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Support Strategies to Foster Adoption of Interorganizational Innovations

*Barrie R. Nault **
*Richard A. Wolfe ***
and
*Albert S. Dexter ****

* Graduate School of Management
University of California, Irvine

** Department of Management
Western Kentucky University

*** Faculty of Commerce and Business Administration
University of British Columbia

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Support Strategies to Foster Adoption of Interorganizational Innovations

We develop strategies suppliers can use to foster the adoption of interorganizational information systems innovations. The strategies focus on adoption support to overcome innovation adoption barriers, accounting for the effect of the innovation on ongoing supplier-customer transactions. Modelling a dimension of the customer, organizational innovativeness, and a dimension of the innovation, its radicalness, we derive optimal supplier strategies for when the supplier can differentiate individual customer innovativeness and when it can not. In the former case knowledge of individual customer innovativeness results in a triage model - some customers adopt without support, some require support to adopt and some do not adopt and should not be supported. Lack of knowledge of customer innovativeness results in an undifferentiated strategy directed at all customers. Knowledge of customer innovativeness increases overall adoption, increases supplier profits, and lowers adoption support to those customers that receive support in both cases.

1 Introduction

The literature in organizational and economics describing innovation and its importance to the corporation and the economy is extensive and long established. The classics ([28], [22], [26]) carry the same message as more recent work ([34]): the development, adoption and implementation of innovations are critical determinants of organizational competitiveness and effectiveness. Increases in competition along with recent advances in computer-based communication technologies have also contributed to dramatic modifications in organizational designs. A common theme among such design changes are that organizational boundaries are less impermeable and are blurring as interorganizational connections form. Innovative communications technologies contribute to coordinating relationships and transactions between organizations, and to the growth of interorganizational linkages ([7]).

The purpose of this paper is to develop strategies to foster the adoption of interorganizational innovations. We define interorganizational innovations as innovations spanning organizational boundaries that support ongoing supplier-customer transactions. Our focus is on innovations that a supplier offers to its customers. We define *adoption support* as assistance, financial or otherwise, to help a customer assess benefits of, overcome organizational resistance to, and achieve necessary organizational adaptation implied by, the innovation. Recent interorganizational technologies illustrate the innovations we have in mind: interorganizational information systems (IOS) are defined as *"...automated information systems shared by two or more companies"* ([2], p. 151). The following are three examples of the type of IOS innovations we consider.

American Hospital Supply Corporation's IOS for order processing, labelled the ASAP system, resulted in customers (hospitals) receiving more certain and timely delivery of supplies ([15]). ASAP was offered to hospitals as part of an overall materials management system. Hospitals benefitted from lower inventory, lower shrinkage and spoilage, and reduced paperwork, all of which decreased costs.

Pacific Pride Systems offered its customers in the commercial fuel industry (trucking companies, vehicle fleets) a "cardlock" IOS. The cardlock system operates similar to automated teller machines used in banking. That IOS provides customers with secure, 24 hour access to fuel across a broad network of locations, improved reporting of fuel purchases, quicker fueling and improved monitoring and tracking information ([16], [23]).

McKesson Drug offered an IOS (Economost) for order processing to small independent drugstores, providing them with delivery and inventory advantages necessary to compete with larger drugstore chains ([3]). Economost allowed customers to enter the drugstore's complete order into a single hand-held device and transmit the order directly to McKesson, reducing transaction costs. Drugstore inventories were significantly reduced as deliveries were made the same or following day.

Although each of the above innovations offered the adopter potential benefits, they were also accompanied by adoption costs. In this paper we study supplier strategies to foster the adoption of IOS innovations by helping customers mitigate these costs. In so doing, we build on insights from the innovation literature. To account for the complex and context-sensitive nature of the innovation process, innovation research must be approached by specifying attributes of both the adopting organization and the innovation ([36]). Although the effects of selected organization and innovation attributes have been examined, little is known about how they interact ([21]). Consistent with the need to carefully specify attributes and to study interaction effects, we build a model that examines the interactions of two attributes, one of the adopting organization and one of the innovation. We model customers as differing in their innovativeness and innovations as differing in their radicalness. An organization's innovativeness has been viewed as the degree to which an organization adopts innovations earlier than others ([27]) and therefore, the degree to which past behavior provides routines or programs useful in innovation implementation ([1]). Traditionally, innovativeness has been considered as a dependent variable, whereas we use it as the dimension on which we differentiate between adopting organizations.

Innovation radicalness is the extent to which an innovation represents technological changes and thus implies new behaviors for organizational subsystems or members ([10], [24]). Damanpour ([8]) explains that as follows:

> *"The adoption of innovation creates changes in the structure and functioning of an organization; however, the extent of these changes is not equal for all innovations. Thus innovations can be classified according to the degrees of change they make in the existing practices of an adopting organization."* (p. 561)

Radicalness is thus related to the degree of organizational change needed to accommodate an innovation and can be described as the degree to which skills, abilities and knowledge developed for existing technologies must be adapted for a new innovation ([32]).[1] Similarly, it has been argued that the more radical an innovation, the more it forces an organization to ask a new set of questions, and to employ new approaches ([17]). The resulting changes have also been described in terms of whether the required changes are to core design concepts, to linkages between concepts and components, to neither, or to both ([17]).

The relationship between organization and innovation attributes has been the subject of debate ([11], [30], [31], [36]). In addressing their relationship, it is important to consider whether organization and innovation attributes are primary or secondary ([11]). A primary

[1] Others divide innovations into two groups, radical and incremental, based on high or low degrees of change (e.g., [10]). Our use of radicalness defines those degrees of change as a continuum rather than as two separate groups, similar to a "radical-incremental" scale ([10], p. 1426).

organization attribute is inherent to the organization without reference to a specific innovation and a primary innovation attribute is inherent to the innovation without reference to a specific organization. Treating innovativeness as a primary attribute, an organization that is more innovative than another is more innovative regardless of the innovation. Similarly, treating radicalness as primary, an innovation that is more radical than another would be more radical to all organizations. Thus, when organization and/or innovation attributes are primary, it is possible to obtain context-free measures of an organization's innovativeness (i.e., without innovation context) and/or an innovation's radicalness (i.e., without organization context) ([11]). Our model applies to situations where the attributes are primary.

An alternative, and more complex, interpretation is that organization attributes can depend on the innovation in question and innovation attributes can depend on the adopting organization. In that case innovativeness and radicalness would be considered secondary attributes ([11]). Thus, the context of a particular innovation is important in determining an organization's innovativeness. Similarly, two organizations may rank the radicalness of two separate innovations differently because characteristics of each adopting organization matters. As we discuss later, because our model is of a supplier offering a particular innovation to a fixed set of organizations (customers), the model also applies to situations where innovativeness or radicalness are secondary attributes.

Although organizational innovativeness and innovation radicalness are important determinants of innovation adoption and implementation, and those are the ones we model, we do not imply that those are the sole determinants. A recent review lists some sixteen innovation attributes ([36]) and a recent meta-analysis provides thirteen organizational attributes ([8]). Our intent here is not to present a comprehensive model based on all or many of those attributes. Rather, our objective is to stress the importance of concurrent consideration of both innovation and organization attributes in determining supplier strategies to foster interorganizational innovation adoption. In doing so we limit our analysis to two important attributes, innovativeness and radicalness, thus presenting a precise and parsimonious model.

We develop supplier adoption support strategies under two different informational scenarios. In our first case, suppliers know the distribution of customer innovativeness, but cannot identify an individual customer's innovativeness. As a result suppliers can only offer a single level of adoption support to all customers. In our second case, the supplier knows individual customer innovativeness and can tailor adoption support to individual customers. In our model the supplier sets the level of adoption support it provides to customers, setting that support to maximize profits.

The model yields the following results. In our first case, not all customers from which the supplier can make profits adopt. Adoption support stops short of those customers because increments of support to entice less innovative customers to adopt must also be given to more innovative customers that would adopt without the increment of support. Because the supplier cannot differentiate between customers based on innovativeness, it can offer only one level of support. In our second case, a *triage* approach is optimal: more innovative customers do not require support, less innovative customers are provided individually calibrated support, and even less innovative customers are not supported. That last group does not adopt. As a result, all customers from which the supplier can make profits are enticed to adopt. Thus, in our second case more customers adopt, the supplier makes greater profits, and each adopting customer receives a lower level of adoption support.

Our results sharpen the meaning and value of "knowing your customer." In our second case, knowing the innovativeness of individual customers results in additional supplier profits from three sources. Firstly, some customers from which the supplier can make profits only adopt in our second case. Secondly, the supplier offers lower levels of adoption support to customers that receive support in both the first and second cases. Thirdly, support is removed from those customers that do not require it in the second case but require it in the first. Our model also determines when adoption support should increase with marginal increases in the radicalness of the innovation and more importantly, when it should not. Essentially, adoption support should be greater for more radical innovations as long as the innovation is not too radical. For extremely radical innovations the costs of adoption may be too high for the supplier to cover with adoption support.

Next we discuss the components of adoption costs and adoption benefits and how suppliers may mitigate customer adoption costs. We introduce our constructs, notation and assumptions, and then outline the customer's problem. Subsequently, we examine the supplier's problem, analyzing each of our two cases in sequence, and then comparing the results. We conclude with a sensitivity analysis of our main condition and assumption, summarize the insights from the model, discuss the practical implications and argue for the generalizability of our results to a broader set of innovation types.

2 Adoption Costs, Benefits and Support

Adoption Costs Adoption costs are incurred over a finite period of time and come from various sources including innovation assessment and acquisition costs, costs incurred in overcoming organizational resistance, and costs that are necessary to change current operations. Assessment and acquisition costs are incurred in investigating and adopting an innovation. Those costs include the costs of justifying the innovation and, if the decision is made to adopt, then the purchase of the innovation and installation costs. It is frequently difficult to justify innovations as potential adopters often do not have a realistic sense of the time and other resources required for successful implementation ([9]) and the benefit to be derived from their adoption is often uncertain. Potential adopters find that they cannot rely on previous experience with capital budgeting to evaluate technological innovations and, therefore, often need help evaluating new technology investments ([20]).

Van de Ven and Poole ([34]) argue that innovations are influenced by the *"...amazing persistence and fixity of organizational life"* (p. 52). A major contributor to that "fixity" is behavioral resistance caused by learned, established and previously successful adaptive behaviors. The perceived benefits of an innovation must be powerful to overcome that resistance. The concept of protecting territorial rights and boundaries has been used to explain inertial influences ([29], [6]) as innovations are often perceived as threats to existing organizational practices ([33]), to careers ([14]), and to vested interests ([19]).

In addition to resistance due to territorial rights and boundaries issues, innovations can stretch the ability of managerial and organizational systems to absorb them ([4]). They are often introduced into organizations designed and managed in a fashion suitable for older, simpler, operations. The implementation of new technology, therefore, fails without careful attention to the necessity of learning new skills, potential personnel displacement and role changes. New relationships among departments may also be necessary as patterns of communication, authority, and responsibility change ([18]). Consistent with such arguments, Ettlie ([12]) found that successful implementation of advanced manufacturing technology was dependent upon significant administrative accommodation and that the more radical the innovation, the more radical the necessary adaptation. The successful implementation of new technology, thus, requires substantial organizational structure and process changes.

The more radical the innovation, the greater each adoption cost is likely to be because the greater the differences from past practices it implies. Radicalness is positively related to the uncertainty surrounding an innovation and to necessary modification in existing structures and processes ([10], [24], [25]). Moreover, each adoption cost is not constant across organizations; each varies according to an organization's innovativeness - the degree to which past behaviors provide routines or programs useful in the innovation process ([1]). The more innovative an organization, the more experience it has in dealing with assessment, resistance and adaptation, and therefore, the lower adoption costs tend to be.

Adoption Benefits Adoption of an interorganizational innovation can result in two types of customer benefits: improved quality of the product and reduced costs from more efficient transactions. We examine quality first. The adoption of an interorganizational innovation can contribute to the quality of goods transacted, and thus, the goods become more valuable to the customer. Evidence of interorganizational innovations providing quality benefits is strong. Referring to airline computer reservation systems, for example, Copeland and McKenney ([5]) state: *"... To the extent that a passenger inquiry could be processed more quickly and effectively, an airline realized a product advantage"* (p. 366). The American Hospital Supply Corporation and Pacific Pride Systems examples given in the introduction also illustrate quality improvements from IOS.

In addition, interorganizational innovations often facilitate supplier-customer transactions in a way that reduces costs. For example, an innovation that facilitates transition to just-in-time manufacturing can lead to significant reductions in materials inventory, work-in-process, and inbound logistics costs. American Hospital Supply Corporation's ASAP system and McKesson's Economost are tangible illustrations of interorganizational innovations reducing the costs of transactions.

Thus, interorganizational innovations can result in improved quality and reduced costs. As in the case of adoption costs, adoption benefits vary with radicalness of the innovation; the more radical, the greater the technological advance, and therefore the greater the likely benefits. Also, as in the case of costs, benefits are not constant across organizations but tend to vary according to an organization's innovativeness. We may argue, similar to the case of adoption costs, that the more innovative an organization, the more experience it has in implementing innovations and the greater the adoption benefits. An alternative argument is that the more innovative an organization, the closer its technology is to the edge of the technological envelope, and therefore, the less it has to benefit from adopting the interorganizational innovation. In the model we develop, we consider both effects.

How Suppliers Can Mitigate Adoption Costs: Adoption Support Customer education and support can contribute to successful innovation adoption and implementation. Because an effective justification process is dependent upon supplier-customer relationships ([12]), suppliers can help with the challenges of evaluating capital investments. By educating customers about innovation capabilities, suppliers contribute to realistic expectations on the part of the prospective customer. Suppliers can also contribute to dealing with adaptations to ongoing operations; for example, training to upgrade human skills and advice concerning modifications to organizational structure and practices.

Ettlie and Reza ([13]) found that innovation suppliers have considerable influence over the success of the implementation process. They report that the supplier-customer relationship is the most important factor in solving major implementation problems and that the nature of that relationship is the factor most frequently credited for successful implementation of advanced technology. Leonard- Barton and Gogan ([20]) found that purchasers of computer aided machinery rely heavily on their suppliers for after-sale consulting, training and troubleshooting.

Hence, suppliers can mitigate the challenges faced in innovation adoption by contributing expertise at the assessment and acquisition stage, and subsequently by helping customers overcome organizational inertia and behavioral resistance, and by facilitating organizational change. Moreover, the extent to which the supplier has knowledge of the innovativeness of potential adopters, the more the supplier is able to directly tailor adoption support to the individual adopter.

3 Constructs, Notation and Assumptions

As described in the previous section, *Adoption costs* are costs the customer incurs as a result of adoption, whereas *Adoption benefits* reflect the benefits the customer receives from use of the innovation. We define *Adoption support* as an incentive used by the supplier to encourage adoption. The *cost of transactions* is the cost per transaction (price) times the number of transactions and reflects how adoption of the interorganizational innovation effects the ongoing relationship between the supplier and customers. The level of adoption support and the cost per transaction is chosen by the supplier, although the latter may be limited by competition.[2]

Our main constructs are radicalness of the innovation and innovativeness of the organization. Interorganizational innovations differ in how radical they are. We employ the notation s to represent how radical an innovation is, where s is a real number and a larger s indicates a more radical innovation. Customers differ in their innovativeness. We use θ to represent innovativeness, where θ is a real number, and $\underline{\theta}$ and $\bar{\theta}$ are the least and most innovative customers, respectively. A larger θ indicates greater innovativeness. When radicalness and innovativeness are primary attributes the interpretations of s and θ are straightforward - one does not depend on the other. If innovativeness is a secondary attribute, then the effects of the innovation on organizational innovativeness must satisfy the mild restriction that small

[2] We abstract from the case where the interorganizational innovation is so valuable that the supplier can charge a separate adoption fee which, together with the cost per transaction, would constitute a two-part price. However, many of our results apply to this case and we point out the instances where that is true. The situation where the supplier of the interorganizational innovation is the buyer in the transaction requires a different formulation to the one presented here.

changes in the innovation - that we describe as marginal changes in radicalness - do not affect which organizations are more innovative.

Suppose there are two customers, X and Y. If X has adopted and implemented more innovations of various types earlier than Y, then we would conclude that X is more innovative than Y, independent of any specific innovation. Innovativeness is then a primary attribute. If innovativeness is a secondary attribute, then a particular innovation is required to provide the context. Suppose that innovation is electronic data interchange (EDI), which we define as the computer-to-computer exchange of business documents in standard formats between organizations. Furthermore, suppose that organization Y's systems are much more EDI-compatible than X's, Y having adopted a more recent version of EDI. Within the context of EDI as the innovation, Y would be more innovative than X. Our model applies here also as long as a small change in the EDI innovation, say the exchange of a larger set of business documents - a marginal change in radicalness - does not change which organization is more innovative.

Adoption benefits depend on the number of transactions the customer makes, q, and as argued in the previous section, the customer's innovativeness and the radicalness of the innovation. We represent adoption benefits by $V(q, \theta, s)$. Adoption costs are composed of assessment and acquisition, resistance, and adaptation costs that we discussed earlier. Each of those elements depends on the customer's innovativeness and on the radicalness of the innovation. Adoption costs are captured by the function μ which aggregates those adoption cost elements, $\mu(\theta, s)$. We refer to adoption benefits less adoption costs as *net* adoption benefits.

The degree to which the supplier can provide customer-specific adoption support depends on how much the supplier knows about individual customer innovativeness. We consider the two polar cases. In the uninformed case, case 1, the supplier does not know individual customer innovativeness, although the supplier does know the distribution of innovativeness over the population. We represent this distribution by $f(\theta)$. As no two customers are identical we arbitrarily scale θ so that $f(\theta)$ is uniform over its support. The distribution has a cumulative density function $F(\theta)$, so $F(\underline{\theta}) = 0$ and $F(\bar{\theta}) = 1$. In the informed case, case 2, the supplier can identify individual customer innovativeness. We represent adoption support by the notation $R(\cdot)$. In the uninformed case adoption support is a constant, R, and in the informed case, adoption support is a function that depends on the customer's innovativeness, $R(\theta)$.

Our assumptions are outlined below. Where each assumption is applied, and the effects of its application, are made clear as it is used in the paper. Because each result does not require all the assumptions, we specify only which assumptions are needed.

Assumption 1: *Adoption benefits are increasing at a decreasing rate (concave) in the number of transactions:*

$$\frac{\partial V(q,\theta,s)}{\partial q} > 0 \quad \text{and} \quad \frac{\partial^2 V(q,\theta,s)}{\partial q^2} < 0.$$

The more transactions the customer makes the greater its benefit because of the increased quality and/or reduced costs from the interorganizational innovation. Those benefits usually decrease or are constant at the margin. Assumption 1 is important throughout the analysis by ensuring a solution to the customer's problem.

Assumption 2: *Net adoption benefits are increasing in innovativeness:*

$$\frac{\partial V(q,\theta,s)}{\partial \theta} - \frac{\partial \mu(\theta,s)}{\partial \theta} > 0.$$

Assumption 2 operationalizes customer innovativeness - more innovative customers have larger net adoption benefits, holding the radicalness of the particular innovation in question constant. Two separate conditions are sufficient for assumption 2. The first is that adoption benefits are increasing in customer innovativeness and the second is that adoption costs are decreasing in customer innovativeness,

$$\frac{\partial V(q,\theta,s)}{\partial\theta} > 0 \quad \text{and} \quad \frac{\partial\mu(\theta,s)}{\partial\theta} < 0.$$

We have argued for the former condition in the previous section, whereas the latter condition is intuitive. These two conditions are not necessary for assumption 2 to be true. However, that assumption is critical to the analysis because it allows the division of customers into adopters and non-adopters where each group is a continuous segment of θ.

Assumption 3: *The marginal adoption benefit is increasing in innovativeness:*

$$\frac{\partial^2 V(q,\theta,s)}{\partial q\partial\theta} > 0.$$

Assumption 4: *The marginal adoption benefit is increasing in the radicalness of the innovation:*

$$\frac{\partial^2 V(q,\theta,s)}{\partial q\partial s} > 0.$$

The conditions in assumptions 3 and 4, along with the conditions in assumption 1, allow us to determine the effects of the cost per transaction, innovativeness and the radicalness of the innovation on the number of transactions from a given customer. As we will see, those two assumptions are not necessary for all our results. Assumption 3 plays a role in theorems 2 and 6 through lemma 1, and assumption 4 plays a role in theorems 2 and 5 through lemmas 1, 5, $3'$ and $5'$.

4 The Customer's Problem

Customers make their decision to adopt based on what they perceive as their total value of adoption. We specify their total value of adoption as

$$\Phi(q,\theta,s) = \begin{cases} V(q,\theta,s) - \mu(\theta,s) + R(\cdot) - pq & \text{if } q \geq 0 \\ 0 & \text{otherwise, } q = 0. \end{cases}$$

The cost per transaction is the unit cost per transaction (price) set by the supplier, p, times the number of transactions, q. If there are no transactions, then there is no value to adoption.[3]

In deciding whether to adopt, each customer considers the total value of adoption under the condition that they choose their optimal number of transactions. If that total value is positive, then the customer adopts. That means the optimization $\max_q \Phi(q, \theta, s)$ is carried out by each customer, observing that there is no budget constraint and that the internal production costs are embedded in $V(q, \theta, s)$. We assume an interior solution is obtained for all customers who adopt, so that the necessary first-order condition is

$$\frac{\partial V(q, \theta, s)}{\partial q} - p = 0, \tag{1}$$

with assumption 1 sufficient to ensure a maximum. (1) implicitly defines the function that describes the number of transactions as a function of unit cost, innovativeness and radicalness of the innovation, $q(p, \theta, s)$.

Lemma 1: *The number of transactions is increasing in innovativeness and in the radicalness of the innovation, and is decreasing in unit cost.*

Proof: Using assumptions 1, 3 and 4 along with the implicit function rule,

$$\frac{\partial q(p, \theta, s)}{\partial \theta} = -\frac{\frac{\partial^2 V(q,\theta,s)}{\partial q \partial \theta}}{\frac{\partial^2 V(q,\theta,s)}{\partial q^2}} > 0 \text{ and } \frac{\partial q(p, \theta, s)}{\partial s} = -\frac{\frac{\partial^2 V(q,\theta,s)}{\partial q \partial s}}{\frac{\partial^2 V(q,\theta,s)}{\partial q^2}} > 0.$$

Using assumption 1 and the implicit function rule,

$$\frac{\partial q(p, \theta, s)}{\partial p} = \frac{1}{\frac{\partial^2 V(q,\theta,s)}{\partial q^2}} < 0.$$

[3]There is no loss of generality in considering no substitutes for the transaction, beyond not purchasing. That specification assumes that preferences are additively separable in transacted and numeraire goods, or alternatively that income changes related to transactions are negligible.

□

Neither adoption support nor adoption costs have an impact on the quantity of transactions a customer demands: they are not part of the *marginal* conditions. What is interesting about lemma 1 is that the change in an customer's number of transactions induced by a change in either attribute depends on how the marginal benefit is changed by that attribute. That is, should either of assumptions 3 or 4 be reversed, we would have results opposite to those in the first part of lemma 1.

5 Supplier Strategies

The supplier controls two strategic variables: adoption support and the cost per transaction. The former is targeted at overcoming customer adoption costs and the latter appropriates for the supplier part of the ongoing added value customers receive from adoption. We differentiate two polar cases based on information the supplier has about customer innovativeness. In case 1 the supplier cannot identify individual customer innovativeness and as a result cannot tailor adoption support to individual customers. In case 2 the supplier has sufficient information about its customers to individually tailor adoption support. In both cases the supplier knows the adoption benefits and adoption costs functions. We treat the cost per transaction as a unit cost that applies to all customers.[4] In our model the two cases are represented by different treatments of adoption support, $R(\cdot)$.

[4]This abstracts from the issue of quantity discounts and special deals where the supplier is able to partially tailor the cost per transaction to individual customers.

5.1 Case 1: Supplier Does Not Know Individual Customer Innovativeness

In case 1 adoption support is a constant, R. Assuming indifferent customers adopt, we define the customer with the lowest innovativeness that chooses to adopt by

$$\hat{\theta} = \inf\{\theta | \Phi(q(p, \theta, s), \theta, s) = 0\}.$$

$\hat{\theta}$ satisfies the condition

$$\Phi(q(p, \hat{\theta}, s), \hat{\theta}, s) = V(q(p, \hat{\theta}, s), \hat{\theta}, s) - \mu(\hat{\theta}, s) + R - pq(p, \hat{\theta}, s) = 0. \quad (2)$$

As a result, $\hat{\theta}$ is a function of R, p and s: $\hat{\theta}(R, p, s)$. From assumption 2 and after cancelling the first-order condition in (1), the total derivative of $\Phi(q(p, \theta, s), \theta, s)$ with respect to θ is

$$\frac{d\Phi(q(p, \theta, s), \theta, s)}{d\theta} = \frac{\partial V(q(p, \theta, s), \theta, s)}{\partial \theta} - \frac{\partial \mu(\theta, s)}{\partial \theta} > 0. \quad (3)$$

Therefore, all customers with innovativeness greater than $\hat{\theta}(R, p, s)$ have positive total value of adoption and adopt and those below $\hat{\theta}(R, p, s)$ do not. (3) is crucial because it allows customers to be divided into two contiguous groups based on their innovativeness.

In order to simplify our notation we represent the arguments of $\hat{\theta}(R, p, s)$ by $\hat{\theta}(\cdot)$ for the remainder of the paper. Normalizing the total number of customers to unity, the proportion of customers that adopt the interorganizational innovation is $N(R, p, s) = \int_{\hat{\theta}(\cdot)}^{\bar{\theta}} f(\theta) d\theta$. Total transactions are $Q(R, p, s) = \int_{\hat{\theta}(\cdot)}^{\bar{\theta}} q(p, \theta, s) f(\theta) d\theta$.

We now examine the effects of adoption support, the cost per transaction and the radicalness of the innovation. Lemmas 2 and 4 show that increases in adoption support makes customers better off, and therefore more customers adopt and total transactions increase. Decreases in the cost per transaction have similar effects. Lemma 3 provides sufficient conditions to determine the effects of changes in the radicalness of the innovation on the proportion of customers that adopt and lemma 5 gives a sufficient condition for total transactions to be increasing in the radicalness of the innovation.

Lemma 2: *The proportion of customers that adopt is increasing in the adoption support and is decreasing in the cost per transaction.*

Proof: Applying the implicit function rule to (2) and using (3) we obtain the marginal effects of R and p on $\hat{\theta}(\cdot)$:

$$\frac{\partial\hat{\theta}(\cdot)}{\partial R} = -\frac{1}{\frac{d\Phi(q(p,\hat{\theta},s),\hat{\theta},s)}{d\hat{\theta}}} < 0, \quad \frac{\partial\hat{\theta}(\cdot)}{\partial p} = \frac{q(p,\hat{\theta},s)}{\frac{d\Phi(q(p,\hat{\theta},s),\hat{\theta},s)}{d\hat{\theta}}} > 0.$$

As a result the partial derivatives are

$$\frac{\partial N(R,p,s)}{\partial R} = -\frac{\partial\hat{\theta}(\cdot)}{\partial R} f(\hat{\theta}(\cdot)) > 0, \quad \frac{\partial N(R,p,s)}{\partial p} = -\frac{\partial\hat{\theta}(\cdot)}{\partial p} f(\hat{\theta}(\cdot)) < 0.$$

□

The marginal effect of the radicalness of the innovation on the proportion of customers that adopt depends on the marginal effect of the radicalness of the innovation with respect to net adoption benefits, on the customer with the lowest innovativeness that chooses to adopt.

Lemma 3: *If net adoption benefits are increasing in the radicalness of the innovation for the customer with the lowest innovativeness that chooses to adopt, then the proportion of customers that adopt is increasing in the radicalness of the innovation, and vice versa.*

Proof: Using the implicit function rule on (2), the marginal effect of s on $\hat{\theta}(\cdot)$ is

$$\frac{\partial\hat{\theta}(\cdot)}{\partial s} = -\frac{\left[\frac{\partial V(q(p,\hat{\theta},s),\hat{\theta},s)}{\partial s} - \frac{\partial\mu(\hat{\theta},s)}{\partial s}\right]}{\frac{d\Phi(q(p,\hat{\theta},s),\hat{\theta},s)}{d\hat{\theta}}}.$$

The denominator is positive from (3). Thus, the sign of $\frac{\partial\hat{\theta}(\cdot)}{\partial s}$ follows the sign of $-[\frac{\partial V(q(p,\hat{\theta},s),\hat{\theta},s)}{\partial s} - \frac{\partial \mu(\hat{\theta},s)}{\partial s}]$. The sign of

$$\frac{\partial N(R,p,s)}{\partial s} = -\frac{\partial\hat{\theta}(\cdot)}{\partial s} f(\hat{\theta}(\cdot))$$

therefore follows the sign of $\frac{\partial V(q(p,\hat{\theta},s),\hat{\theta},s)}{\partial s} - \frac{\partial \mu(\hat{\theta},s)}{\partial s}$. □

Lemma 4: *Total transactions are increasing in the adoption support and are decreasing in the cost per transaction.*

Proof: Using lemma 1 and the proof of lemma 2,

$$\frac{\partial Q(R,p,s)}{\partial R} = -\frac{\partial\hat{\theta}(\cdot)}{\partial R} q(p,\hat{\theta}(\cdot),s) f(\hat{\theta}(\cdot)) > 0$$

and

$$\frac{\partial Q(R,p,s)}{\partial p} = -\frac{\partial\hat{\theta}(\cdot)}{\partial p} q(p,\hat{\theta}(\cdot),s) f(\hat{\theta}(\cdot)) + \int_{\hat{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p,\theta,s)}{\partial p} f(\theta) d\theta < 0.$$

□

Lemma 5: *If net adoption benefits are increasing in the radicalness of the innovation for the customer with the lowest innovativeness that chooses to adopt, then total transactions are increasing in the radicalness of the innovation.*

Proof: From lemma 1 and the proof of lemma 3,

$$\frac{\partial Q(R,p,s)}{\partial s} = -\frac{\partial\hat{\theta}(\cdot)}{\partial s} q(p,\hat{\theta}(\cdot),s) f(\hat{\theta}(\cdot)) + \int_{\hat{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p,\theta,s)}{\partial s} f(\theta) d\theta > 0.$$

□

If the condition in lemma 5 does not hold, then the effect of a marginal increase in the radicalness of the innovation on total transactions is a mixture of opposing effects. Although less customers adopt because a more radical innovation increases adoption costs, those customers that do adopt have greater marginal adoption benefits and demand more as a result.

5.1.1 Supplier Profit Maximization

Supplier profits are profits from the transacted good less total adoption support

$$\Pi(R,p,s) = pQ(R,p,s) - RN(R,p,s),$$

where, with no loss of generality, the marginal cost of the transacted good is zero. The supplier chooses the level of adoption support, R. If the market is competitive, then the unit cost of the transaction, p, is exogenous. Otherwise, the supplier also sets p. In that latter case the two first-order conditions for the supplier are

$$\begin{aligned} \frac{\partial \Pi(R,p,s)}{\partial R} &= p\frac{\partial Q(R,p,s)}{\partial R} - N(R,p,s) - R\frac{\partial N(R,p,s)}{\partial R} \\ &= -pq(p,\hat{\theta}(\cdot),s)f(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial R} - N(R,p,s) + Rf(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial R} = 0 \end{aligned} \tag{4}$$

and

$$\begin{aligned} \frac{\partial \Pi(R,p,s)}{\partial p} &= Q(R,p,s) + p\frac{\partial Q(R,p,s)}{\partial p} - R\frac{\partial N(R,p,s)}{\partial p} \\ &= Q(R,p,s) + p[-q(p,\hat{\theta}(\cdot),s)f(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial p} + \int_{\hat{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p,\theta,s)}{\partial p} f(\theta)d\theta] \\ &\quad + Rf(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial p} = 0. \end{aligned} \tag{5}$$

If p is exogenous, then only (4) is necessary. Directly from the first-order conditions we derive the following theorem.

Theorem 1: *The supplier makes positive net profits from all customers that adopt.*

Proof: Rearranging (4),

$$[R - pq(p,\hat{\theta}(\cdot),s)]f(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial R} - N(R,p,s) = 0, \tag{6}$$

which, using the result and proof of lemma 2, implies $R - pq(p, \hat{\theta}(\cdot), s) < 0$. Therefore, the supplier makes positive profits on $\hat{\theta}(\cdot)$. From lemma 1, $q(p, \theta, s)$ is increasing in θ. Hence, $R - pq(p, \theta, s) < 0$ for all customers that adopt.

That is sufficient for the case where p is exogenous. If p is also chosen by the supplier, then we must show that $R - pq(p, \hat{\theta}(\cdot), s) < 0$ is consistent with (5). Rearranging (5),

$$Q(R, p, s) + [R - pq(p, \hat{\theta}(\cdot), s)]f(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial p} + p\int_{\hat{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p, \theta, s)}{\partial p} f(\theta)d\theta = 0.$$

So

$$R - pq(p, \hat{\theta}(\cdot), s) < 0 \implies Q(R, p, s) > p\int_{\hat{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p, \theta, s)}{\partial p} f(\theta)d\theta.$$

The latter condition is true from lemma 1 and thus the theorem is consistent with both first-order conditions. □

Theorem 1 is important because it indicates that the supplier does not follow the rule of setting adoption support such that the marginal revenue from the adopting customer with the lowest innovativeness is equal to the cost of adoption support for that customer. As we show later, that rule would result in increases in adoption support that are not offset by increases in marginal revenue from the customer with the lowest innovativeness because increases in adoption support must be given to all adopting customers.

Now consider the effect of the radicalness of the innovation on adoption support. Defining (6) as $\Psi(R, p, s) = 0$, we can implicitly define adoption support as a function of the radicalness of the innovation, $R(s)$. Solving for $R'(s)$ using the implicit function rule,

$$R'(s) = -\frac{\frac{\partial \Psi(R,p,s)}{\partial s}}{\frac{\partial \Psi(R,p,s)}{\partial R}}.$$

Starting with the numerator,

$$\frac{\partial \Psi(R, p, s)}{\partial s} = -p[\frac{\partial q(R, \hat{\theta}(\cdot), s)}{\partial \hat{\theta}}\frac{\partial \hat{\theta}(\cdot)}{\partial s} + \frac{\partial q(R, \hat{\theta}(\cdot), s)}{\partial s}]f(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial R} \quad (7)$$

$$+[R - pq(p, \hat{\theta}(\cdot), s)]f(\hat{\theta}(\cdot))\frac{\partial^2 \hat{\theta}(\cdot)}{\partial R \partial s} - \frac{\partial N(R, p, s)}{\partial s}.$$

Using the proof of lemma 2 and (3)

$$\frac{\partial^2 \hat{\theta}(\cdot)}{\partial R \partial s} = [\frac{d\Phi(q(p, \hat{\theta}, s), \hat{\theta}, s)}{d\hat{\theta}}]^{-2} \frac{\partial[\frac{d\Phi(q(p,\hat{\theta},s),\hat{\theta},s)}{d\hat{\theta}}]}{\partial s}.$$

Turning to the denominator,

$$\frac{d\Psi(R, p, s)}{dR} = f(\hat{\theta}(\cdot))\frac{\partial \hat{\theta}(\cdot)}{\partial R} - \frac{\partial N(R, p, s)}{\partial R} < 0.$$

Using these equations we construct our next theorem.

Theorem 2: *Sufficient conditions for the adoption support to be increasing in the radicalness of the innovation are that for the adopting customer with the lowest innovativeness, (a) the marginal effect of the radicalness of the innovation on net adoption benefits is negative,and (b) the cross marginal effects of innovativeness and the radicalness of the innovation on net adoption benefits is negative.*

Proof: The conditions in the theorem are *(a)* $\frac{\partial V(q(p,\hat{\theta},s),\hat{\theta},s)}{\partial s} - \frac{\partial \mu(\hat{\theta},s)}{\partial s} < 0$ and *(b)* $\frac{\partial[\frac{d\Phi(q(p,\hat{\theta},s),\hat{\theta},s)}{d\hat{\theta}}]}{\partial s} < 0$. Using (7), from lemma 1, the proof of lemma 2, lemma 3 and theorem 1, $\frac{d\Psi(R,p,s)}{ds} > 0$. Therefore, $R'(s) > 0$. □

Theorem 2 provides a strong result, adoption support increasing in radicalness, with only two marginal conditions, neither of which is necessary. If conditions *(a)* and *(b)* in theorem 2 are each reversed, then the first term in (7) is ambiguous in sign and the last two are negative. If those last two terms together outweigh the first then we would obtain the reverse result: adoption support *decreases* with the radicalness of the innovation. Intuitively, that could occur if the proportion of adopters is insensitive to adoption support. In that case increasing adoption support to all adopters is more costly than the offsetting benefits of increased adoption.

$\Psi(R, p, s) = 0$ also defines $p(s)$ implicitly and using the implicit function rule, $p'(s) = -\frac{\frac{\partial \Psi(R,p,s)}{\partial s}}{\frac{\partial \Psi(R,p,s)}{\partial p}}$. Although the sign of the denominator cannot be determined, we can still specify the mixture of effects at work: a change in p increases profits through an increased margin but decreases quantities demanded. The impact of a marginal change in the radicalness of the innovation on supplier profits is also subject to a mixture of effects. In essence, the impact of a marginal change in the radicalness of the innovation affects supplier revenue from the transacted good and supplier costs for adoption support in opposing ways. All of the results in the present section continue to hold if R is negative, that is, if the supplier charges an adoption fee rather than providing adoption support.

5.2 Case 2: Supplier Knows Individual Customer Innovativeness

In case 2 the supplier is able to vary adoption support as a function of the customer's innovativeness, $R(\theta)$. We require two breakpoints in the distribution of customers. We define the customer with the lowest innovativeness that chooses to adopt *without adoption support* by

$$\tilde{\theta} = \inf\{\theta | V(q(p, \theta, s), \theta, s) - \mu(\theta, s) - pq(p, \theta, s) = 0\}.$$

From assumption 2, similar to (3), all customers with innovativeness greater than $\tilde{\theta}$ adopt without adoption support. We define the customer with the lowest innovativeness that the supplier is willing to offer adoption support as

$$\check{\theta} = \inf\{\theta | V(q(p, \theta, s), \theta, s) - \mu(\theta, s) = 0\}.$$

Again, from assumption 2 all customers with innovativeness greater than $\check{\theta}$ get value from adoption. Those breakpoints are each implicitly defined by their conditions

$$\Gamma(q(p, \tilde{\theta}, s), \tilde{\theta}, s) = V(q(p, \tilde{\theta}, s), \tilde{\theta}, s) - \mu(\tilde{\theta}, s) - pq(p, \tilde{\theta}, s) = 0 \quad (8)$$

and

$$\Omega(q(p,\check{\theta},s),\check{\theta},s) = V(q(p,\check{\theta},s),\check{\theta},s) - \mu(\check{\theta},s) = 0, \tag{9}$$

resulting in the functions $\tilde{\theta}(p,s)$ and $\check{\theta}(p,s)$. We simplify our notation by writing $\tilde{\theta}(\cdot)$ and $\check{\theta}(\cdot)$ for the remainder of the paper. It is obvious from (8) and (9) that the customer with the lowest innovativeness that chooses to adopt without adoption support is at least as innovative as the customer with the lowest innovativeness that the supplier is willing to offer adoption support, $\tilde{\theta}(\cdot) \geq \check{\theta}(\cdot)$. The following theorem defines our triage model for adoption support.

Theorem 3 (triage): *For any unit cost and any level of radicalness of the innovation, optimal adoption support for the supplier is: (1)* $R(\theta) = 0$ *for* $\theta \in (\tilde{\theta},\bar{\theta}]$*, (2)* $R(\theta) = pq(p,\theta,s) - V(q(p,\theta,s),\theta,s) + \mu(\theta,s)$ *for* $\theta \in [\check{\theta},\tilde{\theta}]$*, and (3)* $R(\theta) = 0$ *for* $\theta \in [\underline{\theta},\check{\theta})$*.*

Proof: We consider each of the intervals. (1) For $\theta \in (\tilde{\theta},\bar{\theta}]$ the supplier does not need to offer any adoption support in order for customers to adopt. (2) For $\theta \in [\check{\theta},\tilde{\theta}]$ the supplier must provide adoption support to make the customer's adoption value at least equal to zero for customers to adopt, adoption support beyond that point is costly. (3) For $\theta \in [\underline{\theta},\check{\theta})$ no positive level of adoption support can yield supplier profits. □

For $\theta \in [\check{\theta},\tilde{\theta}]$ the adoption support, $R(\theta)$, is set so that customers adopt at the least cost to the supplier. Thus, those are the customers that are "treated" with adoption support. Customers with innovativeness above that range do not require support and adoption support to customers below that range is not profitable for the supplier. Normalizing the total number of customers to one, the proportion of customers that adopt is $N(p,s) = \int_{\check{\theta}(\cdot)}^{\bar{\theta}} f(\theta)d\theta$ and total transactions are $Q(p,s) = \int_{\check{\theta}(\cdot)}^{\bar{\theta}} q(p,\theta,s)f(\theta)d\theta$.

If $R(\theta)$ was allowed to be an adoption fee rather than adoption support, then there would be no change in the proportion of adopters or in total transactions. That is because the fee would apply to customers with $\theta \in (\tilde{\theta},\bar{\theta}]$. Those customers would still adopt and the lump-sum fee would not affect their number of transactions. Because $R(\theta)$ is set according to theorem 3, there is no value in examining the effect of overall changes in adoption support. However, in that second case we have analogues to lemmas 2-5, which we denote as lemmas 2′-5′, that determine the effects of changes in the cost per transaction and changes in the radicalness of the innovation on the proportion of customers that adopt and on total transactions.

Lemma 2′: *The proportion of customers that adopt is decreasing in the cost per transaction.*

Proof: Applying the implicit function rule to (9) and using the right hand side of (3), the marginal effect of p on $\check{\theta}(\cdot)$ is

$$\frac{\partial\check{\theta}(\cdot)}{\partial p} = \frac{q(p,\check{\theta},s)}{\frac{d\Omega(q(p,\check{\theta},s),\check{\theta},s)}{d\check{\theta}}} > 0$$

and as a result

$$\frac{\partial N(p,s)}{\partial p} = -\frac{\partial\check{\theta}(\cdot)}{\partial p} f(\check{\theta}(\cdot)) < 0.$$

□

Lemma 3′: *If net adoption benefits are increasing in the radicalness of the innovation for the customer with the lowest innovativeness that chooses to adopt, then the proportion of customers that adopt is increasing in the radicalness of the innovation.*

Proof: Using the implicit function rule on (9), the marginal effect of s on $\check{\theta}(\cdot)$ is

$$\frac{\partial\check{\theta}(\cdot)}{\partial s} = -\frac{[\frac{\partial V(q(p,\check{\theta},s),\check{\theta},s)}{\partial q}\frac{\partial q(p,\check{\theta},s)}{\partial s} + \frac{\partial V(q(p,\check{\theta},s),\check{\theta},s)}{\partial s} - \frac{\partial\mu(\check{\theta},s)}{\partial s}]}{\frac{d\Omega(q(p,\check{\theta},s),\check{\theta},s)}{d\check{\theta}}}.$$

The denominator is positive from assumptions 1, 2 and lemma 1. The sign of $\frac{\partial\hat{\theta}(\cdot)}{\partial s}$ follows the sign of

$$-[\frac{\partial V(q(p,\check{\theta},s),\check{\theta},s)}{\partial q}\frac{\partial q(p,\check{\theta},s)}{\partial s} + \frac{\partial V(q(p,\check{\theta},s),\check{\theta},s)}{\partial s} - \frac{\partial\mu(\check{\theta},s)}{\partial s}].$$

The sign of

$$\frac{\partial N(p,s)}{\partial s} = -\frac{\partial \check{\theta}(\cdot)}{\partial s} f(\check{\theta}(\cdot))$$

therefore follows the sign of $\frac{\partial V(q(p,\check{\theta},s),\check{\theta},s)}{\partial q}\frac{\partial q(p,\check{\theta},s)}{\partial s} + \frac{\partial V(q(p,\check{\theta},s),\check{\theta},s)}{\partial s} - \frac{\partial \mu(\check{\theta},s)}{\partial s}$. □

Lemma 4′: *Total transactions are decreasing in the cost per transaction.*

Proof: Using lemma 1 and the proof of lemma 2′,

$$\frac{\partial Q(p,s)}{\partial p} = -\frac{\partial \check{\theta}(\cdot)}{\partial p} q(p,\check{\theta}(\cdot),s) f(\check{\theta}(\cdot)) + \int_{\check{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p,\theta,s)}{\partial p} f(\theta) d\theta < 0.$$

□

Lemma 5′: *If net adoption benefits are increasing in the radicalness of the innovation for the customer with the lowest innovativeness that chooses to adopt, then total transactions are increasing in the radicalness of the innovation.*

Proof: From lemmas 1 and 3′,

$$\frac{\partial Q(p,s)}{\partial s} = -\frac{\partial \check{\theta}(\cdot)}{\partial s} q(p,\check{\theta}(\cdot),s) f(\check{\theta}(\cdot)) + \int_{\check{\theta}(\cdot)}^{\bar{\theta}} \frac{\partial q(p,\theta,s)}{\partial s} f(\theta) d\theta > 0.$$

□

The total amount of adoption support offered by the supplier depends on the proportion of customers that require adoption support in order to adopt, that is, the proportion of customers in the interval $\theta \in [\check{\theta}, \tilde{\theta}]$. That proportion, in turn, depends on the cost per transaction and the radicalness of the innovation. That proportion can be written as $M(p,s) = \int_{\check{\theta}(\cdot)}^{\tilde{\theta}(\cdot)} f(\theta) d\theta$. It is not possible to determine in general the effect of marginal changes in the cost per transaction or in the radicalness of the innovation on the proportion of customers that require adoption support in order to adopt. An increase in the cost per transaction increases both the upper and lower limits of $M(p,s)$ and an increase in the radicalness of the innovation decreases both the upper and lower limits. However, it is possible to determine those effects on individual customer adoption support.

Theorem 4: *Individual adoption support is increasing in the cost per transaction.*

Proof: From theorem 3 individual adoption support is

$$R(\theta; p, s) = pq(p, \theta, s) - V(q(p, \theta, s), \theta, s) + \mu(\theta, s) \tag{10}$$

conditional on p and s. Directly using lemma 1,

$$\frac{\partial R(\theta; p, s)}{\partial p} = q(p, \theta, s) > 0.$$

□

For those customers that require adoption support in order to adopt, an increase in the cost per transaction makes them worse off. As a result, adoption support must increase to make adoption profitable for those customers.

Theorem 5: *If net adoption benefits are decreasing in the radicalness of the innovation, then individual adoption support is increasing in the radicalness of the innovation.*

Proof: From (10) and using (1),

$$\frac{\partial R(\theta; p, s)}{\partial s} = p\frac{\partial q(p, \theta, s)}{\partial s} - [\frac{\partial V(q(p, \theta, s), \theta, s)}{\partial s} - \frac{\partial \mu(\theta, s)}{\partial s}] > 0.$$

□

Therefore, for those customers that require adoption support, if at the margin an increase in the radicalness of the innovation is costly, then additional adoption support must be provided to offset that cost.

Supplier profits in case 2 are profits from the transactions less the amount of adoption support given to customers:

$$\pi(p,s) = pQ(p,s) - \int_{\check{\theta}(\cdot)}^{\tilde{\theta}(\cdot)} R(\theta;p,s)f(\theta)d\theta.$$

If the market for the transacted good is competitive, then the cost per transaction is set exogenously and the supplier's optimal strategy is to set the adoption support according to theorem 3. If the supplier controls the cost per transaction, then it sets p and through that choice also sets the level of adoption support effectively by theorem 3 because $R(\theta,p,s)$ is a function of p. As with case 1, it is not possible to conclusively determine the effects of a marginal change in the radicalness of the innovation on the cost per transaction or on supplier profits.

5.3 Comparison of Case 1 and Case 2

Comparisons between the two cases can be done if the cost per transaction, p, is the same in each case. That will occur if this unit cost is established by competition and is unlikely if the supplier has full control over p. For the remainder of this section we assume that the cost per transaction is the same in our two cases.

We begin by establishing that there are a greater number of adopters in case 2.

Theorem 6: *If the supplier knows individual customer innovativeness, then more customers will adopt.*

Proof: The proof requires ranking $\hat{\theta}(\cdot)$ and $\check{\theta}(\cdot)$. From assumptions 1, 2 and lemma 1,

$$\frac{d[V(q(p,\theta,s),\theta,s) - \mu(\theta,s)]}{d\theta} > 0.$$

From theorem 1 $R - pq(p, \hat{\theta}, s) < 0$. Hence, $V(q(p, \hat{\theta}, s), \hat{\theta}, s) - \mu(\hat{\theta}, s) > V(q(p, \check{\theta}, s), \check{\theta}, s) - \mu(\check{\theta}, s)$. Therefore, $\hat{\theta}(\cdot) > \check{\theta}(\cdot)$. □

Knowing individual customer innovativeness means the supplier can calculate individual levels of adoption support to induce even those customers who are marginally profitable to adopt.

Corollary 6.1: *For each customer that adopts in both cases, the supplier provides greater adoption support in case 1.*

Proof: Using theorem 3, for $\theta \in (\tilde{\theta}, \bar{\theta}]$, $R(s) > R(\theta; p, s) = 0$. For $\theta \in [\hat{\theta}, \tilde{\theta}]$, again using theorem 3, $R(s) \geq R(\theta; p, s)$. From theorem 6, $\hat{\theta}(\cdot) > \check{\theta}(\cdot)$. □

In case 1, the supplier over-supports all adopting customers except the customer with the lowest innovativeness, $\hat{\theta}(\cdot)$, because all customers with greater innovativeness require less adoption support than R. The ability to identify individual customer innovativeness in case 2 allows the supplier to avoid over-supporting adoption.

The value of the information to the supplier of knowing individual customer innovativeness is the difference between profits in the two cases:

$$\begin{aligned} \pi^d(p, s) &= \pi(p, s) - \pi(R, p, s) \qquad (11) \\ &= \int_{\check{\theta}(\cdot)}^{\hat{\theta}(\cdot)} [pq(p, \theta, s) - R(\theta; p, s)] f(\theta) d\theta + \int_{\hat{\theta}(\cdot)}^{\tilde{\theta}(\cdot)} [R(s) - R(\theta; p, s)] f(\theta) d\theta \\ &\quad + \int_{\tilde{\theta}(\cdot)}^{\bar{\theta}(\cdot)} R(s) f(\theta) d\theta. \end{aligned}$$

Directly from theorem 3, that value is positive. The components of that value can be seen in (11). The first component is the additional profits made from customers that adopt in case 2 but do not adopt in case 1. The second component is the difference in adoption support given to customers that require adoption support in order to adopt in both cases. From corollary 6.1, that component is positive. The third component is the adoption support given to customers in case 1 that is not necessary in case 2. Thus, each component favors case 2.

The effects of changes in the cost per transaction or changes in the radicalness of the innovation on the value of supplier information about customer innovativeness are mixed. The effect of a change in the p is the same combination as in case 1: increased margin with decreased demands. The effect of a change in s depends on the relative magnitudes of changes in adoption support.

6 Conclusions

Our results highlight the value to the supplier of understanding its customers. In the uninformed case the supplier has to rely on customers self reporting if it wants to offer varying levels of adoption support. If the supplier offers levels of adoption support that are decreasing in customer innovativeness, then high innovativeness customers will misrepresent themselves to the supplier in order to get more adoption support - at no cost to them. Thus, the supplier offers only one level of support. The consequence of not knowing customers' innovativeness is that the supplier is unable to perform "triage": the supplier cannot get adoption from all the customers it wants and gives too much support to all customers, but one, that adopt. As a result, in the informed case the supplier achieves greater adoption, provides less adoption support to those customers that receive support and, thus, achieves greater profits.

Our model captures tradeoffs customers make between adoption support and the cost per transaction, tradeoffs that appear in the proportion of customers that adopt and total transactions. Surprisingly, our main results on supplier strategies and the value of knowing customer innovativeness do not depend on the effects of marginal changes in the radicalness of the innovation on net adoption benefits. However, to determine the proper level of innovation support, the relationship between the marginal net adoption benefit and radicalness of the innovation is key. In the extreme, a radical innovation that yields great benefits may not require support. The mechanisms in our model account for interorganizational transactions as well as innovation adoption and, as expected, in our model the most innovative customers adopt. It is well to point out that the triage approach is a result of the model rather than an assumption.

The comparative statics on levels of adoption support depend on the marginal changes in net adoption benefits of the customer with the lowest innovativeness that adopts that result from marginal changes in the radicalness of the innovation. The comparative statics depend on those changes being consistent in direction. As described earlier, both adoption benefits and adoption costs increase at the margin from marginal increases in the radicalness of the innovation. Thus, for net adoption benefits to be decreasing in the radicalness of the innovation requires that at the margin, with respect to radicalness of the innovation, adoption costs outweigh adoption benefits. For net adoption benefits to be increasing as a result of a marginal increase in the radicalness of the innovation requires that marginal increases in the radicalness of the innovation have a larger effect on adoption benefits than on adoption costs.

Examine the situation where net adoption benefits are decreasing with marginal increases in radicalness. Lemma 3 is conclusive: the proportion of customers that adopt in case 1 is always decreasing in radicalness. On the other hand, lemma 5 does not hold: the impact of a marginal change in the radicalness of the innovation on total transactions in case 1 is ambiguous. Theorem 2 is made more general as condition *(a)* is always true, thus the condition on the cross marginal effects is sufficient in case 1 for adoption support to be increasing as a result of marginal changes in the radicalness of the innovation. Moreover, the companion theorem in case 2, theorem 5, is always true. Thus, we find that net adoption benefits decreasing as a result of marginal changes in the radicalness of the innovation makes our results more general, with the exception of lemma 5.

Should net adoption benefits be increasing in the radicalness of the innovation, then lemma 3 would be conclusive in both cases, but in the opposite direction: the proportion of customers that adopt is increasing in the radicalness of the innovation. Moreover, lemma 5 holds in both cases: total transactions are increasing in the radicalness of the innovation. However, our theorems concerning the effects of radicalness of the innovation on adoption support, theorems 2 and 5, no longer apply. The loss of those results is because, although increases in radicalness increases individual demands (lemma 1), the positive marginal effect of radicalness on net adoption runs contrary to increasing adoption support. If we do not specify either direction but simply require monotonicity, then all of our results hold, save lemma 5.

Consistent with suggestions in the innovation literature, we specified how innovation supplier adoption strategies should vary as a function of adopter and innovation attributes: innovativeness and radicalness. Although those attributes are important determinants of innovation adoption and implementation, we recognize that they are not the only attributes that may be important. Other organizational attributes (e.g., interdependence, differentiation, slack resources) and innovation attributes (e.g., compatibility, complexity, pervasiveness) could be included. To the extent that they are conceptually strongly related to, or empirically highly correlated with, the two we have used, they may already be implied in our results. Should those other attributes not be related to the ones we model, the problem would increase in dimensionality. More explicit assumptions about the exact mathematical forms of adoption benefits and adoption costs would be needed to obtain useful results. We believe that the generality of our results obtained from a less restrictive specification, within the context of the two attributes we model, outweigh the costs of requiring assumptions that would further limit the applicability of our work.

We recognize that some of our assumptions may not prevail in some innovation adoption processes. For example, specific costs for the same level of support are not likely to be equal for all customers, as would be the case for travel costs when site visits are an element of adoption support. If the differences in the costs of support were identifiable, as they would be for travel costs, then the qualitative results of the model would still hold. In case 1 there would be basic support for all customers plus additional support for the differences between customers that the supplier could identify - such as the differences in travel costs. The results for case 2 would remain unchanged. The two cases are extremes of the continuum between the supplier not knowing and knowing the differences between customers. Being able to partially differentiate between customers would allow the supplier to partially tailor adoption support.

The practical implications of our model are clear: knowledge of the customer allows the supplier to calibrate adoption support, targeting specific customer adoption costs. Individualized knowledge and support is key. Without that detailed knowledge of the customer, the supplier is forced to provide a general level of support that targets the more innovative segment of customers, and that may mean a focus on a particular adoption cost. Most importantly, because the optimal supplier support can be articulated for both informed and uninformed cases, the payoffs to investments in "knowing the customer" can be evaluated. As we indicate, that knowledge results in increased profits due to an increased number of adopters and decreased adoption support to customers that adopt in both cases due to calibrated support.

Our model is based on interorganizational innovations, specifically innovations that flow from a supplier to customers. Innovations that flow from customers to suppliers requires a modified version of the model presented here. Nonetheless, our main result of increasing benefits from a triage approach versus general support would still apply. That result also extends to innovations within organizations, where knowledge of the potential adopters may be more easily available.

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