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Who Decides about Change and Restructuring in Organizations?

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Abstract

We model the determinants of who makes decisions, the principal or an agent, when there are multiple decisions. Decision making takes effort and time; and, once implemented, the expected loss from a particular decision (or project) increases with the length of time since the last decision was made. The model shows delegation is more likely as: (i) controllable uncertainty increases; (ii) uncontrollable uncertainty decreases; (iii) the number of plants in the firm decreases; (iv) the complexity of the decision increases; and (v) the importance of the decision increases. The theoretical predictions are consistent with our novel empirical results on the delegation of major organizational change decisions using workplace data. Our unique data allows us to identify who made a decision to implement a significant change, as well as key internal and external factors highlighted as potentially important in our theory. Empirically, delegation is more likely in organizations that: face a competitive product market; export; have predictable product demand; have a larger workplace; and that have fewer other workplaces in the same organization producing a similar output. We find business strategy is not related to the allocation of decision making authority; delegation, however, is associated with the use of human resource techniques such as the provision of bonuses to employees.

JEL Codes: D23, L23, L29
Keywords: decision making authority, decentralization, delegation, competition, exports, uncertainty, principal and agent

1 Introduction

In *Sciences of the Artificial*, Simon (1969) asserts that firm design can be analyzed independently of the product market environment in which a firm operates and this approach has dominated subsequent economic research in the area.[1] The purpose of this paper is to show how both a firm's external and internal environments need to be considered in an optimal managerial design. Focusing on delegation of authority, we derive theoretical results to advance this point and provide new empirical evidence to support our claims.

Given the world is an ever changing place, a large part of the success of a firm is determined by the effectiveness with which it makes decisions in response to changing conditions.[2] There exists a tradeoff between bringing more resources to bare on decision making via specialization through delegation and the incentive conflicts inherent in agency. We model a dynamic environment in which a boundedly rational principal must decided when to engage the service of an agent. The results show how aspects of the external environment, likely to be affected by the intrinsic uncertainty related to factors such as competition, globalization and demand fluctuations, play a critical role in the delegation decision.

Previous studies on the optimal allocation of decision making rights have emphasized: providing incentives to a subordinate (Aghion and Tirole (1997), Acemoglu et al. (2007), Zabojnik (2002) and Bester (2004), for example); and strategic communication (Dessein, 2002). The team-theory literature has emphasized complex-task design and endogenous organizational architecture (for example, see the information processing literature including Radner (1993), Bolton and Dewatripont (1994), Van Zandt (1999) and Meagher et al. (2003)). The focus here is somewhat different, although complementary, to these previous studies. The model here focuses on the influence environmental uncertainty has on an organization's allocation of decision-making rights within an environment in which the principal and the agent have differing objectives.[3] Conceptually our approach also differs from standard principal-agent models because organizational structure,[4] and the specialization it implies, are endogenous in our framework.[5]

Our results show how three factors are critical to the delegation decisions: (i) the rate at which decisions become obsolete; (ii) the risk-incentive tradeoff under moral hazard; and (iii) economies of scale in decision making. These three factors have been largely overlooked in the literature on delegation. Obsolescence is almost universally believed to be an important organizational consideration in the management literature (e.g. Stinchcombe (1990) and Brickley et al. (2007)) but has only been seriously considered in economics with regard to hierarchy size (delayering) by Meagher et al. (2003, 2004). The original moral hazard approach to the principal agent relation placed great emphasis on

[1] See for example: Holmstrom (1979) and Hart and Grossman (1983) on the principal-agent problem; Grossman and Hart (1986) and Hart and Moore (1990) on the boundary of the firm; or Radner (1993), Van Zandt and Radner (2001); Van Zandt (1999, 2004) and Garicano (2000) on communication and knowledge in firms.

[2] The Kaldor critique asserts that firm management (as opposed to mere supervision) requires a dynamic stochastic setting otherwise all problems could be resolved in a set up phase by management in the choice some plan. All that would be required thereafter is sufficient supervision to make sure the plan is implemented.

[3] Dynamic environments are modeled in Meagher et al. (2003) and Meagher et al. (2004) for single decision problems in the absence of incentive conflicts.

[4] In the standard principal-agent framework the fact that the agent undertakes an action for the principal is given (Holmstrom, 1979; Hart and Grossman, 1983), this is also true for the more recent models including delegation (Prendergast, 2002)

[5] Although the activities modeled and our inclusion of incentive conflicts are quite different, conceptually our approach shares much with Mount and Reiter (2002), Radner (1993), Van Zandt (2003) and Garicano (2000).

risk-incentive trade-offs but took delegation to the agent as given. The more recent work by Prendergast (2002) and Dessein (2002) on delegation focuses on uncertainty for the principal arising from private information on the part of the agent that generates no risk for the agent themselves. Our model can be thought of as reintroducing risk-incentive trade-offs into the contemporary delegation literature in a frame work based on the information processing models. Finally the classical issue of economies of scale has not been addressed previously because models have either assumed there is only one decision or have made the essentially equivalent assumption that decisions are unrelated (Aghion and Tirole, 1997).

Our empirical analysis is based on data on the delegation of organizational change decisions. The sample covers plants from a broad range of industries giving substantial variety in external (product market) conditions. Information on size and production arrangements for the firm, business strategy and human resource management procedures is also included. The results of our cross sectional analysis of delegation are consistent with our theoretical model and also highlight other important factors in the decision making process.

This is the one of the first studies to examine the effect of product-market and international competition on the decentralization of decision making. In a pertinent paper to this study, Colombo and Delmastro (2004) investigated the relationship between the allocation of decision-making authority and internal aspects of an organization's structure using a survey of Italian manufacturing firms. The other contemporaneous studies have each had a different and complementary focus. Acemoglu et al. (2007) emphasized an establishment's distance from the technological frontier. Empirically, they focus on the choice of profit versus costs centers[6]. In an unpublished paper, for medium sized manufacturing firms Bloom et al. (2007) construct a measure of decentralization based on influence over operational decisions. They found product-market competition and trust were associated with their measure of decentralization while the religious preferences of a region can be associated with centralization. In another unpublished paper, Guadalupe and Wulf (2007) investigate the impact of globalization on the number of layers between division managers and the CEO and the number of positions directly reporting to the CEO.

Our empirical analysis offers something completely new. First, we have a direct measure of the decision-making process that is not ineluctably captured by the aforementioned studies on the profit/cost center choice or when examining how much influence parties have on operational decisions. Second, there is no ambiguity about what is being measured with our decision-making variable: the location of a unique decision maker on a specific type of change. Third, by examining decision-making authority related to one significant non-routine change, we potentially avoid some endogeneity problems that could arise with routine decisions; moreover, the decision to implement a significant new project is precisely the type of decision examined in our theoretical model and, indeed, in models styled on Aghion and Tirole (1997). Finally, we have an extremely rich data set that covers all major industries (rather than just manufacturing firms), includes medium and large firms and contains information on an array of firm and market characteristics.

In our model there are two types of decisions that need to be made: an external decision (such as pricing strategies, development of new products or markets); and an internal decision (related to the operation of the plant for example). The principal must decide whether to centralize both decisions or whether to delegate one of the decisions to an agent. Given the ever-changing environment, a

[6]They also briefly consider delayering and decisions about employment.

decision maker needs to expend effort (or put in time) to become informed about the decision(s) for which they are responsible. There is also a cost of delay related to how long it takes to make each of the decisions, reflecting that as the world changes the previously implemented decision becomes increasingly outdated. The optimal choice for each action (decision) changes over time according to a Brownian motion so that any action that is implemented can be expected to be further from the optimal action, and hence have a larger cost, the greater the time that has elapsed since the decision was made.

The principal faces the following choice — if she centralizes decision making and retains rights for both the internal and external decisions — she will have to split her time between the external and internal decision. As it will take her (relatively) longer to become informed about each separate aspect of the organization, she will incur greater costs of delay from each decision to be made. Alternatively, the principal could choose to delegate the internal decision to the agent, so that each person can specialize in one type of decision. In this case the decision-making process is expedited as each person focuses on just one decision. While the costs of delay are reduced, there is a cost of delegation that takes, for example, the form of the additional cost associated with a standard moral hazard incentive contract.

This trade off — higher delay costs versus an increase in agency costs — allows for several empirically relevant predictions. First, an increase in controllable uncertainty, which can be ameliorated by managerial resources, makes delegation more likely. Second, when systemic (uncontrollable) uncertainty increases, delegation is less likely; as in the standard principal agent models increasing exogenous uncertainty increases the agent's expected remuneration, increasing the relative cost of delegation while leaving the costs of centralization unchanged. Third, as the internal decision becomes more complex the principal is more likely to delegate the internal decision. Fourth, delegation of the internal decision is more likely the larger the size of the business unit.

The predictions of the model are compared with the empirical findings of an analysis of decision making in workplaces. We investigate the hierarchical level in an organization that made the decision to implement a significant workplace innovation. The organization's choice concerning the possible decentralization of decision making is estimated as a function of product market and other firm characteristics, such as size and the number of similar workplaces in an organization. Specifically, the data set used (described in section 3) allows us to study the relationship between product market competition and globalization on who makes decisions. Studying the decision to implement a non-routine (potentially one-off) change reduces the scope for endogeneity between decision making authority and the structure of an organization, which is likely to be designed with the firm's day-to-day operational requirements in mind (this type of endogeneity is a potential issue for other studies).

We find that workplaces that face a competitive product market are more likely to delegate decision making to the workplace, rather than to centralize the decision made to a higher level of the organization. Similarly, workplaces that export their product are more likely to decentralize decision-making rights.[7] Delegation is more likely with larger workplaces; on the other hand, centralization of the decision is more likely when there are other workplaces in the organization performing the same task and when the product market is unpredictable. We also investigate the relationship between the

[7]It is important to note, of course, that while the results we find are consistent with the theory presented, we are unable to imply any causal relationship with our data.

allocation of decision-making authority and a workplace's business strategy and the human resource management techniques they adopt.

2 The Model

We develop a model below that addresses the key question: should the principal make all the decisions herself or delegate a decision to the manager? Consider two players – a principal and a manager. Two decisions need to be made, each on their own dimension: specifically, there is an external environment denoted e and an internal environment i. On each of these two dimensions circumstances change according to a Brownian motion, requiring the selection of an appropriate project or response. Selecting the correct project requires the decision maker's effort, and hence their time.

2.1 Centralization of decision-making

First consider an organization in which the risk neutral principal makes both decisions. Decision-making requires *managerial resources* which in this case is the constant instantaneous disutility of work u for the principal. The required decisions are the choice of the values of each of the control variable x_t^j, $j = i, e$ corresponding to each of the Brownian motion state variables μ_t^j, $j = i, e$. ($\sigma_i^2 > 0$ and $\sigma_e^2 > 0$ measure, respectively, the rate of change in the state μ_t^j, $j = i, e$ of the internal and external environments). Under centralized decision-making, with the principal making both decisions, the loss function for the principal consists of quadratic-loss terms associated with each of the Brownian motion control problems, the shock terms for each decision ε_t^j, $j = i, e$, which are distributed *iid* $N(0, \sigma_\varepsilon^2)$, with $\sigma_\varepsilon^2 > 0$, and the managerial resource cost u. The instantaneous loss for the principal at t, denoted L_t is:

$$L_t = \underbrace{\beta_i(x_t^i - \mu_t^i)^2 + \beta_e(x_t^e - \mu_t^e)^2}_{controllable} + \underbrace{\varepsilon_t^i + \varepsilon_t^e}_{uncontrollable} + u. \tag{1}$$

Where $\beta_j > 0$, $j = i, e$ are scale parameters for the importance of each control problem. We normalize loss by dividing through by β_e and relabel the normalized β_i with β. The size of β is driven by the value at stake, for example in practice β would tend to be larger the greater the scale of the internal business unit being affected by the decision.

Note, for simplicity, there is no interaction between the two control problems in terms of the optimal choices of the control variables. In line with standard principal agent models, this loss also includes additive shock terms over which a decision maker has no control. This term is irrelevant when considering optimal decisions but will be integral to the analysis of incentive contracts. We term the two different types of uncertainty *controllable* ($\mu_t^j, j = i, e$) and *uncontrollable* ($\varepsilon_t^j, j = i, e$).

We now describe the resource costs associated with decision-making by the principal. Assume plans (choice of control variables) are implemented perfectly with full information but that they take time to formulate. That is, at the point in time when a decision is implemented it is possible to 'correctly' choose the control variable to equal the state variable. However formulating a plan takes time so the value of a control variable remains fixed until the next plan has been developed.

In particular, a plan for environment $j = i, e$ takes $\alpha_j d(s_j) > 0$ units of time to formulate where s_j is the instantaneous share of attention allocated to this task. When a larger share of the principal's time is allocated to formulating a plan, that plan will be completed more quickly, thus $d' < 0$.[8] Alternatively if a task receives no attention it is never completed: $d(0) = \infty$. We normalize the time scale so that $\alpha_e = 1$ and the normalized α_i is relabeled α. Here $\alpha > 0$ reflects the difficulty of a task, for example organizational change in a complex high-skill work environment may take longer than in a simple low-skill environment. The principal's attention/time constraint with no delegation is $s_i + s_e = 1$.

The first step in constructing the principal's expected loss (payoff) is to consider one control problem in isolation. If a decision is being implemented every T units of time on environment j, optimality requires $x_t^j = \mu_t^j$ for $j = i, e$. Our analysis will focus on the per-period loss in the steady state which will, with out loss of generality, allow the time subscripts to be dropped from most equations. Expected per-period loss in the steady state for environment $j = i, e$ is[9]:

$$E[L^j] = \frac{1}{T}\int_0^T t\sigma_j^2 dt \tag{2}$$

$$= \frac{\sigma_j^2 T}{2}. \tag{3}$$

The only interaction between the two control problems is that both solutions draw upon the principal's common pool of attention/time. Substituting in the total attention constraint and netting out the uncontrollable shock, which is independent of the shocks to the Brownian motions and has an expected value of zero, gives the principal's optimization problem as:

$$\min_s \frac{1}{2}(d(s)\sigma_e^2 + \alpha\beta d(1-s)\sigma_i^2) + u. \tag{4}$$

Under appropriate conditions this optimization problem has a solution as outlined in the following proposition.

Proposition 1. *If $d(\cdot)$ is strictly convex there exists a unique attention allocation $s^* \in (0, 1)$ that minimizes the principal's loss.*

Proof. By the Wierstrass theorem a minimum exists and is unique due to strict convexity. The optimum is an interior point since $d(0) = \infty$. □

The key issue for the principal is how the performance of this centralized management solution varies with the environments. The result is captured in the following:

Proposition 2. *The steady state optimal expected loss is strictly increasing in $\sigma_i, \sigma_e, \alpha$ and β.*

Proof. By the envelope theorem. □

As either of the environments changes more rapidly the principal may try to reallocate her attention, but due to her fixed budget of time there must be some increase in loss. As the world changes more quickly an individual of constrained cognitive ability will perform less and less well.

[8] Technically this is an information processing model with through-put but no delay. See Orbay (2002) and Meagher et al. (2003) or for a survey Van Zandt (1998).

[9] Derivation of the loss starting from the Brownian motion is covered in Shreve (2004, Chapter 3).

Variation in loss also occurs across firms depending on how easy management is, as measured by the two α parameters respectively.

2.2 Delegation to the manager under perfect information

An alternative to centralization is for the principal to delegate a decision (by assumption the internal one) to the workplace manager (delegation or decentralization). Under delegation each person specializes in just one decision task and hence allocates a share of 1 to their respective task.

Delegation may potentially involve a conflict of interest with the manager preferring some action or effort level, denoted a (from a feasible set $A \subseteq [0,1]$) which results in an increase in the principal's loss, denoted $l(a)$ with $l \geq 0, l' < 0$ and a disutility to the manager of $c(a) > 0$ with $c' > 0$ and $c'' > 0$. Under perfect information the principal simply writes a contract specifying the optimal a, denoted $\tilde{a}$ with instantaneous wage equal to $c(\tilde{a})$. In this case, the expected loss for the principal is:

$$\frac{d(1)\sigma_e^2 + \alpha\beta d(1)\sigma_i^2}{2} + l(\tilde{a}) + c(\tilde{a}) + u. \tag{5}$$

Comparing the expected loss between centralization and delegation yields the following result.

Proposition 3. *There exists a unique threshold $\tilde{\sigma}_e^2$ (respectively $\tilde{\sigma}_i^2$) such that centralization is optimal for $\sigma_e^2 < \tilde{\sigma}_e^2$ (respectively $\sigma_i^2 < \tilde{\sigma}_i^2$) and delegation is optimal for $\sigma_e^2 > \tilde{\sigma}_e^2$ (respectively $\sigma_i^2 > \tilde{\sigma}_i^2$). Thus controllable uncertainty, whether external or internal, makes delegation/decentralization more likely.*

Similarly, holding everything else constant, there exist unique thresholds for α and β, such that centralization is optimal below the threshold and delegation is optimal above the threshold.

Proof. The net per-period loss from decentralization under perfect information, D, (the loss from decentralization less the loss from centralization) is

$$D \equiv \left[\frac{d(1)\sigma_e^2 + \alpha\beta d(1)\sigma_i^2}{2} + l(\tilde{a}) + c(\tilde{a}) + u\right] - \left[\frac{1}{2}(d(s^*)\sigma_e^2 + \alpha\beta d(1-s^*)\sigma_i^2) + u\right] \tag{6}$$

Note D is an affine function of σ_e^2 with a slope of $(d(1) - d(s^*))/2 < 0$ since $s^* < 1$ when $\sigma_i^2 > 0$ and $d' < 0$. It follows that $D = 0$ (and hence the single crossing property holds) for a unique value of σ_e^2. To see that the crossing occurs at a permissible value, that is $\hat{\sigma}_e^2 > 0$ note that by assumption

$$D|_{\sigma_e^2=0} = l(\tilde{a}) + c(\tilde{a}) > 0. \tag{7}$$

The proof for internal uncertainty is analogous with the observation that $\alpha\beta(d(1) - d(1-s^*))/2 < 0$ since $s^* > 0$ when $\sigma_e^2 > 0$ and $d' < 0$.

The results for the α and β terms follow immediately from the equivalent way σ_i^2, α and β enter the loss functions. □

The principal decides to delegate here because the benefit of fast decision making is greater in a more unstable environment. The greater benefit of speed in decision making is balanced out against the additional resources of employing another unit of labor in decision making. Greater delay in reaching a decision, as measured by the α's is equivalent to a faster changing environment and

hence also leads to delegation. Thus we might expect workplaces with more complex (or less well understood) technologies or task environments to be more likely to have delegation.

Greater workplace scale, as it contributes to greater β, makes the additional cost of delegation more worthwhile making delegation more likely as β for the internal environment increases. Once decision making is cast as a process taking time and requiring resources then this result, and those that follow below, flow naturally from standard economic ideas about production. As we will show three tier hierarchies, moral hazard and economies of scale are all within the gamut of this model.

Our results are quite different from the standard principal agent type approaches applied to delegation, such as Prendergast (2002) and Dessein (2002), where the use of an agent is assumed and the analysis is applied to the details of the relationship arising from asymmetric information problems. In many organizational settings agents are not endowed with critical private information but rather acquire it due to the position they hold. If position is the cause of agency problems then in an endogenous organizational design the obvious solution is to do away with the agent altogether not to write a complex and expensive incentive contract.[10] In this way the standard models fail to explain organizational structure surrounding the principal-agent relationship in commonplace organizational contexts. The intuitive reason principals utilize subordinate managers (agents) is the obvious fact that one person cannot do everything. Or to be more precise, and to echo the approach of our model, one person cannot do everything in a timely fashion.

The model also yields the following relationship between delegation and uncontrollable uncertainty.

Proposition 4. *Under full information delegation is independent of the level of uncontrollable uncertainty, σ_ε^2.*

Proof. From equations (4) and (5) expected per period loss under both centralization and decentralization are independent of σ_ε^2 and hence the decentralization decision is independent of uncontrollable uncertainty. □

Under perfect information the uncontrollable uncertainty is just noise affecting payoffs independently of the way in which decision-making is organized and hence has no impact on the decision to decentralize. We shall see in the next section that under moral hazard uncontrollable uncertainty can have an indirect role in the decision to decentralize through its impact on the cost of motivating an agent.

2.3 Extensions

2.3.1 Three tier hierarchy

In the proceeding section we assumed that the principal played the dual roles of senior manager and owner of the firm. This approach is reasonable to the extent that the senior manager in the firm is indeed well incentivized, or well selected, so that she acts to maximize profits. In some cases it may be more appropriate to think of the senior manager as an employee separate from the owner of the firm. We model this alternative as an extension to our existing model with a three tier hierarchy.

[10] It is natural to think of a salesman having private information about how hard hard he is working but less natural to think of every divisional head at Toyota having critical project selection information that was exogenously endowed by nature rather than by virtue of the position they hold.

Assume that hierarchical levels are numbered from the top down with the owner at level 1, a senior manager at level 2 and if delegation is used a junior manager at level 3.

As before, we assume that compared to the principal performing a decision task delegation might produce an additional equilibrium loss of l_i on the internal environment and l_e on the external environment. For simplicity we further assume that the senior and junior managers are identical so that it makes no difference to these losses whom the decisions are delegated to: $l_e = l_i = l \geq 0$. Furthermore we assume each task is equally onerous so that it makes no difference which task (or combination of tasks) are performed by which agent to the required equilibrium instantaneous rate of compensation which we denote $w > 0$.

In the three tier hierarchy the owner is not active in the ongoing managerial decision-making so centralization means all the decisions are made by the senior manager. In this case the expected loss for the principal from centralization is:

$$\frac{d(s^*)\sigma_e^2 + \alpha\beta d(1-s^*)\sigma_i^2}{2} + 2l + w. \tag{8}$$

Decentralization in the three tier hierarchy means one task is allocated to each of the managers giving an expected loss for the principal from decentralization of:

$$\frac{d(1)\sigma_e^2 + \alpha\beta d(1)\sigma_i^2}{2} + 2l + 2w. \tag{9}$$

Comparing these expected losses gives the following proposition which is the three tier hierarchy equivalent of Proposition 3.

Proposition 5. *For the three tier hierarchy there exists a unique threshold Σ_e^2 (respectively Σ_i^2) such that centralization is optimal for $\sigma_e^2 < \Sigma_e^2$ (respectively $\sigma_i^2 < \Sigma_i^2$) and delegation is optimal for $\sigma_e^2 > \Sigma_e^2$ (respectively $\sigma_i^2 > \Sigma_i^2$). Thus controllable uncertainty, whether external or internal, makes delegation/decentralization more likely.*

Proof. The net per-period loss from decentralization in the three tier case, D_3, (the loss from decentralization less the loss from centralization) is

$$D_3 \equiv \left[\frac{d(1)\sigma_e^2 + \alpha\beta d(1)\sigma_i^2}{2} + 2l + 2w\right] - \left[\frac{1}{2}(d(s^*)\sigma_e^2 + \alpha\beta d(1-s^*)\sigma_i^2) + 2l + w\right] \tag{10}$$

Note D_3 is an affine function of σ_e^2 with a slope of $(d(1) - d(s^*))/2 < 0$ since $s^* < 1$ when $\sigma_i^2 > 0$ and $d' < 0$. It follows that $D_3 = 0$ (and hence the single crossing property holds) for a unique value of σ_e^2. To see that the crossing occurs at a permissible value, that is $\hat{\sigma}_e^2 > 0$ note that by assumption

$$D_3|_{\sigma_e^2=0} = w > 0. \tag{11}$$

The proof for internal uncertainty is analogous with the observation that $\alpha\beta(d(1)-d(1-s^*))/2 < 0$ since $s^* > 0$ when $\sigma_e^2 > 0$ and $d' < 0$. □

Again we see the basic logic of our approach: delegation aimed at improving the timeliness of decision-making requires extra managerial resources. The cost of the additional resources is only justified if the benefit of faster decisions making is significantly great. In our case the benefit of

being a nimble organization is measured by σ_i^2 and σ_e^2. In reality, the speed of change in a firms environment is likely to be affected by such processes as increasing competition and globalization which are considered in section 3.

Qualitatively the two and three tier cases are very similar however the thresholds will vary because a non-managerial principal means u is replaced by $l + w$. If the opportunity cost of time for the senior manager and the principal are similar while $l > 0$ then the two tier hierarchy would dominate. Thus our model can be applied to delayering as well as delegation but we do not pursue that direction further here. Next we consider the impact of asymmetric information on our model.

2.3.2 Incentive contracts under moral hazard

The performance of the manager may depend not just on the unit of labor he is contracted to supply for decision making but upon the effort $a \in [0, 1]$ he exerts. Low effort results in more loss to the principal described by the function $l(a)$ with $l' < 0, l(0) = \infty, l(1) = 0$. The manager's effort is costly to the manager and unobservable to the principal so that the manager's behavior is subject to moral hazard. For the moral hazard to bind $l(a) + \varepsilon_i$ must also be unobservable as well as its components. Without an output-based contract the manager will choose zero effort. We assume that contracting problems, such as risk aversion or limit liability, exist resulting in a second best contract. Rather than specify a particular contracting model we instead make the following general assumption.

Assumption 1. *Let the contract duration be T. The optimal contract starting at date S implements a unique effort and wage profile $\{(a_t^*(\sigma_\varepsilon), w_t^*(\sigma_\varepsilon))\}_{t=S}^{t=S+T}$ with $\frac{da_t^*}{d\sigma_\varepsilon} \leq 0$, $\frac{dw_t^*}{d\sigma_\varepsilon} > 0$ and $\frac{d(l(a_t^*)+w_t^*)}{d\sigma_\varepsilon} > 0$ for all t.*

Bilateral moral hazard in dynamic environments is very involved and the literature has tended to produce extremely complex optimal contracts which in many cases are not realistic and are not robust to modeling choices (Bolton and Dewatripont, 2005). Our focus here is not on producing a new set of optimal contract results but rather to draw on the common themes of that literature to better understand delegation decisions — hence our axiomatic approach through Assumption 1.

Proposition 6. *With the optimal moral hazard incentive contract there exists a unique threshold $\hat{\sigma}_e^2$ (respectively $\hat{\sigma}_i^2$) such that centralization is optimal for $\sigma_e^2 < \hat{\sigma}_e^2$ (respectively $\sigma_i^2 < \hat{\sigma}_i^2$) and delegation is optimal for $\sigma_e^2 > \hat{\sigma}_e^2$ (respectively $\sigma_i^2 > \hat{\sigma}_i^2$). Thus controllable uncertainty, whether external or internal, makes delegation/decentralization more likely.*

Proof. The net loss from decentralization, D^*, (the loss from decentralization less the loss from centralization) is

$$D^* \equiv \left[\frac{d(1)\sigma_e^2 + \alpha\beta d(1)\sigma_i^2}{2} + l(a^*) + w^* + u\right] - \left[\frac{1}{2}(d(s^*)\sigma_e^2 + \alpha\beta d(1 - s^*)\sigma_i^2) + u\right] \tag{12}$$

Note D^* is an affine function of σ_e^2 with a slope of $(d(1) - d(s^*))/2 < 0$ since $s^* < 1$ when $\sigma_i^2 > 0$ and $d' < 0$. It follows that $D^* = 0$ (and hence the single crossing property holds) for a unique value of σ_e^2. To see that the crossing occurs at a permissible value, that is $\hat{\sigma}_e^2 > 0$ note that by assumption 1

$$D^*|_{\sigma_e^2=0} = l(a^*) + w^* > 0. \tag{13}$$

The proof for the internal case is analogous with the observation that $\alpha\beta(d(1)-d(1-s^*))/2<0$ since $s^*>0$ when $\sigma_e^2>0$ and $d'<0$. □

Thus faster change in either environment increases the likelihood of decentralization when there is moral hazard just as it did under full information. The thresholds will in general differ between the two cases because the noise inherent in moral hazard increases the expected cost of the manager compared to the full information case. We now examine this informational cost in more detail:

Proposition 7. *Increasing uncontrollable uncertainty, σ_ε^2, makes delegation more unlikely in the sense that $\frac{\partial\hat{\sigma}_e^2}{\partial\sigma_\varepsilon^2}>0$ and $\frac{\partial\hat{\sigma}_i^2}{\partial\sigma_\varepsilon^2}>0$.*

Proof. Since D^* is an affine function of σ_e^2 an increase in its vertical intercept ($D^*|_{\sigma_e^2=0}$) implies an increase in its horizontal intercept, $\hat{\sigma}_e^2$. By assumption 1, $\frac{d(l(a^*)+w^*)}{d\sigma_\varepsilon^2}>0$ so the vertical intercept of D^* is increasing in σ_ε^2 and hence $\frac{\partial\hat{\sigma}_e^2}{\partial\sigma_\varepsilon^2}>0$. A equivalent argument holds for $\frac{\partial\hat{\sigma}_i^2}{\partial\sigma_\varepsilon^2}$. □

The standard insight from contract theory implies that the better able a principal is to filter noise out of the manager's contract the less expensive the manager will become in expectation.[11] In our case this means that the more closely payment is related to effort for the agent the more attractive delegation becomes. This result highlights a negative relationship between uncertainty, when it takes the form of systemic risk, and delegation through the neglected risk-incentive tradeoff of standard contract theory.

2.3.3 Multiple workplaces

Many firms have multiple plants and so the choice to delegate a decision (or decisions) is not simply between one principal and one manager but between a principal and multiple managers. The simplest extension of our perfect information model to a firm with n plants would be to assume that each of the plants requires its own internal decision in response to a plant-specific control variable. If the plant-specific control variables are identical or highly correlated then, as before, a single centralized decision by the principal could be applied to all plants with only a small loss of local information. Our extended model is described below.

There are n plants indexed by $m=1,...,n$ and each plant has a constant bias of z_m from the common internal Brownian motion μ_t^i. Thus the instantaneous loss for plant m at time t is

$$(x_t^i-\mu_t^i-z_m)^2+\varepsilon_{tm}^i. \tag{14}$$

The values of the biases are unknown to the principal when she makes a decision centrally but she knows they are *iid* $N(0,\sigma_z^2)$ and are uncorrelated with the evolution of the Brownian motions. Consider first the expected per period loss (net of managerial resource costs) from centralizing with one plant:

$$E[L^i] = \frac{1}{T}\int_0^T(t\sigma_i^2+\sigma_z^2)dt \tag{15}$$

$$= \frac{\sigma_j^2T}{2}+\sigma_z^2. \tag{16}$$

[11] Applying monotone comparative statics to the standard principal-agent model Holden (2008) shows 'better information' lowers expected remuneration in very general settings.

Summing over the n plants gives the steady state per-period expected loss from centralization:

$$\frac{1}{2}(d(s^*)\sigma_e^2 + n\alpha\beta d(1-s^*)\sigma_i^2) + n\sigma_z^2 + u. \tag{17}$$

Analogous to our previous analysis, an alternative to centralization would be to delegate the internal decision relating to each plant to the manager of that plant. Absent moral hazard each plant manager acts optimally using their local information so that the loss measured by σ_z^2 vanishes. However, delegation will incur n times more labour related costs than in the single plant case. Hence the steady state per-period expected loss from decentralization is given by:

$$\frac{d(1)\sigma_e^2 + n\alpha\beta d(1)\sigma_i^2}{2} + nl(a) + nw + u \tag{18}$$

Centralization has an inherent advantage in terms of economies of scale in the cost of decision-making. When the loss of local information is relatively unimportant then the economies of scale will eventually dominate as the following proposition shows. We prove this economies of scale result for the more general case where $n\sigma_z^2$ is replaced by a general function $k(n)$ measuring the extra loss due to imposing a centralized decision, with $k > 0, k' > 0$. Then the steady state per-period expected loss from centralization is given by:

$$\frac{1}{2}(d(s^*)\sigma_e^2 + n\alpha\beta d(1-s^*)\sigma_i^2) + k(n) + u. \tag{19}$$

Proposition 8. *If k is concave and $k'(n)$ is small, specifically $k'(n) < l(a) + w + [d(1) - d(s^*)]\,\sigma_i^2/2$ for all $n \geq 1$, then there exists a unique N such that centralization is strictly preferred to decentralization for sufficiently large n ($n > N$).*

Proof. Taking the difference between the loss expressions from equation (18) less equation (19) gives the net loss from decentralization for a fixed n, denoted D_n:

$$D_n \equiv [d(1) - d(s^*)]\,\frac{\sigma_e^2}{2} + n([d(1) - d(s^*)]\,\frac{\sigma_i^2}{2} + l(a) + w) - k(n), \tag{20}$$

where D is defined above in equation (10). Now

$$\frac{\partial D_n}{\partial n} = [d(1) - d(s^*)]\,\frac{\sigma_i^2}{2} + l(a) + w - k'(n) > 0 \tag{21}$$

with the inequality holding by assumption. Thus D_n is increasing in n for all n in the feasible range $n \geq 1$ and $\frac{\partial D_n}{\partial n}$ is non-decreasing therefore D_n is increasing without bound. It follows that if $D_n \geq 0$ at $n = 1$ then centralization is preferred for all feasible n, i.e. $N = 1$. Otherwise, if $D_n < 0$ at $n = 1$ then as D_n is increasing without bound it will exceed zero (making centralization strictly preferred) for some unique value of n say N. □

Thus in the simplest multi-plant case, delegation is less likely to occur as the number of plants increases because the increasing resource costs of delegation eventually dominate. Increasing inter-plant heterogeneity, as measured by σ_z^2, reduces the scale economies in decision making because there is increasing loss of local information. This is expressed formally in our final result:

Proposition 9. *Considered a fixed n in the case where $k(n) = n\sigma_z^2$. If $l(a)+w+[d(1) - d(s^*)]\,\sigma_i^2/2 > 0$, so that centralization is preferred in the absence of plant heterogeneity, then there exists a unique level of inter plant heterogeneity, $\hat{\sigma}_z^2$ such that centralization is preferred for $\sigma_z^2 < \hat{\sigma}_z^2$ and decentralization is preferred for $\sigma_z^2 > \hat{\sigma}_z^2$.*

Proof. The result follows immediately from equation (21). □

This view of a multi-plant firm and its delegation choices is simple but it does illustrate the importance of economies of scale in decision-making: as long as plants are similar, and profitability is not too sensitive to a generic solution to problems, then there can be significant advantages to centralization. This incentive to centralize is the opposite of the findings of Aghion and Tirole (1997), who argued that for motivational reasons increasing the number of subordinates performing independent tasks increases the likelihood of delegation of real decision-making authority, as the principal has a credible commitment not to interfere. Other prominent approaches to decentralization and delegation such as Prendergast (2002) and Dessein (2002) do not address scale issues. Taking a broader perspective, the type of activities grouped inside an organization is itself a strategic choice which is the subject of the literature on the boundaries of the firm. Our preliminary analysis here suggests that the relationship between managerial decision-making and the boundaries of the firm may be a fruitful subject for future research.

In addition to avoiding unnecessary replication of the same management tasks, there can be gains from learning by doing through centralization. Coordination, communication and the introduction of a middle manager (who frees up the principal for the external decision but is responsible for the the internal decisions) are just a few of the rich organizational issues suppressed by our simple analysis. These issues, plus others, may well be important for understanding organizations but they are not observed in our data set and hence do not feature in our empirical analysis discussed below.

3 Data Set and Variables

We use the Australian Workplace Industrial Relations Survey 1995 (AWIRS 95) to investigate the theoretical predictions developed in Section 2. AWIRS 95 is a cross-industry survey (excluding agriculture, forestry and fishing and defense) of workplaces (that is, plants or establishments) with 20 or more employees. Details of AWIRS 95 are outlined in Appendix B, however it is worth noting several advantages of the AWIRS 95 data. First, this study — along with Acemoglu et al. (2007) — is one of the first cross-industry studies of delegation of decision-making using novel and interesting data. Colombo and Delmastro (2004), for example, in their study of decision-making focussed on manufacturing industries in Italy. A related study, Guadalupe and Wulf (2007), also use cross-industry data but they investigate delayering rather than the delegation of decision-making explicitly. Second, the AWIRS 95 has information related to the key factors of interest, such as product-market competition, international trade and the unpredictability of product demand. Third, like the United States and the United Kingdom, and unlike much of continental Europe, Australia has a relatively flexible labor market, ensuring that the observed results are driven by economic rather than institutional factors. Further to that, Australia is an open economy, making it a good choice to study the impact of international trade on the delegation of decision-making.

3.1 Delegation of decision-making: dependent variable

The survey identifies whether in the last two years prior to the survey is a workplace introduced some significant, non-routine change, where the possible changes were: new technology; new plant or equipment; a major reorganization of the workplace; or a change to the work of non-management employees. For the estimation sample, the left-hand column of Table 1 shows the proportions of workplaces that implemented the different changes; 54 percent of workplaces implemented technical change, 30 percent introduced major new plant, machinery or equipment, 71 percent undertook a major reorganization of the workplace structure and 56 percent of workplaces made major changes to the work of non-management employees. Approximately 16 percent of the workplaces surveyed did not implement any of the possible changes.

Table 1: What is significant change?[a]

Workplace implemented following type of change[b] ($n = 570$)	If a change was made, the change with most significant effect on employees[c] (proportion of workplaces, $n = 570$)
Technology (not just routine replacement) 306(.537)	Technology (not just routine replacement) 107(.188)
Major new plant, machinery or equipment (not just routine replacement) 174(.305)	Major new plant, machinery or equipment (not just routine replacement) 74(.130)
Major reorganization of workplace structure 403(.707)	Major reorganization of workplace structure 249(.437)
Major changes to how non-managerial employees do their work 319(.560)	Major changes to how non-managerial employees do their work 140(.246)
Total number of changes 1202	Total 570(1.0)

Notes: a. Source AWIRS 1995. b. The number and proportions (in parentheses) of workplaces that implemented the specified change in the last two years from the total number of 570 workplaces from the estimation sample (left-hand column). Multiple changes at a given workplace are possible. c. For each workplace in the sample, the number (and proportion) of each type of change that had the most significant effect on employees at that workplace (right-hand column).

Table 1 also shows, in the right-hand column, the change that had the most significant effect on employees at the workplace.[12] In establishments that implemented some change, major reorganization of the workplace structure was the most significant change for employees in approximately 44 percent of these workplaces; a major change to the work of non-management employees had the most impact on employees in 25 percent of workplaces that made some significant organizational change.

Focussing on the change that had the most significant effect on employees at the workplace, we identify whether the decision to implement the change was made at the workplace (delegation, coded as 0) or whether the decision was made at a higher level of management in the organization above

[12]If there was only one change implemented, this change had the most effect on employees. If more than one change was implemented the general manager was asked to identify the change that 'has had the most significant effect on employees here'.

the workplace (centralization, coded as 1). This is the dependent variable in our estimations. While details for the construction of this variable are in Appendix B, it is worth noting that in this study we focus on the location of the unique decision-maker; in this binary hierarchy higher-level managers in the supervising office could make the decision to implement the change (centralization) or, alternatively, the workplace could have made the decision (delegation).[13] Independent evidence indicates that firms choose their structure of supervising office and a separate workplace for reasons that are independent of the decision we are currently examining. For example, Rossi-Hansberg (2005) and Aiginger and Rossi-Hansberg (2006) argued that the geographic structure of firms (head supervisory offices and other plants) are driven by technical and operational features such as agglomeration effects and transport costs.

Several additional points are important here. First, the organization change we examine is a major decision, rather than routine reinvestment or part of day-to-day operations; that is, we focus on a single design choice by senior management rather than focussing on a path-dependent slow institutional adjustment. While circumstances and the structure of the firm matter, it is not plausible that these choices would be made on the basis that a decision regarding the specific (potentially) one-off change studied here would be made sometime in the future. Stated in another way, change management is a separate process from the daily operations and structure of a firm. This is an advantage of our dependent variable, as compared to more routine decisions used in Colombo and Delmastro (2004) and Bloom et al. (2007) or using the organization's choice regarding a profit or cost center, which is the main measure of delegation of decision-making in Acemoglu et al. (2007) and Christie et al. (2003). While we do not imply causality in our estimations, considering non-routine change aids in reducing the potential endogeneity of the independent organization variables and our decision-making variable. Second, given the decision studied is a major change, it is economically important to the firm. This means that the decision is unlikely to be randomly allocated without some attempt to maximize the benefit from the change-management process. The estimation results, consequently, are instructive to the influences an organization faces in allocating decision-making rights.[14]

3.2 Independent variables

Here we introduce the variables used to elucidate the theoretical propositions outlined in Section 2. Table 2 provides summary statistics for main variables of interest (Table 8 provides details for the other controls). While it is not possible, as is very often the case, to have a perfect correlation between the theory and the empirics, there is a strong case to be made that our data captures important elements of the theoretical model. Broadly, the independent variables are classified as relating to the external context, the business strategy and the internal context of the workplace.

3.2.1 External context

The key predictions of the theory relate to the costs associated with a slow decision-making process. The cost of slow decision making relates to the time it takes to implement a new project and how

[13] We do not impose any structure on the higher-level management in the supervising office or on the internal structure of the workplace itself, and these could vary between organizations.

[14] A potential issue with the hand full of other empirical studies on delegation is that the importance to the firm, or otherwise, of the form of delegation considered is unclear.

Table 2: Summary statistics of the sample (N = 570)

Variable	Mean	Std Dev.
Dependent variable		
Centralization index	.714	.452
External context		
Competition	.570	.495
Export	.186	.389
Import	.168	.375
Unpredictable demand	.207	.406
Business strategy		
Responsiveness to demand	.046	.209
Quality	.240	.428
Internal context		
Workplace size	177.9	282.3
Organization size		
< 100	.054	.227
100 – less than 500	.132	.338
500 – less than 1000	.100	.300
1000 – less than 5000	.242	.429
5000 – less than 10000	.086	.281
10000 – less than 20000	.102	.303
> 20000	.284	.451
No. of other workplaces in org. producing the same output		
0 other	.102	.303
1 other	.032	.175
2-5 other	.170	.376
6-10 other	.114	.318
11-50 other	.182	.387
51-100 other	.084	.278
> 100 other	.316	.465
High productive workplace	.451	.498
Workplace implemented technical change	.188	.391
Workplace implemented new plant or machinery	.130	.336
Workplace implemented reorganization	.437	.496
Workplace implemented change work of employees	.246	.431

Notes: a. Source AWIRS 95.

rapidly the state of the world is changing, represented by the variances of the internal and external control variables. These variances, and the cost of delay, is likely to be increasing in the level of competition in the product market. The theory presented here predicts that an increase in the cost of delay increases the likelihood of delegation. Empirically, this translates to a prediction that competition will be associated with higher costs of delaying a decision, and hence a higher probability of decentralization. It is worth noting that rather than the traditional model of perfect competition,

we are thinking of competition manifesting itself in a process of creative destruction, as in the endogenous growth models of Aghion and Howitt (1992, Chapter 7), or in time-based competition models such as Souza (2002) in which firms introduce new products in order to capture market share.[15] In these competitive environments the greater the number of sources of advancement the more likely a firm will get left behind if it too does not innovate (less market share, profit, etc). In this way, in a highly competitive environment there is an additional cost of a protracted decision-making process. Guadalupe and Wulf (2007) hold a similar belief, arguing that competition increases the need for timely decisions that make better use of local knowledge. For example, Guadalupe and Wulf (2007, page 7) suggest 'we expect intensified competition to increase the value of innovation and quick decisions ... [f]irms may delegate more decision-making to division managers (i.e. specialists with local expertise)'.

AWIRS 95 contains information relating to the level of product market competition the workplace faces. After statistical testing we utilize as a measure of product market competition, a dummy variable with 1 indicating moderate, strong or intense competition and 0 otherwise, representing limited or some competition.[16] Our measure of competition has the advantage that it measures the manager's perception of competitive pressure, and it is this perception upon which the firm will base its choice of who will make the decision, rather than proxies of market competition such as measures of concentration or other competition indices.[17]

We also consider whether or not a workplace exports some of its output. Selling in international markets involves discovering relevant information in a least two separate markets (the domestic and foreign market). This could accentuate the informational requirement regarding the external environment, potentially increasing the cost involved with centralized decision-making. Based on our model, we predict that being an exporter will be associated with delegation. To this end, a dummy variable was created taking on a value of 1 for exporters and 0 otherwise. Similarly, we generated a dummy variable if a workplace faces import competition (1 for workplaces that faced import competition and 0 otherwise). The relationship between these two variables and decision making is potentially different; exporting requires information about at least one overseas market and perhaps many, whereas import competition may simply mean greater competition in the domestic market. This suggests that import competition need not have any additional effects aside from the increase in competition, which is already accounted for via the product market competition variable.

The theoretical model suggested that an increase in uncontrollable uncertainty makes delegation less likely, as greater uncertainty increases the subordinate's expected compensation. Given this hypothesis, we include a dummy variable to indicate when product market demand for the workplace is unpredictable; the dummy variable takes on a value of 1 if product market demand is unpredictable and 0 otherwise.

Again, while we do not make any conclusions about causality from our empirical results, given that our decision is a significant change and not a routine decision, it is reasonable to assume a significant degree of exogeneity of these product market variables with respect to the dependent

[15] Also see the literature on industry clock speed, such as Mendelson (2000) and Souza et al. (2004).

[16] The possible responses were: intense competition; strong competition; moderate; some competition; and limited competition. Estimates obtained using a dummy variable for each of the different levels of competition indicated that there was no statistical difference between the estimated coefficients for moderate, strong or intense competition.

[17] See Tirole (1988, Chapter 5), for example, for a discussion of the lack of a clear relationship between concentration and product-market competition.

variable of the centralization of decision making.

3.3 Business strategy

While there has been little theoretical work on the issue, the management literature has suggested that the business strategies pursued by a firm could influence its organizational structure (see Brickley et al. (2007) and Porter (1985), for example). In the survey, each workplace was asked about their business strategy, in particular whether the most crucial element for competitive success for the workplace's major product or service depended on: the quality of their output; the workplace's responsiveness to customers; the price of the output. Dummy variables were created for the strategies of quality and responsiveness to customers, respectively, representing the so called 'high road' business strategy that emphasizes quality and customer service, as opposed to a focus on cost (and price) minimization (Osterman, 1994).

3.4 Internal context

In the estimates we include several key organizational characteristics as controls. First, we include variables for the size of the workplace in terms of the number of employees at that establishment. Also, seven dummy variables represent the different category levels for organization size in terms of employees to which the workplace belongs, ranging from less than 100 to a dummy variable for organizations that are 20 000 employees or more. To the extent that they are determined by day-to-day production requirements, these internal organization variables will be exogenous with respect to the decision-making process surrounding the implementation of a non-routine change.

Section 2.3.3 predicted that as the number of plants performing the same task increased, the likelihood that delegation would be adopted fell. In a similar manner to Colombo and Delmastro (2004), we have information about how many other workplaces in the organization produce the same product. Using the default of no other workplaces in the organization producing the same product, dummies were created for the surveyed categories: 1 other workplace producing the same output; 2-5 workplaces producing a similar product; 6-10 other workplaces; 11-50 other workplaces; 51-100 workplaces; and more than 100 workplaces producing a similar product.

Acemoglu et al. (2007) found that the delegation was associated with close proximity to the productivity frontier in that industry. We include a variable for workplaces that have self-identified as being of high productivity relative to other workplaces in their industry (coded as 1 and 0 otherwise). As well as providing an important control, this allows us to reexamine their result using alternative data.

The decision being investigated here is concerned with a significant change or innovation that was implemented. There are four possible types of innovation: technical change; new plant machinery or equipment (that is not just routine replacements); or a reorganization of the workplace or change in the work of non-management employees. A dummy variable is created for each of the types of change when it was the most significant for employees, with technical change used as the omitted category.

Dummy variables were constructed for industry at the one-digit level. Dummy variables for the main occupational group at a workplace were also constructed.

Table 3 provides a summary of our empirical predictions.

Table 3: Empirical predictions from theoretical results

Independent variable	Predicted effect on decision-making
External context	
Competition	Delegation
Export	Delegation
Import	Delegation
Unpredictability of demand	Centralization
Internal context	
Workplace size	Delegation
No. other workplaces producing same output	Centralization
Complex work environment	Delegation

Notes: See Propositions 1-9 in section 2.

Table 4: Centralization of decision-making with respect to the external context?[a]

External context	Mean of centralization[b]	Correlation[c]
Competition[d]		−0.142
No	0.788***	
Yes	0.658***	
Export[e]		−0.236
No	0.765***	
Yes	0.491***	
Import[f]		−0.130
No	0.741***	
Yes	0.583***	
Unpredictable demand[g]		0.017
No	0.710	
Yes	0.729	

Notes: a. Source AWIRS 1995. For the centralization (of decision-making) index, a difference-in-means test was conducted with respect to each external context variables. *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level. b. The decision to implement the change that had the most significant effect on employees at the workplace was decentralized if made at the workplace and centralized if made by higher levels of management. Multiple changes at a given workplace are possible. c. Correlation between centralization (of decision-making) index and the respective context variable. d. Competition is Yes (equal to 1) if the workplace faces moderate, strong or intense product-market competition, and No (0) otherwise. e. A workplace exports some of its product (Yes, coded as 1) or No otherwise (0). f. A workplace facing import competition coded as Yes (1) or No (0) otherwise. g. A workplace with unpredictable product-market demand is coded as Yes (1) or No (0) otherwise.

4 Empirical Results

Table 2 shows the list of variables of interest and their summary statistics for the sample used in the estimations.[18] Details of the sample are provided in Appendix B. In summary, we focus on workplaces that: implemented a major change in the previous 2 years; have a higher-level of management (hence are part of a larger organization); and have uniquely identified a decision maker for the implemented change. This produces a sample size of 570 workplaces for the basic estimations.

[18]Table 8 for the additional control variables.

The dependent variable in this study is the centralization of decision-making variable. Table 4 shows some interesting relationships between this decision-making variable and the key control variables. The table shows the centralization of decision-making variable is significantly lower (indicating more decentralization) for workplaces with a competitive product market than those that face limited competition; the difference-in-means test was significant at the 1 % level. The centralization of decision-making variable was also significantly lower for exporting workplaces than the workplace that did not export and for workplaces that faced import competition as compared with workplaces that did not face import competition (again, both of these differences in means were significantly at the 1 % level). The decision-making index was higher (centralization) for workplaces facing unpredictable demand, however this difference was not statistically significant. The table also presents the correlation between the decision-making variable and the context variables.

The theoretical predictions are largely supported by the simple univariate analysis. To investigate more deeply we now turn to multivariate analysis. For our multivariate analysis, we estimate a probit model of the probability that an organization decentralizes this decision as a function of the internal and product-market factors outlined above.[19]

To begin with we estimated the probability of centralized decision making using the full set of independent variables (Model 1), for which the coefficients of interest are outlined in the first column of Table 5.[20] It is not possible to reject the hypothesis that the industry dummy variables (and the business-strategy variables discussed below) are jointly insignificant ($\chi^2(12) = 13.11$), so Model II was estimated without the industry dummies. Further, from Model I a joint test that the industry dummies, the business-strategy variables (detailed below) and the occupational dummy variables (with the exception of the professional dummy variable) are equal to zero cannot be rejected ($\chi^2(17) = 17.31$). Following this, Model III does not include industry dummy variables, the main occupation group at the workplace (with the exception of the professional category dummy variable) and the business-strategy variables. From the results of the three models outlined in Table 5, it is evident that the coefficients and their levels of significance are relatively stable between the different specifications. Given these similarities, we will focus on Model II. It is notable from Model III, however, that if the main group of employees at a workplace are professional, the decision is more likely to be decentralized to the workplace (significant at the 5 percent level for Model III). One interpretation of this result is that the activities undertaken by professionals are particularly complex making change decisions more involved in workplaces dominated by this occupational group.

4.1 Business strategy

Firms can follow several different business strategies in the pursuit of success. As noted above, it is conceivable that firms pursuing cost/price minimizing objectives might implement different decision-making structure to firms that emphasize quality and customer service. However, in our estimates the coefficients for both business strategy dummy variables denoting strategies that emphasized quality and responsiveness to consumers were not statistically significant, and the hypothesis that

[19]Define centralization of the decision to be $c = 1$ and decentralization as $c = 0$. Letting X be the independent regressors and β' the vector of coefficients to be estimated, the latent variable y can be expressed as $y = \beta' X + \varepsilon$, where ε is an error term normally distributed. The probit can then estimated as $Prob(c = 1) = \Phi(\beta' X)$ and $Prob(c = 0) = 1 - \Phi(\beta' X)$, where $\Phi(.)$ is the standard cumulative normal.

[20]The other coefficients, such as the industry dummy variables, the professional occupation dummy and the type of change coefficients are outlined in Table 9 in Appendix A.

Table 5: Centralization of decision-making: probit coefficients (standard errors in parentheses)[a]

	Model I		Model II		Model III	
	Coeff	SE	Coeff	SE	Coeff	SE
External context						
Competition	-.650*	(.344)	-.728**	(.334)	-.741**	(.332)
Export	-.575**	(.238)	-.516**	(.220)	-.504**	(.206)
Import	.202	(.227)	.115	(.210)	.087	(.207)
Unpredictable demand	.382**	(.179)	.330*	(.169)	.347**	(.164)
Business strategy						
Responsiveness to demand	.110	(.359)	-		-	
Quality	-.048	(.183)	-		-	
Internal context						
Workplace size*1000	-.558**	(.251)	-.473*	(.242)	-.484**	(.238)
Organization size						
100 – less than 500	1.032***	(.330)	.978***	(.323)	1.015***	(.322)
500 – less than 1000	1.324***	(.350)	1.249***	(.341)	1.256***	(.340)
1000 – less than 5000	1.078***	(.328)	1.086***	(.319)	1.114***	(.317)
5000 – less than 10000	.934**	(.386)	.940**	(.377)	.958***	(.374)
10000 – less than 20000	1.778***	(.393)	1.706***	(.384)	1.732***	(.383)
> 20000	2.156***	(.384)	2.152***	(.366)	2.199***	(.365)
No. of other workplaces in org. producing the same output						
1 other	.506	(.398)	.527	(.389)	.567	(.385)
2-5 other	.697***	(.248)	.723***	(.241)	.748***	(.239)
6-10 other	.307	(.275)	.409	(.263)	.415	(.260)
11-50 other	.560**	(.271)	.562**	(.253)	.570**	(.251)
51-100 other	.859**	(.354)	.859**	(.337)	.868***	(.334)
> 100 other	.575*	(.301)	.580**	(.283)	.608**	(.278)
High productive workplace	-.229*	(.133)	-.235*	(.130)	-.234*	(.129)
Other variables						
Industry	Yes		No		No	
Main occupations	Yes**		Yes		No	
Prof occ (only)	-		-		Yes**	
Type of change	Yes***		Yes***		Yes***	
Constant	Yes		Yes		Yes	
Log likelihood	-248.3		-255.9		-257.6	
Pseudo R2	0.272		0.250		0.245	
No. of obs	570		570		570	

Notes: a. *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level.

they are jointly equal to zero cannot be rejected (along with the industry and occupation dummies). Consequently, these two business-strategy variables are not included in Models II and III.

Table 6: Marginal effects from probit of decentralization of decision-making (Model II)

	Marginal Effects
External context	
Competition[a]	-.230
Export[a]	-.184
Unpredictable demand[a]	.102
Internal context	
Workplace size(*1000)[a]	-.156
Organization size	
100 – less than 500[d]	.374
500 – less than 1000[b]	.463
1000 – less than 5000[b]	.412
5000 – less than 10000[b]	.362
10000 – less than 20000[b]	.573
> 20000[b]	.635
No. of other workplaces in org producing the same output[c]	
1 other	.206
2-5 other	.274
6-10 other	.161
11-50 other	.218
51-100 other	.317
> 100 other	.224
High productive workplace[a]	-.078

Notes: (a) Marginal effects calculated for an organization of 1000-5000 employees with 2-5 other workplaces performing the same task; all other variables set to their means. Marginal effects for discrete variables calculated for a change from 0 to 1. (b) Marginal effects calculated for an organization with 2-5 other workplaces performing the same task with a default of an organization with 0 to 100 employees; all other variables set to means. Marginal effects for discrete variables calculated for a change from 0 to 1. (c) Marginal effects calculated for an organization of 1000-5000 employees with a default of no other workplaces performing the same task; all other variables set to means. Marginal effects for discrete variables calculated for a change from 0 to 1. (d) Marginal effects calculated for an organization with 2-5 other workplaces performing the same task with a default of an organization with 0 to 100 employees and the workplace size set to 30 employees; all other variables set to means. Marginal effects for discrete variables calculated for a change from 0 to 1.

4.2 External context

The empirical estimates show that higher levels of competition are associated with an increased likelihood of decentralization. From Table 5, workplaces that face moderate, strong or intense product-market competition are more likely to decentralize their decision-making as compared with workplaces that face limited or some competition. These results were significant at the 5 percent level in Model II and Model III. The marginal effects, displayed in Table 6, show that a 23 percentage

point increase in the probability of decentralization for workplaces facing moderate, strong or intense product-market competition compared with workplaces that do not face such competitive pressures. To the extent that competition increases the cost of a slow decision-making process, this result is consistent with the theoretical predictions of the theory presented above and is quite large.

Turning to international competition, workplaces that export some of their output are more likely to have decentralized decision-making; the coefficient on the export dummy was significant at the 5 percent level in Model II. Moreover, an exporting workplace has a 18 percentage point increase in the probability that decision-making is decentralized compared with a workplaces that sold exclusively in the domestic market (Table 6). Notably, however, the coefficient on the import-competition dummy variable was not statistically significant. While exporting places additional informational requirements on the workplace, imports do not necessarily involve any additional information requirements; rather, imports could act merely to increase product-market competition. This is consistent with our empirical finding that imports are positively correlated with decentralization (Table 4), but that this relationship is not statistically significant in the multivariate analysis once product-market competition is included as a separate variable.

Prendergast (2002) suggested a positive relationship could exist between uncertainty and the use of output-based incentives. Our model in section 2 reestablishes the traditional negative relationship between systemic (uncontrollable) uncertainty and the use of incentives, by allowing the principal the option to centralize the performance of the internal decision (task). This follows, as an increase in uncontrollable uncertainty increases the expected cost of the subordinate's remuneration, making delegation less likely. Our empirical finding – that workplaces with unpredictable product demand were more likely to centralize decision making to higher levels of management – is consistent with this prediction.

4.3 Internal context

First, decentralization is associated with an increase in workplace size; the coefficient for workplace size was negative and was significant at the 5 percent level in Model II. This indicates, from the marginal effects in Table 6, an increase in the workplace size by 1000 employees increases the probability that the decision was decentralized to the workplace by 17 percentage points. This result is consistent with the theoretical model; the larger the size of the workplace, the more likely that there is a higher cost of delay from not implementing an up-to-date (internal) decision.

Second, taking workplaces that belong to organizations of less than 100 workers as the default, an increase in the size of an organization is associated with higher levels of centralization. The size of the coefficients, and the marginal effects in Table 6, were typically increasing in the organization size. All of these organization size coefficients were significant at the 1 percent level in Model II.

Third, overall, an increase in the number of workplaces performing the same task is associated with an increased probability of centralized decision-making. Tables 5 and 6 display these coefficients and marginal effects respectively. For example, there is a 27 percentage point increase in the probability that the decision to implement the change is centralized if there are 2-5 other workplaces performing a similar task relative to an organization with no other workplaces performing the task (the coefficient significant at the 1 percent level). A similar result applies when there are 11-50 other workplaces (significant at the 5 percent level), 51-100 other workplaces (5 percent level of

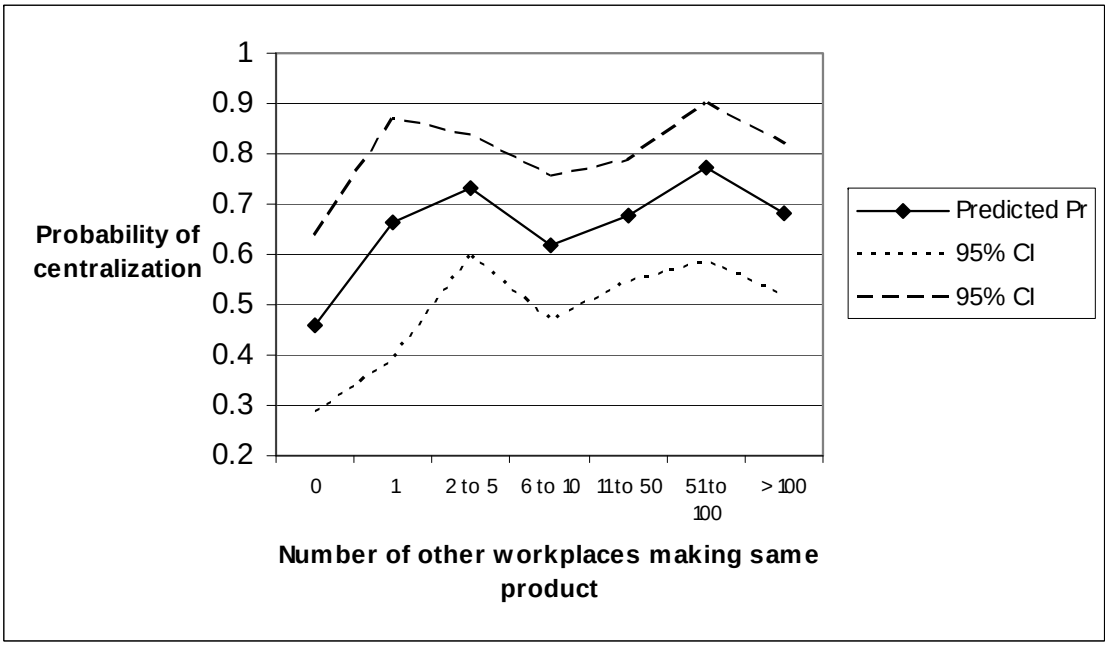

Figure 1: Impact on the predicted probability of centralization from a change in the number of workplaces performing the same task

significance) or more than 100 other workplaces (1 percent level significance) performing a similar task, the exception being the insignificance of the coefficient for the 6-10 other workplaces dummy variable. While there is an increase overall, it is notable that there is a non-monotonic relationship between the increase in the number of other workplaces and the probability of centralization. This is reflected in the size of the marginal effects for the successive dummy variables as well as the predicted probability of centralization as the number of workplaces is altered, illustrated in Figure 2.

The result that an increase in the number of workplaces performing the same task is associated with centralization accords with the empirical findings of Colombo and Delmastro (2004) for manufacturing firms. Furthermore, this finding is consistent with the multi-plant extension to the model in Section 2 that showed that when the economies-of-scale advantages that makes delegation less likely. Other factors such as coordination costs could also play a role in this result but are not reported in our data.

Finally, it is worth mentioning that a decision regarding a change in the work of non-management employees was more likely to be decentralized, relative to the default of a non-routine adoption of a technical change, and this was significant at the 1 percent level (in Model II, Table 9). In Colombo and Delmastro (2004), labor-related decisions were more likely to be decentralized, while capital-related decisions tended to be centralized. Our finding suggest a similar story with respect to labor-related decision.

5 Extensions

Here we consider several extensions to Model II. First, we investigate the impact on the estimates of the inclusion of various human resource management (HRM) techniques (Section 5.1). Second, we explore the robustness of our estimates by considering: sample selection in regards to those workplaces that did (and did not) innovate (Section 5.2); and an alternative specification of the dependent variable (Section 5.3).

5.1 Human resource management and decentralized decision-making

Previous studies have shown that human resource management (HRM) techniques, such as bonuses, training and staff appraisals are often implemented in combination on the shop floor, and can affect firm productivity (Bartel et al., 2004; Ichiowski et al., 1997; Osterman, 1994). In this section we explore the relationship between certain HRM techniques and decentralization of decision-making in organizations, focusing on several key HRM techniques, namely: the use of bonuses; training; the use of total quality management techniques (TQM); staff appraisals; whether the workplace had a skills audit of employees and the interaction between the presence of a bonus and staff appraisals

To do this we include these additional HRM variables into Model II. The estimated coefficients and marginal effects are presented in Table 5.1 and Table 10 respectively. They show that the use of bonuses by a workplace (on their own) are associated with decentralization of decision-making and this is significant at the 5 percent level. Taking into account the interaction term outlined below, the use of a bonus by a workplace is associated with a 13 percentage point increase in the probability of decentralization (Table 10). The coefficient on the staff-appraisal dummy variable was not significant. An interaction term between the presence of staff appraisals and the use of bonuses was also included in the estimates, but it was not statistically significant. No significant relationship was found between training of employees and the allocation of the decision. The coefficient for the use of a skillaudit by a workplace, on the other hand, was significant at the 1 percent level; use of a skillaudit was associated with a 16 percentage point increase in probability that decision-making was centralized. One possible interpretation for this result is that if a skillaudit increases the information higher levels of management have about a workplace this may allow upper-level managers to be in a better position to make effective centralized decisions.

Finally, the coefficients on the external and internal context variables from the basic model were not altered substantially by the inclusion of the HRM variables into the estimation, suggesting that our main results outlined above are robust to the inclusion of HRM techniques in the estimations.

5.2 Sample selection

We study the level in an organization's hierarchy a decision to implement a workplace innovation was made. It is possible that there is a sample selection bias between workplaces that did not implement any change and those that did. Following Wynand and van Praag (1981), to correct for any possible sample selectivity we estimated a probit model with sample selection.[21] The sample-selection equation estimated is: (1) did the workplace implement a major change in the last two years or not; (2) if a change did occur, given change occurred, was the decision centralized or

[21] Also see Greene (1997).

Table 7: Marginal effects for probit model with HRM variables (N = 570)

	Marginal Effects
External context	
Competition[a]	-.263
Export[a]	-.201
Unpredictable demand[a]	.093
Internal context	
Workplace size(*1000)[a]	-.148
Organization size	
100 – less than 500[d]	.404
500 – less than 1000[d]	.461
1000 – less than 5000[b]	.432
5000 – less than 10000[b]	.382
10000 – less than 20000[b]	.584
> 20000[b]	.639
Number of other workplaces in organization producing the same output[c]	
1 other	.252
2-5 other	.305
6-10 other	.164
11-50 other	.233
51-100 other	.313
> 100 other	.225
High productive workplace[a]	-.086
Human resource management	
Bonuses[a]	-.127
TQM[a]	-.073
Training[a]	-.017
Skill audit[a]	.148
Staff appraisal[a]	.087

Notes: (a) Marginal effects calculated for an organization of 1000-5000 employees with 2-5 other workplaces performing the same task; all other variables set to their means. Marginal effects for discrete variables calculated for a change from 0 to 1. (b) Marginal effects calculated for an organization with 2-5 other workplaces performing the same task with a default of an organization with 0 to 100 employees; all other variables set to means. Marginal effects for discrete variables calculated for a change from 0 to 1. (c) Marginal effects calculated for an organization of 1000-5000 employees with a default of no other workplaces performing the same task; all other variables set to means. Marginal effects for discrete variables calculated for a change from 0 to 1. (d) Marginal effects calculated for an organization with 2-5 other workplaces performing the same task with a default of an organization with 0 to 100 employees and a workplace size of 30; all other variables set to means. Marginal effects for discrete variables calculated for a change from 0 to 1.

decentralized. The instruments for the sample selection equation are: the age of the workplace; a dummy variable whether product-market demand is expanding or not; a dummy is product-market demand is contracting; and industry dummies. The centralization of decision-making equation is as in Model II with the inclusion of the HRM variables, as in Section 5.1. These estimations are outline in Tables 11 and 12; the hypothesis that of two independent equations (no significant sample-selection bias) cannot be rejected ($\chi^2(1) = 0.16$). Further, the estimated coefficients for the variables of interest are very similar to the basic estimates presented in above.

5.3 Alternative specifications

Thus far we have considered a binary measure of who makes the decision; as noted previously, decentralization was defined as when the unique decision maker was located at the workplace (coded as 0) or the decision was centralized if it was made at a higher level of management (coded as 1). In this section we investigate decentralization using an alternative measure.

In AWIRS 95, the general manager was asked whether the decision was made by: higher levels of management beyond this workplace; senior workplace managers; other workplace managers here; and employees likely to be affected at this workplace. From this it is possible to construct a four-level hierarchy, were the unique decision maker could be located at: (1) higher-levels of management; (2) senior workplace managers at the workplace; (3) other workplace managers (at the workplace); (4) or the workplace employees likely to be affected by the change. The index used previously collapses all the decisions made at the workplace (levels 2, 3, and 4) into one group (decentralization) because very few decisions are made by either other managers or by employees (levels 3 and 4).[22] However, to ensure that this simplification is appropriate, we estimate an ordered probit using this four-level decision-making hierarchy for the explanatory variables in Model II. The results are displayed in Table 13. The results demonstrate that there is little difference in terms of the signs and significance of the estimated coefficients of interest between this model and the basic model (shown in Table 5).

Finally, we estimate Model II using a linear probability and a logit model (not shown) and obtain very similar results.

6 Concluding Remarks

This paper developed a theoretical model of delegation that emphasized, for the first time, the cost of slow decision-making due to the changing environment when the principal and agent have differing incentives. When there was greater uncertainty about the appropriate decisions to implement, the principal would be more likely to delegate one of the decision to an agent to increase the throughput of decisions, thus reducing the loss associated with a slower (centralized) decision-making process. On the other hand, when systemic uncertainty increased, the expected cost of delegation would also increase as the moral hazard compensation scheme would become more costly; consequently greater environment uncertainty decreased the likelihood of delegation. The economies of centralizing decision-making were also addressed. We showed that with multiple plants (and hence multiple decisions to be made), the principal would be more likely to centralize, provided the decisions were

[22] For the estimation sample, the numbers of decisions made at the four levels were 407 by higher management, 151 by senior workplace managers, 8 by other managers and 4 by employees affected respectively (total sample size 570 workplaces).

relatively similar, to avoid the duplication of managerial costs that would arise. Several other predictions were derived. For example: an increase in the complexity of the internal environment increased the likelihood of delegation; and delegation is also more likely the more important the decision (the bigger the scale of the workplace).

The second contribution in this paper is our novel empirical results. Our study of who makes a big (non-routine) decision provides a completely new perspective on delegation compared to the contemporaneous studies that examine operational decisions, delayering and the choice of profit or cost centers. Our empirical results, while not implying causality, are consistent with our theoretical predictions: for example, product market competition and exporting is associated with delegation while a centralization of decision making authority is more likely when there is demand uncertainty.

Together, our theoretical and empirical results make an important point; the external (or product-market) environment matters, just as much as the internal environment, for firm design. This suggests a need for ongoing research connecting the characteristics of the product market to a firm's internal architecture, including its allocation of decision-making authority. While recent papers, such as Meagher et al. (2004), Alonso et al. (2008), Meagher and Wang (2008) and the model presented here, are making steps towards an integrated approach, this remains an important area for future research.

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Appendix A: Tables

Table 8: (Table 2 cont.) Summary statistics: industry, profession and other variables[a]

Variable	Mean	Std Dev.
Industry		
Manufacturing	.158	.365
Electricity, gas and water	.047	.213
Construction	.023	.149
Transport	.053	.223
Business services	.170	.376
Retail	.126	.332
Wholesale	.035	.184
Arts	.035	.184
Other industries	.058	.234
Accommodation	.028	.165
Government administration, health or education	.232	.422
Profession of main group of employees		
Laborers	.142	.349
Plant operators	.154	.362
Tradesperson	.084	.278
Sales	.223	.416
Clerks	.105	.307
Professionals	.165	.371
Para-professionals	.126	.332
Other variables		
Age of workplace		
0 – 5 years	.049	.216
5 – 10 years	.086	.281
10 – 20 years	.202	.402
20 – 50 years	.346	.476
$>$ 50 years	.316	.465
Demand expanding	.595	.491
Demand Contracting	.089	.286

Notes: a. Sources AWIRS 95.

Table 9: (Table 5 cont.) Additional probit coefficients for centralization of decision-making (standard errors in parentheses)

	Model I		Model II		Model III	
External context	Coeff	SE	Coeff	SE	Coeff	SE
No competition info DV	-.216	(.393)	-.182	(.349)	-.196	(.344)
No export info DV	-.072	(.852)	-.041	.(814)	-.017	(.806)
No import info DV	-.003	(.879)	-.049	(.838)	-.112	(.831)
Internal context						
Plant equipment change	-.285	(.281)	-.227	(.268)	-.278	(.260)
Reorganization of workplace	-.381*	(.222)	-.310	(.212)	-.347*	(.210)
Change of employee work	-.851***	(.230)	-.778***	(.220)	-.81***	(.217)
Industry and profession						
Mining	.108	(.448)	-		-	
Manufacturing	-.417	(.348)	-		-	
Electricity, gas & water	.109	(.395)	-		-	
Construction	-.669	(.443)	-		-	
Transport	-.706*	(.379)	-		-	
Business services	-.132	(.276)	-		-	
Retail	-.587*	(.356)	-		-	
Wholesale	-.665	(.425)	-		-	
Arts	-.361	(.381)	-		-	
Other	-.691**	(.346)	-		-	
Accommodation	-.917**	(.453)	-		-	
Laborer	.385	(.286)	.240	(.267)	-	
Plant operator	-.016	(.291)	-.143	(.263)	-	
Sales	.350	(.327)	.142	(.272)	-	
Clerk	-.006	(.341)	.032	(.298)	-	
Paraprofessional	.0577	(.360)	-.021	(.310)	-	
Professional	-.585*	(.332)	-.420	(.280)	-.464**	(.188)
No. of obs	570		570		570	

Notes: *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level; Tradesperson omitted occupation; government, health and education omitted industry. Tradesperson omitted occupation; government, health and education omitted industry.

Table 10: Centralization of decision-making with HRM for Model II probit coefficients (standard errors in parentheses)[a]

	Model II	
External context	Coeff	SE
Competition	-.897**	(.353)
Export	-.534**	(.228)
Import	.035	(.216)
Unpredictable demand	.323*	(.175)
Internal context		
Workplace size	-.495*	(.252)
Organization size		
100 – less than 500	1.075***	(.334)
500 – less than 1000	1.270***	(.348)
1000 – less than 5000	1.151***	(.330)
5000 – less than 10000	1.000***	(.387)
10000 – less than 20000	1.798***	(.393)
> 20000	2.285***	(.378)
No. of other workplaces in org producing the same output		
1 other	.658*	(.412)
2-5 other	.819***	(.247)
6-10 other	.416	(.272)
11-50 other	.604**	(.264)
51-100 other	.844**	(.350)
> 100 other	.582**	(.290)
High productive workplace	-.275**	(.134)
Human resource management		
Bonuses	-.699**	(.286)
TQM	-.233*	(.141)
Training	-.056	(.154)
Skill audit	.495***	(.154)
Staff appraisal	.104	(.179)
Bonus*staff appraisal	.433	(.323)
Other variables		
Industry	No	
Main occupations	Yes*	
Type of change	Yes***	
Constant	Yes	
Log Likelihood	-244.383	
Pseudo R2	0.284	
No of Obs	570	

Notes: a. *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level.

Table 11: Probit coefficients with sample selection (standard errors in parentheses)

	Implement change (Selection equation)		Centralization	
	Coeff	SE	Coeff	SE
External context				
Competition	.243	(.214)	-.903***	(.351)
Export	.343*	(.186)	-.604***	(.230)
Import	.248	(.176)	. 017	(.219)
Unpredictable demand	.332**	(.146)	.303*	(.184)
Demand expanding	-.239**	(.120)	-	
Demand contracting	-.133	(.179)	-	
Internal context				
Workplace size*1000	-.058	(.191)	-.470*	(.252)
Organization size				
100 – less than 500	.300	(.210)	1.021***	(.368)
500 – less than 1000	.697***	(.247)	1.159***	(.426)
1000 – less than 5000	.871***	(.231)	1.041**	(.444)
5000 – less than 10000	.590**	(.281)	.910**	(.447)
10000 – less than 20000	.762***	(.271)	1.700***	(.483)
> 20000	1.151***	(.273)	2.135***	(.544)
Number of other workplaces in organization producing the same output				
1 other	-.581**	(.266)	.723*	(.430)
2-5 other	.035	(.200)	.810***	(.249)
6-10 other	-.095	(.233)	.402	(.271)
11-50 other	-.006	(.223)	.604**	(.263)
51-100 other	-.039	(.282)	.837**	(.349)
> 100 other	-.169	(.256)	.592**	(.289)
High productive workplace	.1478	(.107)	-.284**	(.135)
Age of workplace				
5 – 10 years	.131	(.272)	-	
1 – 20 years	.495*	(.257)	-	
20 – 50 years	.299	(.241)	-	
> 50 years	.435*	(.251)	-	

(continued)

Table 12: Probit coefficients with sample selection continued (Standard errors in parentheses)

	Implement change (Selection equation)		Centralization	
	Coeff	SE	Coeff	SE
Human Resource Management				
Bonus	.760***	(.269)	-.754**	(.313)
TQM	.056	(.110)	-.239*	(.141)
Train	-.013	(.117)	-.051	(.153)
Skillaudit	.209*	(.120)	.467***	(.174)
Staffappraisal	.219	(.136)	.089	(.189)
Bonus*staffapprasial	-.875***	(.293)	.495	(.363)
Other variables				
Industry	Yes		No	
Main occupation	Yes		Yes	
Type of change	No		Yes***	
Constant	Yes***		Yes	
Log likelihood				
ρ^b	-.217	(0.522)		
No. of obs.	793		569	

Notes: a. *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level. Tradesperson omitted occupation; government, health and education omitted industry, Age of workplace $0-5$ years . Demand expanding is: 1 if demand for the workplace's output is expanding; 0 otherwise. Demand contracting is: 1 if demand for the workplace's output is contracting; 0 otherwise.
b. ρ: LR test of independent equations ($\rho = 0$); $\chi^2(1) = 0.16$.

Table 13: Ordered probit results for 4 unique levels of the centralization of decision-making

External context	Coeff	SE
Competition	-.887***	(.342)
Export	-.499**	(.208)
Import	-.032	(.198)
Unpredictable demand	.296*	(.164)
Internal context		
Workplace size*1000	-.355	(.229)
Organization size		
100 – less than 500	.658**	(.278)
500 – less than 1000	.768***	(.296)
1000 – less than 5000	.748***	(.279)
5000 – less than 10000	.646*	(.337)
10000 – less than 20000	1.418***	(.348)
> 20000	1.856***	(.329)
No. other workplaces in org producing the same output		
1 other	.714*	(.371)
2-5 other	.809***	(.219)
6-10 other	.535**	(.244)
11-50 other	.638***	(.240)
51-100 other	.891***	(.333)
> 100 other	.561**	(.270)
High productive workplace	-.272	(.125)
HRM		
Bonuses	-.522	(.256)
TQM	-.249	(.133)
Training	-.006	(.142)
Skill audit	.443	(.144)
Staff appraisal	.075	(.169)
Bonus*staff appraisal	.268	(.295)
Other variables		
Industry	No	
Main occupations	Yes	
Type of change	Yes	
Cut 1	-2.951	(.542)
Cut 2	-2.494	(.522)
Cut 3	-.527	(.505)
Log likelihood	-298.745	
Pseudo R2	0.237	
No of obs.	570	

Notes: *** Significant at 1% level, ** significant at 5% level, * significant at 10 % level. Tradesperson omitted occupation; government, health and education omitted industry.

Appendix B: Dataset and Variables Construction

The Australian Workplace Industrial Relations Survey 1995 (AWIRS 95) contains several complementary surveys.[23] The main survey sampled 2001 workplaces with over 20 employees in all major ANZSIC divisions across all States and Territories of Australia. This paper makes use of the General Management Questionnaire, which was conducted by personal interview and completed by the most senior manager at the workplace, and the Employee Relations Management Questionnaire, conducted by personal interviews with the employee relations manager. Note that in this survey a workplace (which is an establishment or plant at a particular address) can be part of a larger organization.

Organization change

The senior manager at each of the establishments surveyed was asked in the General Management survey, asked 'which, if any, of the changes listed, happened at this workplace in the last 2 years? (1) technology (not just routine replacement); (2) Introduction of major new plant, machinery or equipment (not just routine replacement); (3) Major reorganization of workplace structure (for example, changing the number of management levels, restructuring whole divisions/sections and so on); (4) Major changes to how non-managerial employees do their work (for example, changes in the range of tasks done, changes in the type of work done); or (5) None of the above' (Question BF1).

If more than one change was implemented the senior workplace manager was asked which change had the most significant effect on the employees here (Question BF3).

From the change made, or the most significant change in terms of its affect on employees if more than one change was made, 4 dummy variables for types of change implemented: *Technical change* coded 1 if the change was made was technical change, 0 for all other changes; *New plant or machinery* coded 1 if the change was made was introducing new plant or machinery, 0 for all other changes; *Reorganization* coded 1 if the change was reorganization of workplace or if there were multiple changes and most important was not specified, 0 for all other changes; *Change work of employees* coded 1 if the change was made was change in type of work of non-management employees, 0 for all other changes.

Dependent variable

Centralization index: for the change that most affected the employees, as described above, the general manager was asked how involved in the decision to introduce the innovation were: higher levels of management beyond this workplace; senior workplace managers; other workplace managers here; and employees likely to be affected at this workplace (question BF7). The possible answer options were: (1) made the decision; (2) had significant input; (3) were consulted; (4) were informed; (5) were not informed; and (6) not relevant for this organization. This information was compiled to create a hierarchy in which decision-making occurred either: at the workplace (decentralization, coded as 0); or above the workplace (centralization, coded as 1). That is, the decentralization category includes when the decision was made by the senior workplace manager, other workplace managers or employees (0); centralization is when the decision was made by higher levels of management beyond the workplace (1)the senior workplace manager. We consider only workplaces part of an organization with multiple workplaces (as there needs to be a higher level of management) and for workplaces that are owned or controlled by another workplace in the organization (Question BA9).

External context

Competition coded 1 if the senior workplace manager rated the degree of product market competition strong, intense or moderate and 0 if there was some competition or with limited competition and 0 otherwise; No competition info DV 1 if BC6 missing and 0 otherwise.

[23] The survey and the data are described in detail in Morehead et al. (1997).

Export 1 if nature of market for workplace's major product or service is domestic with some export or primarily export and 0 otherwise (from question BC3); No export DV coded as 1 if BC3 missing and 0 otherwise.

Import 1 if workplace faces import competition for its major product or service and 0 otherwise (from question BC4); No import info DV coded as 1 if BC4 missing and 0 otherwise.

Unpredictable demand generated from Question BC10 '[g]enerally speaking, is the demand for your main product or service fairly predictable, or is it largely unpredictable?' coded (1) if largely unpredictable and 0 if largely predictable.

Demand expanding 1 if demand for workplace's major product or service is expanding; 0 if demand is stable or contracting (Question BC8).

Demand contracting 1 if demand for workplace's major product or service is contracting; 0 if demand is stable or expanding (Question BC8).

Business context

Responsiveness to demand coded as 1 if Question BC7 is 1 and 0 otherwise.

Quality coded as 1 if Question BC7 is 2 and 0 otherwise.

Internal context

Size is equal to BB1

Organization size dummy variables for < 100, 500-less than 500, 1000-less than 1000, 1000-less than 5000, 5000-less than 10000, 10000-less than 20000 and > 20000 from Question BB17.

No. of other workplaces in org producing the same output For *0 other* coded 1 if Question BB16 was 1, and 0 if BB16 not 1 (that is, if it was 2, 3, 4, 5, 6 or 7); *1 other* coded 1 if Question BB16 was 2, and 0 if BB16 not 2; *2-5 other* coded 1 if Question BB16 was 3, and 0 if BB16 not 3; *6-10 other* coded 1 if Question BB16 was 4, and 0 if BB16 not 4; *11-50 other* coded 1 if Question BB16 was 5, and 0 if BB16 not 5; *51-100 other* coded 1 if Question BB16 was 6, and 0 if BB16 not 6; $>$ *100 other* coded 1 if Question BB16 was 7, and 0 if BB16 not 7.

High productive is coded 1 if the workplace's productivity is a lot or a little higher than its major competitors and 0 otherwise (Question BD12).

Industry dummy variables created from Question BB6

Occupational categories generated from BB4.

Human resource management (HRM) techniques, such as use of bonuses, TQM, training, skill audits and staff appraisals derived from Question CA17.

Age of workplace dummy variables for 0 – 5 years, 5 – 10 years, 10 – 20 years, 20 – 50 years and $>$ 50 years generated from Question BB7.