the costs of maintaining certification they will let their ISO 9000 registration lapse. Alternatively, certification may be sought to improve internal coordination of operations. But again, real economic value of ISO 9000 registration should be revealed by the characteristics of those firms that seek certification, expend the resources

⁴ This is a common problem in organization theory and has been given the name *sub-goal identification* (Simon 1978). Explicit examples of this in the industrial purchasing process are provided in Woodside (1992).

necessary to pass a certification audit and then maintain it. The discussion now turns to explicit consideration of these theoretical perspectives to get a better appreciation of the observable firm characteristics that may be productive in informing this debate.

III. Theoretical Considerations

A. Signaling: Why High Ability Agents Prefer Revealing Private Information

The anecdotal evidence of ISO 9000 firms still having to pass customer specific quality audits is consistent with a signaling function of certification. Indeed, the fact that the standards lack any 'hard' requirements regarding outcome or process reinforces this interpretation. From the signaling perspective, ISO 9000 certification may provide information on the general capability of a supplier to meet the customer's specific quality control requirements. That is, acquiring certification is an activity undertaken by higher ability firms to make public unobservable characteristics. As an example, quality control certification may be analogous to the requirement that job applicants possess a college degree in any discipline. Completing the degree does not directly contribute to the skills needed to function in the job but it may provide information on the applicant's ability to learn.

The context of the signaling problem is defined as follows: there exist high ability and low ability agents (e.g., suppliers) but information on their ability is unobservable; principals (e.g., customers) actively compete for agents; the system is in equilibrium if the principals' expectations of agent ability are realized. The critical determination is whether a signal can provide useful information to the principal in correctly distinguishing high ability from low ability agents: i.e., does the signal support a separating equilibrium?

The critical parameters supporting a separating equilibrium are the relative abilities of agents, the cost of acquiring a signal and the beliefs of principals (e.g., does information on higher ability justify a wage premium high enough to compensate for the cost of the signal). More specifically, the sufficient conditions for a separating equilibrium require (Macho Stadler 1997)

- 1) that high ability agents can acquire the signal at lower cost than low ability agents;
- 2) that the expected profit with a signal are greater than the cost of acquiring the signal for high ability agents; and
- 3) that the expected profit with a signal are less than the cost of acquiring the signal for low ability agents.

If a separating equilibrium exists then high ability agents pay the signaling cost to transform the problem from one of adverse selection to one of symmetric information. This is inefficient as the central assumption is that acquiring the signal does not affect the ability of the agent. But its welfare effect is ambiguous as there is a trade-off between the gains from an optimal contract versus the cost of a signal.

Our concern in this paper is not to determine whether or not ISO 9000 certification supports a separating equilibrium. Information on costs of certification; the existence of an ISO 9000 premium in contracting; or even the relative number of firms that pursue certification, firms that are audited for certification and those that eventually pass are not available. Rather, the

empirical leverage is provided solely by Condition 2 above. We assume that the expected profit from certification will vary systematically by firm and industry characteristics. And thus, the probability of acquiring the signal should be positively related to greater expected profits. Examples of industry characteristics described in more detail below include the percent of industry output going to intermediate production, the selling complexity of the industry (i.e., does the industry sell to a small or large number of other industries?), and the prevalence of just-in-time supply contracts in the industry. As evidence of the variation in certification rates across industries, ISO 9000 incidence by 2-digit SIC is provided in **Table 1** for the U.S. and for the study area. The extent to which these firm and industry characteristics are powerful in explaining certification probability will be more or less suggestive of the existence of a separating equilibrium.

Before proceeding to consideration of the alternative theoretical framework it is prudent to consider the ways that ISO 9000 certification may fail to comply with some of the central assumptions of the signaling explanation. First, the assumption that acquiring the signal does not materially affect the ability of the agent may be more heroic in the ISO 9000 case relative, say, to the labor market case. For instance, Sabel (1994) has described certification as confirmation that the firm is 'fluent' in modern quality control practice. From this perspective, it is difficult to argue that increasing the ability of the supplier to communicate with a customer is not a substantive augmentation of skill. Yet, there are those in the business community who see certification as nothing more than an added cost of doing business—these executives attribute no added firm capabilities to the certification process (see Thayer 1993).

Second, in contrast to a signal such as a college degree, ISO 9000 certification can be revoked if the agent fails to comply with the expectations of the principal; e.g., fails to meet quality control stipulations in a contract. From this perspective, certification does not serve merely as a way to convey private information on firm capabilities but effectively comprises a bond the supplier puts up to guarantee compliance with a contract. A firm renegeing on a contract would open itself up to having certification revoked, thus losing the resources it expended to acquire certification. In this instance certification would serve as an augmented signal: i.e., information provided by certification would reinforce competence trust—or ability to comply—between the contracting parties while the bond attribute would reinforce contractual trust—or desire to comply (See Sako 1993).

B. Heuristics: How Satisficing Agents Make Good Decisions in Complex Environments

The behavioral theory of the firm supports inductive—or reality based—theorizing about how firms actually make decisions (Woodside 1992). The biggest contrast with mainstream rationalist theories of firm decision-making is that it cannot be assumed that all agents perceive a given problem the same way, that search across alternatives is bounded by the information processing capabilities of agents, and that the selection criteria is framed by meeting certain 'thresholds' not by a boundless search for the optimal alternative. Herbert Simon (1979) summarizes the behavioral approach in his address on receiving the 1978 Nobel Prize in Economics. His contention is that in complex environment it is impossible for people to apply substantive rationality to find the optimal alternative for every decision. He argues economists should rather concentrate on the rational processes required of making good decisions in turbulent and complex environments. That is, he argues for the study of 'procedural rationality' rather than the study of realistically unattainable substantive rationality.

Table 1
ISO 9000 Certification Incidence By 2-Digit SIC Code
United States and Kentucky, Spring 1998

2-DIGIT SIC CODE	ISO FIRMS US	ISO FIRMS KY	ALL FIRMS US	ALL FIRMS KY	CERT %US	CERT %KY
20	97	2	21285	240	0.456%	0.833%
21	2	0	112	10	1.786%	0.000%
22	240	2	6452	42	3.720%	4.762%
23	23	0	24216	176	0.095%	0.000%
24	32	0	37601	737	0.085%	0.000%
25	111	2	11611	114	0.956%	1.754%
26	684	7	6552	90	10.440%	7.778%
27	184	2	64690	686	0.284%	0.292%
28	1905	44	12328	157	15.453%	28.025%
29	147	0	2042	41	7.199%	0.000%
30	1583	45	16611	205	9.530%	21.951%
31	17	0	1957	14	0.869%	0.000%
32	339	8	16214	270	2.091%	2.963%
33	982	27	6768	87	14.509%	31.034%
34	2190	37	36314	435	6.031%	8.506%
35	2045	28	55476	620	3.686%	4.516%
36	2728	26	17058	150	15.992%	17.333%
37	980	35	11256	126	8.706%	27.778%
38	1398	4	11378	53	12.287%	7.547%
39	74	3	17899	141	0.413%	2.128%

A critical component of procedural rationality in complex environments is the shift from unprogrammed decisions—requiring the unique formulation of the constraints and attributes framing each problem—to programmed decisions. Programmed decisions or heuristics recognize the similarity in various classes of problems and requires the construction of formulation templates that are applied to the appropriate problem class. This is essentially parallel to the central objective of the ISO 9000 standards that require the codification of the decision process across a wide variety of business functions.

By making these heuristics transparent to an auditor or potential customer, it can be decided whether the particular heuristics the firm uses in a complex environment are a reliable means of assuring quality control. It is important to note that this function differs significantly from the signaling rationale. From the heuristics perspective the documents that make up the quality control manual are important because they describe what the firm actually does. From the signaling perspective certification is merely an arduous task that can be completed much more easily by high ability firms thus making public the previously unobservable characteristics of the firm.

In this way, heuristics also reinforce competence trust (Sako 1993) but not by affirming higher ability of the firm as in signaling. Rather, the quality control manual serves a central role in those instances plagued by incomplete information; i.e., cases where both principal and agent face a common uncertainty. The processes codified in the certification process are meant to provide information to a customer on any factor which might hinder the supplier's ability to meet a condition of the contract (e.g., timely deliver in the case of weather emergencies). The logic is that any such information should be communicated to the customer immediately to avoid the possibility that uncertainties are used as excuses for a breakdown of contractual trust.

Finally, the heuristics rationale for ISO 9000 certification also addresses the potentially erroneous assumption from the signaling and economics of information framework that all information, once made public, is uncontested. For example, in poker everyone knows that a jack beats a ten and 3-of-a-kind beats a pair. This same assumption is applied to the industrial purchasing environment despite it being much more nuanced. By making explicit the processes used in a firm, codification may promote a convergence of possibly divergent perceptions of reality both internally and between supplier and customer.

The behavioral theory of the firm is much less elegant than the frameworks developed using the economics of information. There are thus no list of sufficient conditions suggesting when a firm might switch from unprogrammed to programmed decisions. However, there is a clear indication that this switch should be highly correlated with the complexity of the environment. Indeed, heuristics will lead to large inefficiencies in simple environments because there is no justification for 'satisficing' when one could optimize. In the empirical model it is assumed that indications of greater internal complexity—thus, greater internal coordination problems—are positively related to the probability of a given establishment having ISO 9000 certification.

V. Empirical Specification of a Theoretically Motivated Model

Both the external signaling and internal coordination explanations of ISO 9000 certification define explicit hypotheses that can be empirically tested. The null and alternative hypotheses

that would either refute or support the **signaling** explanation, respectively, are formally stated as follows:

H₀: Establishments with more structurally complex—or spatially separated—selling relationships do not demonstrate a higher likelihood of acquiring ISO 9000 certification.

H_A: Establishments with more structurally complex —or spatially separated—selling relationships demonstrate a higher likelihood of acquiring ISO 9000 certification.

The null and alternative hypotheses that would either refute or support the **heuristics** explanation, respectively, are formally stated as follows:

H₀: Establishments with more structurally complex internal coordination problems do not demonstrate a higher likelihood of acquiring ISO 9000 certification.

H_A: Establishments with more structurally complex internal coordination problems demonstrate a higher likelihood of acquiring ISO 9000 certification.

The principal concern of this section is to examine the types of firm and industry characteristics that can be used to test these hypotheses.

The most serious empirical challenge presented by both sets of hypotheses is how to proxy external or internal sources of structural complexity. Both explanations are dependent on the informational content of either external or internal relations. This suggests that information theory may provide a proxy that is parallel in the signaling and heuristics frameworks. The Theil statistic provides one measure of the information in a system needed by agents to function effectively (Pryor 1997). In this measure, the expected informational content of an ‘event’ is inversely proportional to the probability of that event (p). For purposes of analysis we assume that the probability of selling to (buying from) another industry is defined by the share of total output sold to (bought from) other manufacturing industries. These shares are derived from the direct requirements matrix of the national input-output table. These probabilities can be incorporated into the computation of the Theil statistics as follows:

$$H = \sum_i p_i \ln \left(\frac{1}{p_i} \right)$$

where p_i = the share of total output sold to another industry for all i in the manufacturing sector to define **selling complexity**, or the share of total inputs bought from another industry for all i in the manufacturing sector to define **buying complexity**.

The statistic will take on the value of 0 in the extreme case of all output sold to (input bought from) a single industry. The other extreme is defined by output sold to (input bought from) all

other manufacturing industries. In the sample, selling complexity ranges from 0.1358 to 4.9009; buying complexity ranges from 0.8248 to 4.1707. Buying and selling complexity are the only two constructed variables in the analysis. Description of the variables used in the Signaling and Heuristics short regressions are provided below.

A. Variables Included from the Signaling Short Regression:

1. The percent of output sold to other manufacturing industries (MFGSELL--Industry specific). The variable indicates the importance of intermediate goods as an output of the industry. It is important to remember that this an industry proxy that may not represent the share of business in intermediate markets of any single establishment from a given industry in the analysis. However, the proxy does provide a valid instrument for assessing the relative probability of any firm in a given industry supplying industrial customers as opposed to final markets. It is thus critical to assessing the external relationships thought to be central to ISO 9000 certification. The expected sign of the coefficient is positive.
2. The structural complexity of an industry's intermediate selling relationships (SELLCOMP--Industry specific). The assumption is that expected profits from certification will be greater for those firms with the potential to sell to a large number of different industries. Different industries will likely have specific quality control requirements. Firms in supplier industries serving a wide variety of industrial customers will thus have to demonstrate greater quality control ability relative to a supplier industry serving few types of industrial customers. The expected sign of the coefficient is positive.
3. The percentage of firms in an industry supplying just-in-time supply contracts (JIT_CUS--Industry specific). Quality control ability will be more important for firms in industries with a high probability of filling a just-in-time contract. Common practice in just-in-time supply is for final quality assurance to be checked at the suppliers' facilities. We use the incidence of JIT practice for each 3-digit SIC industry as an instrument for the firm's expectation of having to fill a JIT contract. The estimates are derived from unpublished results from the USDA/ERS 1996 Manufacturing Survey. The expected sign of the coefficient is positive.
4. Establishment supplies the automotive industry (AUTO—firm specific). This is a firm specific variable parallel to the industry just-in-time variable. Automobile assembly plants have been aggressive in promoting just-in-time supply and relational or obligational contracting relative to most other industries. The variable also has interest from a policy perspective as automobile manufacture has been a target industry for the Commonwealth of Kentucky. The expected sign of the coefficient is positive.
5. Establishment exports to countries other than Japan or those in Western Europe (XPORTOTH--firm specific). ISO 9000 certification is often erroneously associated only with firms operating in export markets. While the standards have value to firms operating only domestically, the expected profits from certification may be greatest for firms operating in export markets from the signaling perspective. Since close interaction between customer and supplier may be precluded, a signal of higher quality control ability may be essential. In the analysis we differentiate between export to Western Europe, Japan and the rest of the world. The *a priori* assumption is that regions where ISO 9000 certification has been fastest (Western Europe) or where obligational contractual relations are most common (Japan) should have a stronger demand for ISO 9000 certification of suppliers. The expected sign of the XPORTOTH estimate is positive but of smaller magnitude relative to Japan and Western Europe.
6. Establishment exports to Japan (JAPAN--firm specific). The expected sign of the coefficient is positive.

7. Establishment exports to countries in Western Europe (WESTEUR—firm specific). The expected sign of the coefficient is positive.
8. Establishment is located in a nonmetropolitan county (RURAL--firm specific). The justification for the added value of signaling in the export context extends to the domestic context. Suppliers more likely to be physically separated from customers due to rural or remote rural location may have greater need to signal their quality control ability. The expected sign of the coefficients is positive.
9. Establishment is located in a nonmetropolitan county that is not adjacent to a metropolitan county (NONADJ—firm specific). The expected sign of the coefficients is positive.

B. Variables Included in the Heuristics Short Regression

10. The percent of inputs purchased from other manufacturing industries (MFGBUY--Industry specific). The variable indicates the importance of intermediate inputs from other manufacturing industries. Again, this is an industry proxy that may not represent the purchasing dependency of any single establishment in the analysis. However, the proxy does provide a valid instrument for assessing the relative probability of any firm in a given industry being dependent on intermediate products. The expected sign of the coefficient is positive.
11. The structural complexity of an industry's purchasing relationships (BUYCOMPL--Industry specific). It is assumed that internal coordination problems of purchasing in an industry will be positively associated with greater input complexity. Firms buying from few different industries will derive fewer benefits from programming the purchasing decision. The expected sign of the coefficient is positive.
12. The percentage of firms in an industry using just-in-time inventory management (JIT_OWN—industry specific). Firms with a greater likelihood of using JIT inventory management are likely to have greater internal coordination problems related to quality assurance of supplied components. The expected sign of the coefficient is positive.
13. Establishment imports inputs from another country (IMPORT—Firm specific). Firms importing inputs will likely be denied more *ad hoc* means for evaluating the quality control abilities of a supplier. Importation will also tend to complicate the purchasing process as import compliance procedures and the distance to the supplier will increase the time between order and delivery. The expected sign of the coefficient is positive.
14. Firm size by employment (EMPLOYME--Firm specific). Expected sign of the coefficient is positive. A larger number of departments and individuals are likely to be involved in purchasing decisions in larger firms. The potential value of ISO 9000 as a heuristic in this environment is to limit the problems introduced by subgoal identification (different perceptions of a given reality) and to promote conflict avoidance by delegating responsibility in a way that is understood by all parties in the activity. The expected sign of the coefficient is positive.

C. Control Variables

15. The establishment is owned by a publicly traded company (PUBLIC--Firm specific). This variable likely informs both the Signaling and Heuristics rationale for certification. In comparison to closely held companies, the owners of a publicly traded firm are less likely to have detailed information on the quality control processes of the firm. Thus, a transparent standard may effectively communicate the quality control processes in place to both current and potential investors. Also, **on average** the management staff of a public firm can be assumed to be more competent than that of a closely held firm because management

performance is constantly scrutinized in the market. Thus, these firms may be more able to acquire certification. From the Heuristics perspective, internal coordination problems may be greater in multi-establishment firms that are more likely to be publicly traded while closely held firms are more likely to be unit plants. Either perspective supports the expectation of a positive coefficient.

16. The establishment is unionized (UNION—Firm Specific). Unionized firms may be induced to acquire certification to compensate for potentially higher wage and production costs. Alternatively, unionized firms may be better able to implement certification due to the experience of unions in the codification of work rules. Or, as firms more likely to be operating in the core sector, these establishments may be able to hire more able employees with long tenure that may facilitate modern quality control practice. The expected sign of the coefficient is positive.

D. Possible Omitted Variables

Various analyses of ISO 9000 certification suggest that the phenomenon may be ‘overdetermined’—i.e., the probability of acquiring certification may be explained by a range of business strategies depending on the specific context rather than being the result of some elemental underlying force. An analysis of German firms suggests that more transparent standards may be critical for a wide range of business transactions outside the I-O relationships considered here (Hancke and Casper 1996). Firms seeking product liability insurance were often required to obtain ISO 9000 certification by their insurance company thus decreasing requirements on the insurer to assess idiosyncratic quality control processes across firms. If claims were filed, a certified firm might have an advantage in court demonstrating that its processes were consistent with industry best practice. Unfortunately, information on product or worker liability claims across industries is extremely difficult to come by as recognized in a recent report by the General Accounting Office (1997).

A variable to examine the existence of demonstration effects is highly intriguing and is suggested in an analysis of ISO 9000 incidence in the South (Wojan 1998). It is not included in this report due to time constraints. However, the most appropriate specification of a proxy is not obvious. Using GIS software it would be possible to compute the distance to the nearest firm with an earlier certification date. There are good reasons to expect that adoption will be positively affected by having other certified firms nearby if only because there is better information on the costs involved in certification and on the potential benefits from certification.

Other variables which are potentially very important to certification rates but were unavailable for this analysis include the ownership status (i.e., domestic or foreign) of establishments, whether the certified establishment is a single location firm or a branch plant of a multiple location firm. This information is available in various forms but it is not known if these data are available for all establishments in this study.

VI. Estimation and Empirical Results

A logistic regression estimator is used in the quantitative analysis of the data⁵. Two concerns regarding the appropriateness of this estimator to examine available data are both addressed by

⁵ PROC LOGISTIC in SAS Version 6.12 for Windows NT.

the sample size. Since the small sample properties of the estimator are not known a relatively large sample is required for the asymptotic properties of the estimator to hold. This requirement is amply met by the 2800 observations used to estimate 17 unique parameters. A potentially more serious concern relates to the proportion of observations represented by ISO 9000 certification. Only 7.8% of the firms in the sample are certified which violates the general rule of thumb in econometrics suggesting that at least 10% of the sample should possess the qualitative characteristic of interest. The epidemiologic literature often has to explain rare events and the issue has been more rigorously examined there. Selvin (1996) suggests that an event which occurs in only 4% of subjects will require a sample size of at least 1700 to produce valid results (p. 94).

A. Signaling Short Regression

The regression results (**Table 2**) suggest that the signaling variables are powerful in predicting the probability of ISO 9000 certification of establishments. About 90% of the observations are predicted correctly and 6 of the 11 coefficients are significant at the 0.01 level. While the signs of the significant variables are as predicted, there are some surprises with respect to the relative magnitude. Exports in general tend to be a very important characteristic in predicting certification. However, it is the export to countries other than Japan and Western Europe that is most important. In fact, this variable has the largest standardized coefficient estimate of any of the variables in the regression. Export to Japan is significant but of much smaller magnitude. Export to Western Europe was not significant.

While the industry specific JIT_CUS variable was not significant, the firm specific variable indicating whether the establishment supplied the auto industry (AUTO) was. The value of the standardized coefficient suggests that this variable was second in importance after export to countries other than Japan and W. Europe.

The percentage of output sold to other manufacturing industries (MFGSELL) was a significant industry specific variable. This corroborates the widely held belief that ISO 9000 certification will be most valuable to intermediate producers. The result also suggests the productiveness of using the direct requirements matrices of input-output tables to proxy firm level relationships. However, the constructed variable to proxy the complexity of an industry's selling relationships was not significant. The constructed variable proxies first order complexity—that is, the measure is derived from the number of industries the target industry sells to. The real value to ISO 9000 as a signal may derive from second order complexity—i.e., do the customer industries have simple or complex input relationships?

Finally, results from the rural location variables are mixed. After controlling for industry mix and other factors, rural firms were more likely to acquire certification relative to their urban peers. This is suggestive of the signaling rationale for certification. However, those firms that were most remote in nonadjacent counties did not demonstrate a greater likelihood of certification. This may be indicative of weaker demonstration effects or lower firm and worker ability. It may also be representative of an Eastern Kentucky effect as ISO 9000 certified firms are rare in this part of the state and there are few metropolitan counties.

Table 2
Probability of ISO 9000 Certification as Function of Signaling Variables
Short Regression

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio	Sample Mean
INTERCEPT	-5.6674	0.3659	239.9652	0.0001	.	Intercept	.
MFGSELL	1.8790	0.3622	26.9138	0.0001	0.264119	6.547	0.31804
SELLCOMP	0.0890	0.0862	1.0659	0.3019	0.059212	1.093	3.0744
XPORTOTH	1.6668	0.2241	55.3295	0.0001	0.443133	5.295	0.36749
JAPAN	0.6154	0.2286	7.2478	0.0071	0.099234	1.850	0.09441
WESTEUR	0.2575	0.2175	1.4010	0.2366	0.051401	1.294	0.15514
RURAL	0.6655	0.2104	10.0035	0.0016	0.183496	1.946	0.49666
NONADJ	-0.3657	0.2312	2.5027	0.1137	-0.094611	0.694	0.32713
JIT_CUS	-0.0679	0.4969	0.0187	0.8913	-0.007332	0.934	0.47955
AUTO	1.7765	0.1823	94.9319	0.0001	0.298903	5.909	0.10389
PUBLIC	1.3932	0.1914	53.0072	0.0001	0.236157	4.028	0.10565
UNION	0.3701	0.2056	3.2398	0.0719	0.067244	1.448	0.12390

System Statistics:

Event (ISO 9000 by 4/98)	223
Nonevent	2626
Percent	7.83%

Chi-Square for Covariates

-2 LOG L	517.006 with 11 DF (p=0.0001)
Score	656.180 with 11 DF (p=0.0001)

Association of Predicted Probabilities and Observed Responses

Concordant = 90.0%	Somers' D = 0.803
Discordant = 9.7%	Gamma = 0.805
Tied = 0.3%	Tau-a = 0.116
(585598 pairs)	c = 0.901

B. Heuristics Short Regression

While the Heuristics short regression does less well in correctly predicting certification status relative to the Signaling regression (85.2% compared to 90% correct predictions), all but the JIT_OWN estimates are significant at the 0.01 level (**Table 3**). Most importantly, the constructed variable to proxy the structural complexity of purchasing by industry is both significant and arguably the most important variable given the magnitude of the standardized coefficient. Along with the significance of the share of industry inputs purchased from other manufacturing industries, the implications is that firms with more difficult purchasing decisions are more likely to acquire certification. Consistent with survey research it may be that external relations of the firm are the main impetus to begin preparing for certification. However, the benefits that firms enjoy in coordinating internal activities may tilt the cost-benefit calculus in favor of passing and maintaining certification relative to those firms that enjoy relatively simple purchasing relationships. Of course, a question to be answered in the next section is the extent to which correlation between the input and output measures may obscure the 'true' relationship in the full regression model.

The other Heuristics variables also corroborate this interpretation of the importance of the standards helping to coordinate internal activities. The significance and magnitude of the IMPORT estimate is something of a surprise as it is rarely mentioned as a characteristic likely to be associated with certification. The fact that larger firms may be greater for purchasing heuristics is corroborated by the firm size estimate (EMPLOYME). However, it may also be that larger firms have greater resources to acquire certification.

C. Full Regression

Estimation of the full regression models allows us to assess whether the Signaling and Heuristics variables are explaining distinct aspects of the certification phenomenon (**Table 4**). If the sets of variables from the two short regressions are strongly correlated then we would expect the full regression estimates to be unstable. This does not appear to be the case. None of the significant variable estimates change signs. Only firm size measured by employment (EMPLOYME) demonstrates a significant shift in significance level from the short Heuristics (p-value 0.0052) to the full regression (p-value 0.064). Rather, the trend appears to be one of decreased magnitude of the full regression estimates relative to the short regression estimates. But this is to be expected as a larger number of factors are used to explain certification probability. Correctly predicted responses increased to 91.3%.

The standardized coefficients provide insight into the relative importance of the Signaling and Heuristics variables. The two variables with the largest standardized coefficients are from the Signaling argument: XPORTOTH and MFGSELL. This is consistent with the belief that export orientation and intermediate production are the two primary rationales for acquiring certification. Structural complexity of the purchasing relation emerges as the third largest standardized coefficient suggesting that the heuristics rationale is also important. In Kentucky, establishments supplying the automobile industry appear to have a strong need for certification. The magnitude of the RURAL estimate is greater in the full regression compared to the signaling regression. This suggests that certification may be more valuable to rural firms relative to their urban peers after controlling for both external and internal coordination problems of firms. Finally, the MFGBUY and the IMPORT variables are the least important of

Table 4
Probability of ISO 9000 Certification as Function of Signaling and Internal Coordination Variables
Short and Full Regression Results

Variable	Full Regression Results		Signaling Short Regression Results		Heuristics Short Regression Results		Variable
	Estimate (Std.Est.)	Chi-Square (p-value)	Estimate (Std.Est.)	Chi-Square (p-value)	Estimate (Std.Est.)	Chi-Square (p-value)	
INTERCPT	-10.1350***	104.4125 (0.0001)	-5.6674***	239.9652 0.0001	-9.0084	114.5510 0.0001	INTERCPT
MFGSELL	2.1128*** (0.296988)	27.8013 (0.0001)	1.8790*** (0.264119)	26.9138 0.0001			MFGSELL
SELLCOMP	0.0552 (0.036712)	0.3387 (0.5606)	0.0890 (0.059212)	1.0659 0.3019			SELLCOMP
XPORTOTH	1.2884*** (0.342538)	29.3073 (0.0001)	1.6668*** (0.443133)	55.3295 0.0001			XPORTOTH
JAPAN	0.5373** (0.086637)	5.1371 (0.0234)	0.6154*** (0.099234)	7.2478 0.0071			JAPAN
WESTEUR	0.2714 (0.054174)	1.5056 (0.2198)	0.2575 (0.051401)	1.4010 0.2366			WESTEUR
RURAL	0.7221*** (0.199101)	11.0593 (0.0009)	0.6655*** (0.183496)	10.0035 0.0016			RURAL
NONADJ	-0.3300 (-0.08536)	1.8885 (0.1694)	-0.3657 (-0.094611)	2.5027 0.1137			NONADJ
JIT_CUS	0.2772 (0.029916)	0.2751 (0.6000)	-0.0679 (-0.007332)	0.0187 0.8913			JIT_CUS
AUTO	1.3982*** (0.235254)	51.1789 (0.0001)	1.7765*** (0.298903)	94.9319 0.0001			AUTO
MFGBUY	3.3600*** (0.184970)	10.1218 (0.0015)			4.0766*** (0.224417)	18.4160 0.0001	MFGBUY
BUYCOMPL	0.9425*** (0.265632)	19.1578 (0.0001)			1.3212*** (0.372376)	48.8794 0.0001	BUYCOMPL
IMPORT	0.7784*** (0.174364)	18.3768 (0.0001)			1.4551*** (0.325945)	84.8008 0.0001	IMPORT
EMPLOYME	0.000338* (0.059992)	3.4318 (0.0640)			0.000591*** (0.105013)	7.8067 0.0052	EMPLOYME
JIT_OWN	0.1658 (0.013550)	0.0814 (0.7754)			-0.3248 (-0.026545)	0.4057 0.5242	JIT_OWN
PUBLIC	1.3045*** (0.221124)	41.9566 (0.0001)	1.3932*** (0.236157)	53.0072 0.0001	1.5929*** (0.270007)	75.2270 0.0001	PUBLIC
UNION	0.4169* (0.075751)	3.7785 (0.0519)	0.3701* (0.067244)	3.2398 0.0719	0.5657*** (0.102770)	8.4640 0.0036	UNION
System Statistics	% Correct	91.3%	% Correct	90.0%	% Correct	85.2%	
	Chi ² -2LogL	571.864	Chi ² -2LogL	517.006	Chi ² -2LogL	359.583	

those estimates significant at the 0.01 level. This suggests that the internal coordination benefits of certification may be masked in more casual analysis. However, these effects are substantial and emerge after controlling for other firm characteristics.

To summarize, the empirical results are encouraging from a number of perspectives. The results suggest that variables related to either the signaling or heuristics explanations have substantial power predicting the firms most likely to acquire certification. Perhaps the strongest research finding in this respect is the statistical significance of most of the industry specific I-O characteristics used to explain the certification of individual establishments. If nothing else, this result corroborates the potential value of I-O relationships for understanding the evolution of the economic system (Pryor 1997). It also suggests that detailed industry information may provide a good proxy of relationships of interest in the absence of firm specific information for the analysis of some phenomena.

VII. The Policy Environment and Specification

The empirical analysis suggests that both signaling and heuristics may be important determinants of the expected profitability from certification.⁶ Thus, factors related to both the external and internal relations of firms are important in identifying those most likely to benefit from certification. In the context of perfect information and perfect capital markets we would expect to see all establishments needing ISO 9000 certification acquire it. However, if information on the costs and benefits of certification is not readily available—or if firms that would profitably benefit from certification cannot secure the capital to fund a certification audit and costs of preparation leading up to it—then there may be a role for policy to facilitate certification. In keeping with the long tradition of Cooperative Extension, industrial extension efforts may be most effective in resolving the information constraints of smaller or more isolated manufacturing firms.

The problem then become one of identifying those firms that may have substantial needs for certification but are otherwise disadvantaged in acquiring it. The previous analysis goes a long way toward identifying firms with substantial needs for certification. Both industry- and firm-specific variables can be used to isolate those specific firms with high needs for certification. Identifying firms with low capabilities to acquire certification may be more difficult. The control variable (PUBLIC and UNION) can be interpreted as capabilities variables as can firms size (EMPLOYME). In addition, the sign of the nonadjacent variable was negative suggesting that more remote firms may be disadvantaged in acquiring certification either from a lack of demonstration effects or lower management capabilities.

A useful abstraction is to consider firms ranking high or low with respect to the needs and capabilities dimensions. The four possibilities are represented in the **Policy Matrix** below. Those firms with little need for certification—whether they are high or low capability firms—

⁶ It is important to remember that results from the signaling regression cannot be used as evidence of the existence of a separating equilibrium owing to certification. If the analysis did support this finding—and only this finding—then it would be difficult to justify any role for policy. Indeed, if the costs of ISO 9000 did effectively define a separating equilibrium then any government subsidy to ‘low ability’ firms might transform certification into a pooled equilibrium. That is, without intervention the signal would convey useful information but the signal might lose this ability in the presence of government subsidies.

would not be potential targets of industrial extension or technical assistance services. Rather, policy to facilitate adoption of ISO 9000 standards would have the strongest justification for those firms with high needs but low capabilities in the lower left-hand cell.

Policy Matrix

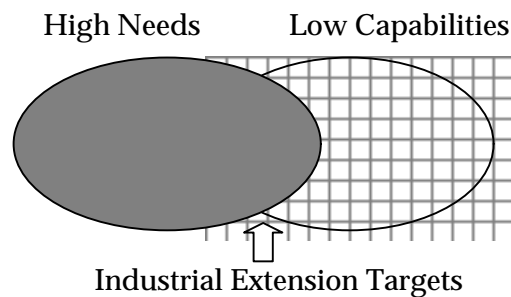
	High Need for Quality Control Certification	Low Need for Quality Control Certification
High Capability to Acquire Certification	<p>Certified Firms or Late Adopters</p> <p>Weak Justification for Policy Intervention</p>	<p>Uncertified Firms</p> <p>No Justification for Policy Intervention</p>
Low Capability to Acquire Certification	<p>Uncertified Firms</p> <p>Strongest Justification for Policy Intervention</p>	<p>Uncertified Firms</p> <p>No Justification for Policy Intervention</p>

The protocol for identifying firms in these four categories is to define two short regressions as follows:

Needs: MFGSELL XPORTOTH JAPAN WESTEUR RURAL AUTO
MFGBUY BUYCOMPL IMPORT and

Capabilities: PUBLIC UNION EMPLOYME NONADJ

Those firms with a relatively high predicted probability of certification on the basis of the Needs regression would define the left column of the policy matrix. Similarly, those firms with a low predicted probability of certification from the Capabilities regression would define the lower row of the policy matrix. Identification of those firms that may be viable industrial extension targets can be represented by the following Venn diagram.



VIII. Empirical Results for the Policy Specification: Targeting Statistics

The central interest from the policy specification is not the magnitude or significance of coefficient estimates. Rather, it is the identification of the relative needs and capabilities of individual firms. For this reason, results from the policy specification are not presented. Attention is focused instead on the characteristics of firms selected into the target and nontarget groups. For purposes of analysis, three groups are defined. The Target Group is defined by establishments demonstrating a high need for certification (predicted probability of event greater than 10% from needs regression) and a low capability to acquire certification (predicted probability of event less than about 5% from capabilities regression).⁷ The Nontarget Group is defined by establishments demonstrating little need for certification, corresponding to the right hand column of the Policy Matrix (predicted probability of event from the needs regression less than 0.5%). The intermediate group for policy purposes is defined as the High Needs/High Capability Group. These firms are most likely to have acquired certification or they may be late adopters (predicted probability of event greater than 10% from both the needs and capabilities regressions).

Perhaps the most telling statistic distinguishing the 3 groups is the percent of establishments that are already certified. Close to 50% of the high needs/high capability firms are certified. There are both a significant number of late adopters as well as firms that have been able to acquire certification. In contrast, only 1 of approximately 300 firms in the low needs groups are certified suggesting that firm and industry characteristics are powerful in accurately identifying needs. Finally, about 10% of the Target (high needs/low capability) firms are currently certified. This suggests that some firms have been able to overcome disadvantages but that there are still a large number of firms that may benefit from industrial extension services.

Looking at the Target Group characteristics more closely, these firms are predominantly in durable manufacturing sectors (77.25%), are relatively small compared to high needs/high capability firms, and are active in both export and import activity relative to low needs firms. Perhaps the most political variable in the capabilities regression is whether or not the firm is unionized. Inclusion of this variable in the analysis will tend to bias technical assistance to nonunion firms. However, before policy implementation it would be prudent to understand the ways that unionization affects certification probability. Interestingly, the great majority of firms in the Target Group are located in counties having one or more certified firms. However, these same counties also contain the majority of manufacturing firms. There may be substantial demonstration effects to certification that warrants further analysis. More than half of the firms in the target group are located in rural areas (52.35%). This is roughly equivalent to the number of rural firms in the full sample (49.6%). There is also a slight overrepresentation of establishments from nonadjacent counties relative to the full sample (i.e., 35.57% in the target group compared to 32.71% in the full sample).

IX. Concluding Comments

This analysis provides evidence that measurable firm and industry characteristics have power in explaining quality control certification. While there may be general characteristics that can

⁷ The selection of cut-off thresholds was somewhat arbitrary. The objective was to have roughly 300 firms selected into each of the 3 categories defining well articulated groups.

Table 5
Targeting Statistics
Certified or Late Adopters (Hi Need/Hi Capability), Target (Hi Need/Lo Capability), & Nontarget (Lo Need) Establishments

Variable	Hi Need/Hi Cap	Hi Need/Low Cap	Low Need
AUTO	0.3953	0.3624	0.0000***
BUYCOMPL	3.4245	3.4312	2.8029***
DEMO	0.7774	0.8591***	0.8251
EMPLOYME	410.06	50.37***	35.87***
IMPORT	0.6544	0.5436***	0.0132***
ISO	0.4717	0.1041***	0.0033***
JAPAN	0.4119	0.2483***	0.0000***
JIT_CUS	0.5367	0.5373	0.3459***
JIT_OWN	0.4602	0.4574	0.4501
MFGBUY	0.3236	0.3116	0.2242***
MFGSELL	0.5004	0.4874	0.0712***
NONADJ	0.2425	0.3557***	0.2682**
PUBLIC	0.4784	0.0000**	0.0311***
RURAL	0.4950	0.5235	0.3642***
SELLCOMP	3.1722	3.4493***	1.9448***
UNION	0.4512	0.0000**	0.1026***
WESTEUR	0.5448	0.4295***	0.0000***
XPORTOTH	0.9302	0.8758**	0.0000***
N	301	298	302

*** represents the estimate is statistically different from the estimate to the left at the 0.01 level.

** represents the estimate is statistically different from the estimate to the left at the 0.05 level.

be isolated as ISO 9000 firm characteristics (e.g., export orientation or importance of intermediate production) the analysis suggests certification probability is conditioned by a relatively large number of variables.

From a theoretical perspective this analysis is informative in suggesting that both the external relations and internal coordination problems of firms are important in explaining certification. These characteristics can be related to a signaling and heuristics explanation of certification, respectively. Survey and case study analysis corroborate these findings but they have not been generalizable nor has there been any consistent way to rank the relative importance of characteristics corresponding to the alternative theoretical frameworks. While external factors appear to be the most important, a critical dimension of the phenomenon would be missed by abstracting from the internal coordination justification for ISO 9000 certification. This becomes especially important in moving from an analysis motivated by theoretical interest to one that may have some impact on the formation of manufacturing modernization policy.

The targeting statistics from the policy exercise are suggestive of the types of firms that may benefit most from industrial extension assistance related to quality control. This targeting exercise was powerful in isolating the observable phenomena: i.e., high needs/high capability establishments had even odds of being certified while low needs firms demonstrated an incidence rate of only 0.3%. This reinforces confidence in the model to isolate the unobservable—or latent—phenomena embodied in the high needs/low capability firms. However, a pragmatic test of the study would be to examine whether these identified target firms were more responsive to industrial extension services related to quality control than a random draw of firms.

A possible implementation strategy would be to assess the interest of targeted firms in receiving industrial extension assistance. The next step could track the actual utilization of assistance provided by industrial extension centers or community colleges. Finally, this analysis could be extended to examine the percentage of the target firms actually acquiring certification. All of these assessments could be compared to a random sample of manufacturing firms used as a control group. Alternatively, a matched sample of firms, using firm size and location as the matching criteria, could be provide a more powerful test of the effectiveness of the targeting protocol.

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