**ADAPTATIONS TO KNOWLEDGE TEMPLATES IN BASE-OF-THE-PYRAMID MARKETS: THE ROLE OF SOCIAL INTERACTION**

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**ABSTRACT**

While templates may facilitate knowledge sharing within the base-of-the-pyramid, it is often necessary for entrepreneurs to adapt the template for reasons of resource scarcity. We explore the role of social interaction in determining whether these adaptations are beneficial or detrimental. Our results suggest that interactions between the entrepreneur and technical experts who understand the ‘why’ behind each practice can result in improved performance while interactions with entrepreneurial peers can produce more varied results. Thus, the type of knowledge generated through social interaction plays a significant role in the degree to which adaptations to templates are principled versus presumptive in nature.

**INTRODUCTION**

Recent work regarding the base-of-the-pyramid has emphasized the importance of knowledge transfer to microenterprises (e.g. small-scale agriculture, small-scale manufacturing, etc.) as a means of increasing productivity and improving welfare (Pietrobelli & Rabelloti, 2006; Perez-Aleman, 2011). However, the BOP has several characteristics that make knowledge transfer difficult, including a lack of human, social, and financial capital (Alvarez & Barney, 2014; Armendariz, & Morduch, 2007; Becker, 2009; Woolcock, 1998). In the face of these challenges, templates present a particularly promising mechanism for knowledge transfer in the BOP, as they capture complex tacit knowledge in an accessible format, even when recipients lack a deep understanding of the knowledge itself (Winter & Szulanski, 2001; Szulanski & Jensen, 2006). Templates are, however, potentially problematic when knowledge cannot be replicated perfectly (Jensen & Szulanksi, 2004, 2007), as may be the case when resource constraints force adaptations to practices. In such cases, recipients may choose to look beyond the template for knowledge, and turn to their social networks.

Prior work has shown that, independently, both the use of templates and social interaction can facilitate knowledge transfer (Adler & Kwon, 2002; Szulanski & Jensen, 2006). However, relatively less work has focused on how the use of templates and social interaction, together, might affect knowledge transfer (Hass & Hansen, 2007; Morris et al., 2009). This is especially likely to be important in the BOP context where, due to resource and other constraints, knowledge recipients may seek out additional information from peers or other individuals in order to decide how to adapt one or more of the practices prescribed within the template (Jensen & Szulanski, 2007; Lin, 2011). Thus, the BOP is an ideal context to explore the role of social interaction when resource constraints force adaptation to established templates.

The purpose of this paper is to examine how social interaction can either enhance or impair the performance of microentrepreneurs in the BOP when adaptations to templates are necessitated by resource constraints. The particular context examined in this paper is the sharing of knowledge regarding best practices between a development organization (which possessed expert knowledge regarding dairy practices) and 1812 dairy farmers in rural Nicaragua in an attempt to improve their milk production. Our results suggest that templates can serve as an important knowledge transfer mechanism for improving performance within base-of-the-pyramid (BOP) settings. However, when templates require modification, the information garnered through the entrepreneur’s social interactions can have a significant impact on their subsequent performance. More specifically, frequent interactions with technical experts that understand the ‘why’ behind each practice, and combination of practices, can result in ‘principled adaptations,’ or practices that adhere to the underlying causal principles and thus improve performance. Compararatively, interactions with entrepreneurial peers can have a much more varied effect on performance, as such adaptations can be either ‘principled’ or ‘presumptive’ in nature.

**THE TRANSFER OF KNOWLEDGE IN THE BOP**

Base-of-the-pyramid markets are defined as the impoverished regions of the world, particularly within Africa, Latin America, and South-East Asia, where the average individual survives on less than two dollars per day (Prahalad & Hart, 2002; London, 2009). In addition to economic poverty, such individuals often suffer from illiteracy and a general lack of human capital due to poor educational systems (Becker, 2009; Webb, Kistruck, Ireland, & Ketchen, 2010). As a result, the vast majority of individuals residing within BOP markets are microentrepreneurs which operate within the informal economy at subsistence levels (Renko, 2012). Knowledge transfer has been viewed as a critical tool for integrating such microentrepreneurs into larger, more formal markets, and helping to reduce poverty (Pietrobelli & Rabelloti 2006).

Knowledge consists of both factual statements and know-how regarding the means by which specific activities are carried out (Kogut & Zander, 1992). Thus, while knowledge regarding routines or practices usually contains simple information, it is also often comprised of multiple components which are, at least in part, tacitly linked to one another (Orlikowski, 2002). Indeed, scholars have argued that building and maintaining such complex knowledge within the bounds of an organization can serve as a source of competitive advantage (Barney, Wright, & Ketchen, 2001; Grant, 1996; Peteraf, 2006). The capability to transfer complex knowledge across individual and firm boundaries is often desirable for many reasons (Markman, Phan, Balkin & Gianiodis, 2005).

At a macro level, the transfer of best practices across and within least developed countries is seen as a critical factor in attempts at alleviating poverty (Bruhn & Zia, 2011; Pietrobelli & Rabelloitti, 2006). At a more micro level, such efforts are typically undertaken by development-oriented nongovernmental organizations that seek to redress the underlying causes of poverty through capacity building, reducing transaction costs, and generating additional business opportunities for entrepreneurs (Kistruck, Beamish, Qureshi, & Sutter, 2013). For microentrepreneurs, knowledge transfer is especially valuable as it can help improve productivity (McKenzie & Woodruff, 2012), meet the standards required by more formal markets (Perez-Aleman, 2011), and ultimately improve social wellbeing (Becker, 2009).

While knowledge transfer from one actor to another is often desirable, it has also been characterized as ‘sticky’ given the difficulties inherent in the transfer process (Szulanksi, 1996; Von Hippel, 1994). The primary difficulty rests in the social complexity and causal ambiguity associated with what are often multiple interrelated routines and practices. For example, knowledge of a particular business model may be composed of a large number of parts that, for reasons of interdependence, are each an important component to generating the desired outcome (Adler & Kwon, 2002; Kogut & Zander, 1992). These interdependencies can lead to uncertainty with regard to linking appropriate resources to performance (Rivkin, 2000). As a result, exploring potential mechanisms for overcoming knowledge stickiness in the transfer process has been a primary source of discussion for management scholars (e.g., Cohen & Levinthal, 1990; Dyer & Singh, 1998; Gupta & Govindarajan, 2000; Hansen, 1999; Nahapiet & Ghoshal, 1998; Tsai, 2001). The problem of knowledge ‘stickiness’ is particularly pertinent in transferring knowledge within BOP markets (Kistruck, 2008). This concern arises from a number of factors including a lack of formal institutions and infrastructure which support knowledge transfer in more developed markets, such as educational institutions, internet, libraries, and so forth. Such institutional voids make it difficult for entrepreneurs to access and process the knowledge they need (Khanna, Palepu, & Sinha, 2005).

One critical tool that can help mitigate some of the impediments of knowledge stickiness in the transfer process is a template (Szulanski & Jensen, 2004; Greenwood & Hinings, 1993; 1996; Nelson & Winter 1982). Templates are working examples of the knowledge to be transferred and often represent accumulated experience regarding organizational practices (Winter & Szulanski, 2001). In other words, they constitute a “blueprint,” which can be referred to repeatedly throughout the transfer process, and can thus provide a procedural map for simplifying and ordering a complex and causally ambiguous series of actions (Szulanski, Cappetta & Jensen, 2004). Templates also allow knowledge recipients to view the work in practice, rather than artificially separating daily details from codified abstractions of knowledge (Brown & Duguid, 1991), and help persuade recipients of the value of the practices by serving as “proof” of the potential results, thus reducing motivational impediments to transfer (Jensen & Szulanski, 2007).

 Prior research has linked the use of templates with increased knowledge transfer (Jensen & Szulanski, 2004), improved performance (Jensen & Szulanski, 2007), increased network growth (Szulanski & Jensen, 2006), and lower organizational failure rates (Szulanski & Jensen, 2008; Winter, Szulanski, Ringov, & Jensen, 2011). Templates have also been found to be a critical knowledge transfer mechanism when introducing new knowledge to nascent ventures (Szulanski & Jensen, 2006; 2008). However, previous research suggests that characteristics of the specific context, the knowledge source, and the knowledge recipients can affect the ability of organizations to transfer knowledge using templates (Gupta & Govindarajan, 2000; Kostova & Roth, 2002; van Wijk, Jansen, & Lyles, 2008). Thus, we attempt to explore the efficacy of templates to transfer knowledge within base-of-the-pyramid markets.

**THE USE OF TEMPLATES WITHIN BOP MARKETS**

We argue that the use of templates as a mechanism to transfer technical knowledge may address a number of difficulties inherent in in BOP settings. As mentioned previously, templates consist of working examples of a set of procedures or routines which can be referred to throughout the transfer process (Nelson & Winter, 1982; Winter & Szulanski, 2001). These working examples, supported by codified pictures or drawings to illustrate each practice may help overcome some of the challenges inherent due to formal institutional voids, such as literacy problems, inadequate communications infrastructure, a lack of quality educational institutions and related challenges prevalent amongst BOP entrepreneurs. Templates also allow the recipient to imitate every aspect of an established technical process. Such imitation is particularly important within BOP markets, given that valuable tacit knowledge is often embedded within everyday practices and routines (Orlikowski, 2002). Templates thus ensure that valuable cause-effect relationships are not lost through human error as recipients try to understand the complexity behind the technical practices (Szualnski & Jensen, 2008).

Deviations from established templates within BOP markets may exacerbate the problems associated with “knowledge stickiness” (Jensen & Szulanski, 2004). The more that entrepreneurs deviate from the technical practices prescribed within the established template, the more the template loses value as a referent when they might experience implementation problems because they can no longer rely on the template as a diagnostic tool (Szulanksi & Jensen, 2006). Furthermore, adaptations made to even a single component of a template without an explicit understanding of the underlying causal linkages can have a number of adverse ancillary effects (Szulanski & Jensen, 2006). A great deal of the purported value of a template rests in not requiring recipients to understand “why” something works but only to know “how” it works—a much more manageable task in complex business models (Brown & Duguid, 1991). However, perhaps the greatest detriment of template deviation is that adaptation will likely entail a costly trial and error process without guaranteeing the ultimate success of the exercise (March, 1991; Shenkar, 2010; Winter & Szulanski, 2001). For entrepreneurs operating in BOP markets, which already face significant shortage of time and money, such additional costs can prove extremely consequential.

Therefore, we hypothesize, as a main effect, that deviating from a best practices template within BOP markets decreases the effectiveness of an otherwise valuable medium for transferring technical knowledge (Jensen & Szulanski, 2007; Winter & Szulanski, 2001). As a result, we would expect that the more exactly entrepreneurs replicate a template of multiple practices, the better their overall performance.

*Hypothesis 1: Replication of practices within a template by BOP entrepreneurs will produce higher levels of performance in BOP markets.*

**NECESSITY ADAPTATIONS AND THE ROLE OF SOCIAL NETWORKS**

Virtually all of the research exploring the relative effects of replicating templates on performance has been based on the underlying assumption that knowledge recipients possess the ability to implement a template if so desired. However, in many knowledge transfer contexts, the ability to replicate within a new environment may be severely constrained by forces beyond the recipients’ control, such as government regulation (Teece, 1998), incompatible technologies (Kogut & Zander, 1992), or inadequate resources (Koburg, 1987; Pfeffer & Salancik, 1978). In such situations, knowledge recipients typically undertake a series of necessary adaptations to an established template.

 The transfer of knowledge to entrepreneurs residing within BOP markets is a prominent example of a context in which knowledge recipients often face severe resource constraints. Knowledge transfer within such settings is a common obstacle for businesses attempting to expand into the potentially higher growth markets of the BOP (London & Hart, 2004; Makino & Delios, 1996) as well as for nongovernmental and multilateral agencies seeking to improve the well-being of such countries’ inhabitants (Hoekman, Maskus, & Saggi, 2005). Necessity adaptations, as a result of resource scarcity, are an everyday reality within such environments: mechanics must use makeshift tools to work on cars, doctors must modify their treatments to account for the limited selection of medicines and facilities, and teachers must instruct with limited textbooks and classroom facilities. Of course, necessity adaptations due to resource constraints is not a unique challenge to the developing world — it is common for many organizations and individuals to face some degree of resource constraint that inhibits the exact replication of existing templates as a result of the uniqueness and heterogeneity of each of their resource sets (Maritan & Brush, 2003). However, the relative influence of resource constraints is much greater in BOP markets.

 This prevalence of resource constraints in most environments, albeit to varying degrees, presents several important questions for the study of knowledge transfer. While adaptation may not deliver superior performance to replication, what are the prescriptions that can be offered to help mitigate the downside of template deviation? In the presence of necessity adaptations to existing templates, where do knowledge recipients turn for information to assist with their modifications to prescribed practices? Does the source they turn to, and the frequency with which they interact, impact the quality of their solutions and ultimately their performance?

 To answer these questions we turn to insights from the literature on social interaction, which provides a rich discussion of the relationship between social interaction and knowledge exchange (Adler, 2001; Granovetter, 1985; Reagans & McEvily, 2003; Uzzi, 1999). While previous academic work on templates as a mechanism for knowledge transfer has viewed templates in isolation, in practice, knowledge recipients may frequently interact with one another (Adler & Kwon, 2002; Kang, Morris, & Snell, 2007; Nahapiet & Ghoshal, 1998).

 In considering the value of such social interaction, we follow recent work in placing special emphasis on the content of the knowledge provided through such interaction (Dokko, 2004; Kang et al. 2007; Rodan & Galunic, 2004). This literature contends that it is not only the structure of social relationships, but the information possessed by the actors within a network that is important in determining the benefits of social interaction. For example, Adler & Kwon’s (2002) definition of social capital emphasizes not only relationships but also the different types of information that such relationships provide. Because different actors possess different types of information, the degree to which social interaction provides valuable new knowledge may depend on *with whom* the interaction takes place. We begin by hypothesizing the effects of more frequent social interaction with entrepreneurial peers on performance outcomes, and then proceed to contrast such predications with interactions with technical experts.

***Social interaction with entrepreneurial peers.*** Interaction between entrepreneurs in BOP markets and their entrepreneurial peers, who are also attempting to follow a prescribed template, may potentially provide a number of benefits. Entrepreneurial peers possess information regarding the local culture, logistics, and politics as well as experience with implementation of the template. Thus, increased interaction with the entrepreneur’s peers may improve the overall efficiency of a trial-and-error process (Winter & Szulanski, 2001). Specifically, the sharing of stories could potentially speed up the overall learning curve and reduce the chances that adaptations that are detrimental to performance would be repeated. Furthermore, the similarity between entrepreneurial peers can facilitate communication and may facilitate sharing ideas regarding practices within a given template and designing adaptations in the face of resource constraints (Hansen, 1999).

However, frequent interaction with entrepreneurial peers also potentially leads to a number of pitfalls. As has been mentioned previously, when knowledge recipients deviate from a template, the template loses value as a referent, and recipients are subsequently forced to seek out other sources of knowledge (Jensen & Szulanski, 2007). These sources of knowledge are not necessarily unambiguously helpful; incorrect or misunderstood knowledge can also be transferred (Huber, 1991). This is especially true when the template embodies ‘technical knowledge’ related to scientific or mechanical aspects of the work (Haas, 2006, pg. 1176). While the entrepreneur’s peers may possess a great deal of knowledge regarding local practices or attributes of the local environment, they are unlikely to understand the technical causal relationships and interdependencies embedded within the template (Szulanski & Jensen, 2006; Szulanski & Jensen, 2008). Furthermore, frequent interaction with peers represents an opportunity cost, leading to decreased ability to seek knowledge from other sources (Hansen, 1999). Thus, shared understandings created through repeated peer interactions are unlikely to adequately accommodate the technical complexities and interdependencies embedded within the template due to the nature of the information exchanged in such interactions.

Such adaptations can be considered presumptive in nature, in the sense that they are based on untested (and often incorrect) assumptions (Szulanksi & Jensen, 2006). While social interaction may facilitate the recombination of knowledge (Nahapiet & Ghoshal, 1998), the resulting aggregated ‘new knowledge’ will most likely be incorrect if part of the content upon which it was based was in some way flawed. Furthermore, such interaction may simply amplify confusion surrounding subsequent adaptations. As the template increasingly loses value as a referent through increased presumptive adaptations, entrepreneurs may be forced to rely even more heavily on the guesses and untested beliefs of peers. This reliance may be especially detrimental when there are fewer ‘correct’ adaptation solutions to a particular process (Nickerson & Zenger, 2004). In such cases, a wider variety of inappropriate technical solutions provided through peer interaction may simply decrease the odds of finding a solution that works.

A number of knowledge recipients within the same peer network who adopt a particular adaptation simultaneously may also confer a certain amount of unjustified legitimacy to the practice and encourage further emulation. Research on group dynamics has suggested that, when participants share similar characteristics, they are likely to follow the actions of others within the group without critically evaluating the decisions being made (Esser, 1998; Janis, 1982). This behavior is potentially problematic within a knowledge transfer setting involving multiple recipients who trust one another, as they are less likely to be critical of the information being shared (Levin & Cross, 2004; Lount & Pettit, 2012). In the absence of a deep technical understanding of the template model, there is a risk that social interaction between trusting peers will simply reinforce incorrect ideas.

 We therefore hypothesize that more frequent social interaction between knowledge recipients and their entrepreneurial peers is likely to decrease overall performance as the number of adaptations increase because the technical knowledge that is exchanged is predominantly presumptive in nature. In other words, rather than providing insight based on technical cause-and-effect principles, adaptations arising from peer interactions are likely to be based on untested information, and negatively amplified through increased social interaction. Thus, when resource constraints necessitate adaptation, interaction with peers is likely to produce a detrimental combinative effect in which the negative effects of deviating from the template are worsened with increased interaction. Therefore, we hypothesize:

*Hypothesis 2a: Increased interaction between BOP entrepreneurs and their peers will negatively moderate the relationship between number of adaptations and performance in BOP markets.*

***Social interaction with technical experts.*** Analternative source of information for entrepreneurs in BOP markets when undertaking adaptations within the knowledge transfer process is technical experts. Technical experts are those individuals who possess not only a detailed understanding of individual practices within the template but also a deep understanding of *why* things work. While using a template provides knowledge recipients with a detailed understanding of “how” the practices and routines within the template work, it typically contains very little information on “why” such practices work. Indeed, one of the strengths of a template as a medium is that it allows for fast and simple communication of what are, in actuality, a very complex set of interrelated practices. Technical experts are typically agents of the organization that initiates the knowledge transfer process and have undergone extensive technical training regarding the underlying intent of each template practice, or professionals who have received formal educational training in the field of study. As compared to knowledge recipients, technical experts are much more acutely aware of how different practices within a template are interrelated.

Prior research focused on the particular content of transferred knowledge has begun to untangle some of the differences between presumptive beliefs, which are based on untested beliefs and assumptions, and principled understanding (Baden-Fuller & Winter, 2005; Morris, Snell & Hammond, 2010). Such work has suggested not that adaptation from best practices is necessarily harmful per se, but rather that successful adaptations adhere to the principles underlying the original practices (Baden-Fuller & Winter, 2005). We argue that, when undertaking necessity adaptations, accessing principled knowledge through frequent interaction with technical experts is imperative. Because technical experts have a principled understanding of “why” practices work, the exchange of information with knowledge recipients can be highly targeted in nature and match appropriate adaptations with specific needs without destroying the intended value of the practice.

In addition, the recombination of knowledge between the technical expert, who possesses a deep knowledge of the principles underlying the interrelated practices, and the entrepreneur, who possesses a deep knowledge of his or her own unique resource bundle and local environment, can lead to a valuable recombination of knowledge. In such instances, new adaptations can be created without violating the intended principles of the practices. Furthermore, by ensuring that such adaptations continue to meet the technical intent of the original practice, the template can maintain its value as a guide and referent throughout the remainder of the implementation process (Jensen & Szulanski, 2007). In this way social interaction can serve as a complement to templates as a knowledge transfer mechanism (Hansen, 1999; Regans & McEvily, 2003).

Therefore, we propose that increased interaction of entrepreneurs within BOP markets with technical experts when undertaking adaptations to an established template will result in increased performance. By interacting frequently with such experts, the entrepreneur will be able to garner technical knowledge leading to a more principled understanding of the often tacit meanings underlying the codified practices. Such principled understanding may facilitate adaptations that maximize the intent of each practice within the bounds of his or her individual resource constraint. We refer to these adaptations as ‘principled’ because they adhere to the principles underlying the functioning of the template. Comparatively, without the technical information resulting from frequent interaction with technical experts, the entrepreneur may be more likely to undertake presumptive adaptations which do not maintain the integrity of the overall template, negatively impacting overall performance. Thus, we hypothesize:

*Hypothesis 2b: Increased interaction between BOP entrepreneurs and technical experts will positively moderate the relationship between number of adaptations and performance in BOP markets.*

**METHODS**

We tested our hypotheses using data from a large-scale development project undertaken in Nicaragua over a three-year period that entailed the transfer of best practice knowledge from “Milktech,” an international nongovernmental organization, to 1,812 rural dairy farmers. The primary objective of the project was to increase the quantity of high-quality milk that the farmers produced and link them with larger and more profitable urban markets. The project introduced a dramatic change in farm management, transforming the farms from traditionally-run, subsistence farms into business-oriented, technologically-managed ventures. The farmers, as the knowledge recipients within the project, were located within the Western Departments of Leon and Chinandega, which are two of the poorest regions of the country. The project had been in place for two years at the time the data were collected.

The primary tool used for transferring the knowledge surrounding best practices was a template that consisted of 45 interrelated dairy practices encompassing a number of distinct areas. Farmers had access to templates through several ways. First, farmers were taken to distant locations (either in a neighboring country or neighboring region of Nicaragua) to observe an established template in action. Second, one farm from each group of farmers was chosen to serve as a ‘model farm.’ This farm received extra inputs and help from Milktech in order to serve as a working template which other farmers could observe. Finally, Milktech had created six posters dealing with different aspects of the template, which together comprised the overall set of best practices that the organization was trying to convey to the farmers. Each poster had pictures and words describing 5-8 practices. The subjects for the posters included reproduction, the care of newly born calves, the use of minerals, the use of sugarcane, the use of legumes, and hygienic milking.

The practices had been designed and validated by Milktech specifically for the Nicaraguan context and represented years of experience in and scientific research on best practices for milk production in sub-tropical regions. These practices had been designed specifically for BOP producers and were based on experience in similar regions in Honduras and Costa Rica. While each of the practices had the potential to provide some benefit if implemented independently, the practices were also highly interrelated. For example, while practices related to the cultivation and use of sugarcane were logistically separate from those related to the use of legume tree leaves in the cows’ diet, sugarcane is much more beneficial when combined with the protein-rich legume tree leaves. Similarly, the potential benefit provided by the practices associated with summer feeding depended significantly on the extent to which salts and minerals were also made available to the cattle.

Many of the 45 practices that comprised the overall template represented a vast departure from the practices used previously by the dairy farmers. Traditional means of operating a dairy farm within the regions of Leon and Chinandega typically dictated very little active management – cows were simply allowed to graze in open fields and then milked each morning. The newly prescribed best practices, such as the use of minerals, the division of pastures, or even hygienic milking practices, were therefore unfamiliar to the farmers and their efficacy not readily apparent. For instance, most dairy farmers did not see any real need for hand washing prior to milking or perceive any potential linkages between the absence of hand washing and the high bacteria counts within milk that would limit the markets to which they could sell.

 One of the biggest challenges for farmers participating in the project was that many of them did not possess sufficient financial resources to replicate all of the practices as designed. Nicaragua remains one of the poorest countries in the Western Hemisphere with per capita GNI per capita of approximately US$1,100 (World Bank, 2012). Furthermore, Leon and Chinandega are two of the poorest districts within the country. As a result, many farmers within these districts needed to undertake adaptations to one or more of the 45 practices that comprised the overall template; these farmers would, by necessity, implement makeshift or modified solutions for distributing the prescribed salts and minerals to the cattle, constructing physical structures, or planting certain types of grass and other feed. For example, in the case of providing salts and minerals, many producers could not afford to provide minerals to all of the cows every day. Thus, they needed to make a decision of whether to give the prescribed amount to only a subset of cows within their herd or to give less than the prescribed amount to all of their cattle. Such decisions could have very different implications for the overall level of milk production.

This research setting proved a fruitful context for the study of knowledge transfer using templates and necessity adaptation for a number of reasons. First, the dairy sector in rural Nicaragua was undergoing rapid transition and growth as it shifted from primarily serving small, local markets to engaging in multinational milk markets (Perez-Aleman, 2011). Successful integration into multinational markets required an improvement in quality standards as well as an increase in quantity of milk per farm, both of which necessitate a significant change in farm management techniques. Second, the context involved very small farms where factors such as geographic co-location and the subsequent social interaction provided important opportunities for informal learning (Almeida, Dokko & Rosenkopf, 2003). Finally, the practices were complex and highly causally ambiguous to the rural farmers, but not to the veterinarians and Milktech technicians acting as experts.

The surveys were conducted by the first author or by one of two sixth-year veterinary students recruited from a local reputable university. The students were familiar with the geographic area as a result of a recent three-month internship. They were also given training by the first author on survey administration and traveled with the first author when conducting surveys. The survey was initially face validated by the five main managers of fieldwork for the development organization and then pretested with 20 farmers. Minor changes in formatting and wording were made subsequent to the pre-test. The surveys were conducted in person at both regional milk collection centers and on the farmers’ property. The surveys averaged approximately 15 to 20 minutes to administer.

The difficulty of road access to farmer communities, which at times required several hours of travel over dirt roads, made complete randomization logistically infeasible. However, efforts were made to obtain as representative a sample as possible. These efforts included making careful plans to obtain surveys from each of the four sub-regions involved in the project (northern Leon, southern Leon, northern Chinandega, and southern Chinandega) and from 11 of the 24 different municipalities within the sub-region. A total of 165 surveys were conducted from the total population of 1812 dairy farmers who had participated in the project. Out of the 165 surveys that were conducted, 7 surveys were removed from our sample because the producers were not milking any cows at the time of being interviewed and thus failed to provide performance data. Thus, our final sample size was 158 farmers. To check for potential biases within our sample, we obtained baseline milk production data from Milktech for all their participating farmers gathered prior to the project and at the end of the first year of the project. We conducted a one-way ANOVA test and found no significant difference in production between those in our sample and the total population for either year in which data was available.

**Measures**

***Performance*.** To measure our dependent variable, performance, we asked each farmer to indicate how many cows they had milked that morning and how many liters of milk they had produced that day. Preliminary discussions with project managers at Milktech had revealed that milk production does not vary greatly from day to day within any given month (the largest variance is between the wet and the dry season and all surveys were gathered within a four week period during the wet season). However, the managers also indicated that asking the farmers to average their milk production could be problematic and lead to either over or underestimation in their answers. Similarly, asking farmers directly about milk production per cow could lead to bias on the part of farmers or be associated with problems of numerical competency. Based upon prior experience, Milktech advised asking the producers how many cows they had milked that morning and, separately, how many total liters were produced that day would likely mitigate such problems. Both of these pieces of information were well known to the farmers because they were actively involved in the milking of all of their cows and were used to selling the milk they produced by the liter. This information was then used to calculate the average number of liters produced per cow per day.

***Replications.*** Our measure of replications was based on a similar measure used by Westphal, Gulati, and Shortell (1997), as well as by Szulanski and Jensen (2006). For each of the 45 practices, the survey asked the farmer to indicate whether they replicated the practice exactly as it was laid out on the template, adapted the practice from what was prescribed on the template, or did not do the practice at all. Thus, replication was calculated by summing the number of practices the farmer indicated he or she replicated exactly as laid out in the template.

***Adaptations*.** Similarly, our measure of adaptations was calculated by adding the total number of times each farmer indicated he or she adapted one of the 45 different practices from what was prescribed on the template.

***Interaction* *with Entrepreneurial Peers.*** As part of the survey, each farmer was asked to indicate how often he or she spoke to other farmers participating in the program. Specifically, farmers were asked to indicate how many times each month, on average, they discussed the practices they were implementing on their farms with these peers over the last year. The respondents were asked to average the number of times they interacted with other farmers because prior research has suggested that individuals have an easier time recalling overall patterns of social interaction as opposed to recalling specific events (Freeman, Romney & Freeman, 1987). Interviews with technicians from the development organization as well as farmers indicated that prior to the project, seeking dairy advice from peers was relatively uncommon.

***Interaction with Technical Experts.*** The survey also asked farmers to indicate how often they interacted with technical experts. Technical experts included both technicians employed by ‘Milktech’ and veterinarians within the region who had a similarly deep understanding of the underlying function and interrelatedness of the practices being introduced. Again, we asked the farmers to indicate the average number of times each month that they interacted with such experts over the last year.

***Controls.*** We included a number of theoretically-relevant controls within our statistical model to account for potential covariance. Three measures of human capital were included in the survey to account for individual-level differences that could affect the potential success or failure of an adaptation to the established template. The first measure, *Education,* was calculated by asking the farmer to indicate the highest level of education attained. Farmers were assigned a score from 0-13, depending on how many years of formal education they had received. Any formal education beyond grade 12 was coded as a 13, and 13 included formal training in a professional school, a vocational school or a university. The second measure of human capital was *Experience*, which indicated how many years the farmer had been engaged in dairy farming. Finally, *Trainings* was a measure of the number of trainings that the farmer had received outside of the development project with Milktech.

The control *Cattle* was calculated as the total number of cattle owned by the farmer as a proxy for the wealth level of the farmer. Inclusion of this variable within our models was important because it helped control for the correlation between farmer wealth and the need for adaptation rather than replication, as well as for a potential correlation between the amount of financial capital a farmer possessed and the potential quality of the adaptation. We also included a control for *Baseline Utility*, which was obtained from archival data possessed by Milktech. Baseline utility is a measure of profitability of each farm prior to the implementation of the development project. When the development project began, Milktech had gathered production information for all 1812 farmers and estimated their daily profitability in Cordobas (at the time 1 US$ was equal to approximately 20 Cordobas) and used this information to calculate the measure ‘baseline utility’. We were able to collect baseline utility from archival data provided by Milktech and we included it as an additional control for the a priori ability of producers to invest in new practices at the beginning of the project. A control was also included for whether or not the respondent had been designated as one of a handful of *Group leaders* who would have experienced increased levels of social interaction simply as a result of assuming this role. *Employees* was a control for the number of paid employees on the farm and was included to help account for differences in the organizational size of the farms. Finally, *Farm size* was a measure included to account for differences in the number of manzanas (one manzana is approximately 1.73 acres) for each farm, which may have affected farmers’ physical ability to implement some of the practices as prescribed by the template.

**ANALYSIS AND RESULTS**

To statistically test our hypotheses, we used ordinary least squares regression with a robust variance estimator. The regression models were estimated using Stata version 11. The models included the dependent variable *performance* and the independent variables outlined in Table 2. One potential concern in estimating the regression models was a potential lack of independence for observations from farms in the same geographic cluster that may be subject to a host of group effects. In order to account for the potential correlation of the error terms for farms within the same geographic cluster, we used a robust variance estimator (“cluster”) in our models (Huber 1967; White 1980, 1982). This technique accounts for the within-group correlation of error terms. An alternative option for addressing potential interdependence would have been to include a fixed effect for geographic cluster in our models. We ran this analysis as a robustness check, and the results were not qualitatively different from the analysis presented herein.

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**Insert Table 1a about here**

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**Insert Table 1b about here**

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 Table 1a provides the means, standard deviations and minimum and maximum values for each variable, and Table 1b shows the correlations between variables. To reduce potential problems with multicollinearity, we centered all variables prior to creating the interaction terms. A post-hoc analysis of the variance inflation factors showed that multicollinearity was not a significant concern. Model 1, illustrated in Table 2, includes all of the control variables but excludes independent variables of interest.

 With model 2, we examine hypotheses 1, which predicts that replication of practices within a template will produce superior performance. The results of model 2 are shown in Table 2. The replication of practices within the template is positively related to performance (β=0.05, p<0.01) and the overall model is significant (p<0.000). Thus, Hypothesis 1 is supported. Model 3, again shown in Table 2, examines the moderating effects of social interaction, and the overall model is statistically significant (p<0.000). Hypothesis 2a, which predicted that the relationship between adaptation and performance would be negatively moderated by higher levels of interaction with entrepreneurial peers, did not receive statistical support as the interaction was nonsignificant (p=0.64). However, Hypothesis 2b, which predicted that the relationship between adaptation and performance would be positively moderated by interaction with technical experts did receive support (β=0.12, p<0.05).

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**Insert Table 2 about here**

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**DISCUSSION**

Consistent with prior literature, our main effect results suggest that replicating an established template that consists of a large number of complex and interrelated practices within BOP markets results in an increase in performance (Jensen & Szulanski, 2007; Szulanski & Jensen, 2006). Specifically, the more technical practices that knowledge recipients are able to copy exactly as instructed by the template, the better their performance. Thus, the use of templates within contexts characterized by extreme economic and human capital deficiencies remain a valuable transfer mechanism for technical knowledge.

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**Insert Figure 1 about here**

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Our subsequent tests for moderating effects suggest that, when recipients make necessity adaptations to a template, social interaction may help explain whether those adaptations are helpful or detrimental to performance. To better interpret how social interaction with technical experts moderates the relationship between adaptation and performance, we graphed the interaction effect at +1 and -1 standard deviations (see Figure 1). The graph indicates that, as the number of adaptations increased, the performance of farmers that interacted frequently with technical experts improved, while the performance of those in the infrequent interaction condition declined. The performance implications of interacting with technical experts while adapting are large; farmers in the high social interaction condition produced 19% more milk than their peers in the low interaction conditions when undertaking a high number of adaptations. This is a substantial difference in real economic terms. Interestingly, there was very little performance difference between farmers who interacted frequently or infrequently with technical experts when there were very few necessity adaptations; it is only when the number of adaptations increased that a significant performance gap began to emerge.

There were a number of anecdotal stories relayed by managers and technicians at Milktech that may help shed further light on how the information provided through social interaction with entrepreneurial peers or technical experts impacted the quality of the adaptations. For example, a farmer in the city of Los Zarzales did not possess sufficient financial capital to set up an electric fence to divide his land into separate pastures as the template prescribed. The farmer adapted the practice, creating a “living fence” by planting small trees for fence posts and stringing them together with barbed wires. However, the farmer quickly realized that the cows would eat the variety of small trees he had planted. The functional intent of the particular practice, as the farmer learned by establishing a dialogue with one of Milktech’s technicians, was to improve grass growth by alternating where the cows walked and grazed. Together, they developed an inexpensive solution of “painting” the newly planted trees using a mixture of manure and water so that the cows would not eat the fence and the functional intent of the practice could be fulfilled.

Similarly, a number of producers in Achuapa lacked the capital to build the milking shed indicated by the template. By conversing with technicians, they understood that the purpose of the milking shed was to prevent manure or mud from splashing into the milk pail during milking. Together with the technician, they developed the solution of milking their cows in the road, thus avoiding the mud and manure present in the corral, where milking was traditionally done. Thus, by interacting with experts who both understood the “why” of each individual practice and how the multitude of practices were interrelated, the knowledge recipients were able to experience some performance improvements within the confines of their resource constraints.

This finding suggests that adaptation need not always be detrimental, even in the case of resource scarcity (Kostova & Roth, 2002, cf Jensen & Szulanski, 2004). However, it also suggests that the effectiveness of such adaptations depends significantly on the degree to which the adaptor possesses a sufficient understanding of the functional intentions underlying the practices within the template. When knowledge recipients interact frequently with technical experts, they are more likely to access such knowledge and engage in principled as opposed to presumptive adaptations (Baden-Fuller & Winter, 2005). As a result, the more adaptations the knowledge recipient undertakes, the more important it is for them to engage in frequent interaction with technical experts.

When compared to the high number of positive stories relayed to us regarding frequent interaction with experts when undertaking adaptation, accounts involving frequent peer interaction contained much more mixed results. For instance, one farmer within a small community in El Sauce had noticed that mud was only visible on the udder during the wet season and not during the dry season, and thus the farmer only engaged in thoroughly washing the cow’s udder during the wet season. Through social interaction with other farmers within the same community, this presumptive adaptation received widespread adoption, resulting in a significant drop in the quality of milk in the area due to high bacteria counts. Similarly, a group of farmers in Chinandega decided collectively to undertake the castration practice only during a particular phase of the moon. A myth had developed amongst the farmers within the community that, if the moon were in the wrong phase, the calf would bleed to death. Again, the farmers in this case had elected not to seek out advice from technical experts, and the end result was a strong constraint on the timing of routine practices, which could undermine the overall management of the farm. These peer interactions present a potential negative effect on performance.

At the same time, however, there were a number of illustrations in which interaction with peers played a very positive role in preventing detrimental adaptations. For instance, one farmer placed larger quantities of nitrogen in the mineral mix than prescribed by the template in an attempt to increase milk production even further. However, this practice had the opposite effect and actually killed some of his cows. The results of this dangerous and presumptive adaptation were quickly spread to other farmers within the region, who were careful not to make the same mistake. Similarly, a farmer in Sabana Grande reported to other farmers that his crop of legumes had failed when he had boiled the seeds and planted them immediately, rather than adding the seeds to the water after it had cooled and allowing them to soak overnight as the template prescribed. Several other examples of presumptive versus principled adaptation are detailed in Table 3. Such insights suggest that the effectiveness of traditionally examined knowledge transfer mechanisms, such as templates and social interactions (e.g., Schreyogg & Kliesch-Eberl, 2007; Zollo & Winter, 2002), are contingent upon whether or not the social contacts can help to effectively identify the cause-and-effect relationships necessary to maintain performance while making adaptations. In our study, it was clear that experts were much more likely to understand these vital technical relationships than peer contacts. Nonetheless, it was not clear that peer contacts were necessarily detrimental to successful adaptation.

Hence, some of the purported benefits of social interaction with peers emphasized in prior literature, such as the sharing of trial-and-error results, appeared to be much more relevant than anticipated in our study. It is also possible that at least some of the farmers, having dealt with severe resource constraints as part of their day-to-day lives in the poor regions of Nicaragua, had developed a capability to innovate successfully – and become bricoleurs, so to speak (Mair & Marti, 2009). Finally, the template in our study was primarily technical in nature. In this case, technical experts from Milktech possessed the relevant knowledge regarding causal relationships. However, had the template relied heavily on local culture, politics, or logistics, we would expect entrepreneurial peers to possess superior knowledge regarding causal relationships. In such cases knowledge possessed by outside technical experts would probably be much less helpful in adapting a template. Following Haas (2006), the nature of the necessary knowledge – local or technical – would help predict with whom useful interactions might take place. We would emphasize that technical experts do not always provide information that is superior to the information possessed by entrepreneurial peers – rather, it depends on the nature of the knowledge embedded within the template.

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Insert Table 3 about here

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Our study makes a number of important theoretical contributions to the literature on the BOP and on knowledge transfer. First, our contributes to the BOP literature by providing insight regarding the value of information exchanged within social relationships – a key area of interest given the informal markets that dominate the BOP (Arnould & Mohr, 2005; London, 2007; Webb et al, 2010). Second, we contribute to an understanding of knowledge transfer in BOP markets where templates are quite valuable but resource constraints were a major trigger for adaptation. In this context, the assumption of resource availability that underlies much prior work on knowledge transfer is potentially problematic. Specifically, prior work involving knowledge transfer has typically assumed that sufficient levels of financial capital or access to credit, human capital, and other factors of production such as land either exist or can be readily acquired from the surrounding environment. As a result, in the traditional context, the primary obstacle to effectively leveraging knowledge is found in organizational governance structures, informal social interactions, or even individual behavioral mechanisms (e.g., Kang, Morris & Snell, 2007). However, in the BOP context the levels of such capital are often lacking. Thus, while in an ideal context, “adaptation should potentially be delayed until the practice has been completely transferred and implemented” (Jensen & Szulanksi, 2004, p. 518), developing markets often necessitate high levels of adaptation from the outset. Thus, our study suggests that resource constraints posed from the external market must be incorporated into existing models of knowledge transfer to a much greater degree to account for the impact that such variance can have on descriptive and prescriptive outcomes.

Secondly, we delineate between two distinct types of adaptation - principled and presumptive. While presumptive adaptation is based on unproven beliefs by the recipient unit, principled adaptation is based on a deep understanding of the cause-and-effect relationships underlying the replicated routines and practices. Previous research exploring the effects of adaptation in the process of knowledge transfer has focused almost exclusively on presumptive adaptation and its corresponding negative effects on performance when deviating from existing templates (e.g. Szulanski & Jensen, 2006). As a result, impetuous deviations from such templates are likely to result in negative performance outcomes as the recipient unit attempts to presumptively “guess” at the meaning of causally ambiguous and complex practices. However, our study suggests that, when this option is not available to the knowledge recipient and he or she needs to adapt, frequent social interaction with a template expert may serve to significantly overcome such “guesswork,” and can lead to more principled deviations from the initial template.

Finally, our study also considers the mechanism of social interaction in combination with the use of templates. Prior work examining the transfer of complex routines has considered the use of templates independent of alternative complementary mechanisms for facilitating knowledge transfer (Nelson & Winter, 1982; Winter & Szulanski, 2001). In so doing, our study suggests that, while templates may be ill suited to lead to principled adaptation as a standalone mechanism, they likely serve as a conversation guidepost around which discussion during interactions can occur. In fact, we would argue that the utility of social interaction would be greatly reduced in the absence of a template, as the knowledge exchanged during such interactions would potentially be so unstructured and confusing that the ability of the recipient unit to attain a level of principled adaptation may be severely inhibited.

**LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH**

While this study makes several important contributions, it is not without its limitations. First, our study is cross-sectional in nature, and thus we are unable to make strong assertions regarding the direction of our causal relationships. For example, it is possible that the decision of how to engage in adaptations could subsequently influence the level of social interaction rather than occur simultaneously. Notwithstanding, our correlation table (Table 1b) provides some information which reduces the concern that the frequency of social interaction is driven by the decision to adapt: our results show that the variables for number of adaptations and frequency of social interactions are not significantly correlated but rather operate independently. Another potential causal concern is the possibility of omitted variable bias (Bascle, 2008). For example, an unobserved variable, such as producer expertise, could potentially drive both increased milk production as well as increased interaction with experts. While we have tried to capture producer expertise through proxies such as education and training, we cannot rule out the possibility that our results are biased by endogeneity. Another potential concern is the limited nature of our measure for social interaction as we only capture the frequency of interaction with peers and experts. We would encourage future research examining social interaction and templates to use additional techniques such as network analysis or direct measures of the content of shared information.

Another potential limitation is that our data were also drawn from a single large project undertaken within a single developing country, and, as such, the generalizability of our results is constrained. However, we feel that the underlying theoretical claims do generalize to other contexts where resource scarcity is present and we would suggest that our study is relevant beyond the developing world. The need to adapt in the face of resource constraints may be more pronounced in a BOP context but is certainly a factor in the replication of knowledge in more developed contexts as well (Koburg, 1987; Maritan & Brush, 2003). Another possible boundary condition for our theory is that it does not generalize to cases of complete causal ambiguity. If the knowledge to be transferred is completely causally ambiguous and causal relationships cannot be understood, even *ex post*, then it seems unlikely that social interaction could positively moderate the relationship between adaptation and performance. In such cases ‘technical experts’ as defined in this paper, would simply not exist.

Overall, we believe that the results of our study suggest several potentially fruitful directions for future research. For example, this study seeks to build theory by re-examining knowledge transfer within a BOP environment. This re-examination leads to several departures from much of the extant work on knowledge transfer. While we focus on resource scarcity, several other salient differences within the BOP could lead to new theoretical insights. For example, future work could spend more time exploring the implications of knowledge transfer across (rather than within) organizational boundaries. Such inter-organizational knowledge transfer may play a critical role in fostering entrepreneurship in the Base-of-the-Pyramid, yet may vary from knowledge transfer in other contexts due to issues such as the autonomy and heterogeneity of knowledge recipients. Future studies could explore how these conditions alter extant theory regarding knowledge transfer. Furthermore, while we considered social interaction with experts as one general complementary mechanism to the use of templates, future research could examine with more precision the role of other knowledge transfer mechanisms such as experimentation, training sessions, informal mentorship, etc. Finally, this study does not directly measure whether adaptations are principled or presumptive, but infer this from their effect on performance. We encourage future researchers to build more precise measurements for the adaptations themselves. For example, researchers might consider using expert raters to characterize individual adaptations as presumptive or principled in nature.

**CONCLUSION**

Our study examines the comparative efficacy of replication versus adaptation in the transfer of knowledge templates in Base-of-the-Pyramid environments. We propose that templates are a potentially valuable knowledge transfer mechanism in BOP environments. We also more closely explore the role of social interaction as a potential explanatory mechanism for why adaptations may often produce both positive and negative outcomes among entrepreneurial recipients. While prior studies have focused solely on the negative impacts of deviating from a prescribed set of causally ambiguous and complex practices, we argue that certain types of social interaction can help knowledge recipients overcome the challenges associated with necessity adaptation. Specifically, increased interaction with technical experts can produce principled adaptations that maintain the functional intent underlying the set of interrelated practices. Comparatively, infrequent interaction with experts and interaction with peers often leads to presumptive adaptations based upon untested assumptions and myth.

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**TABLES AND FIGURES**

**Table 1a: Mean, Standard Deviation (SD), Minimum and Maximum (n = 158)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Mean | SD | Min | Max |
| Performance | 3.64 | 1.23 | 0.75 | 7.33 |
| Education | 4.95 | 3.76 | 0 | 13 |
| Experience | 27.49 | 13.08 | 1 | 60 |
| Trainings | 0.36 | 0.52 | 0 | 3 |
| Cattle | 57.84 | 38.74 | 13 | 214 |
| Employees | 1.87 | 1.68 | 0 | 10 |
| Baseline Utility | 504.77 | 323.19 | 99.94 | 2258.58 |
| Farm Size | 53.21 | 34.08 | 6 | 200 |
| Replicate | 24.30 | 5.82 | 11 | 39 |
| Adapt | 6.70 | 3.28 | 0 | 16 |
| Peer Contacts | 4.60 | 10.05 | 0 | 60 |
| Expert Contacts | 1.65 | 1.90 | 0 | 16 |

**Table 1b: Correlations**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Performance | Education | Experience | Training | Group Leader | Cattle | Baseline Utility | Farm Size | Peer | Expert | Replicate |  |
| Education | 0.28\*\*\* |  |  |  |  |  |  |  |  |  |  |  |
| Experience | -0.01 | -0.19\* |  |  |  |  |  |  |  |  |  |  |
| Trainings | 0.14† | 0.10 | -0.04 |  |  |  |  |  |  |  |  |  |
| Group Leader | 0.17\* | 0.11 | -0.02 | 0.13 |  |  |  |  |  |  |  |  |
| Cattle | 0.15† | 0.11 | 0.15\* | 0.09 | 0.13 |  |  |  |  |  |  |  |
| Employees | 0.21\*\* | 0.23\*\* | 0.07 | 0.09 | 0.05 | 0.56\*\*\* |  |  |  |  |  |  |
| Baseline Utility | 0.12 | 0.18\* | 0.10 | 0.16\* | 0.08 | 0.47\*\*\* |  |  |  |  |  |  |
| Farm Size | 0.16† | 0.13 | 0.17\* | 0.06 | 0.05 | 0.41\*\*\* | 0.28\*\*\* |  |  |  |  |  |
| Peers | 0.35\*\*\* | 0.12 | 0.03 | 0.26\*\*\* | 0.05 | 0.06 | 0.17\* | 0.01 |  |  |  |  |
| Experts | 0.22\*\* | 0.07 | 0.08 | 0.27\*\*\* | 0.15† | 0.08 | 0.08 | -0.02 | 0.36\*\*\* |  |  |  |
| Replicate | 0.34\*\*\* | 0.10 | -0.02 | 0.13† | 0.20\* | 0.23\*\* | 0.08 | -0.05 | 0.28\*\*\* | 0.18\* |  |  |
| Adapt | -0.02 | 0.01 | 0.02 | -0.03 | -0.00 | -0.03 | 0.00 | 0.15† | 0.15† | 0.05† | -0.39\*\*\* |  |

|  |
| --- |
| n=158†  *p <0.1 (two-tailed)* |
| *\* p <0.05 (two-tailed)* |
| *\*\* p <0.01 (two-tailed)* |
| *\*\*\* p<0.001 (two-tailed)* |

**Table 2: Regression Results**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Model 1: Controls** | **Model 2:****H1** | **Model 3:****H2a and H2b** |
| Constant | 2.96\*\*\*(0.27) | 1.60(0.47) | 1.70\*\*\*(0.39) |
| Education | 0.06\*(0.03) | 0.06\*(0.03) | 0.06\*(0.03) |
| Experience | -0.00(0.01) | -0.00(0.01) | -0.00(0.01) |
| Trainings | -0.00(0.22) | -0.04(0.21) | 0.01(0.20) |
| Cattle | -0.00(0.00) | -0.00(0.00) | -0.00(0.00) |
| Group Leader | 0.40(0.25) | 0.27(0.23) | 0.32(0.24) |
| Employees | 0.11†(0.07) | 0.07(0.07) | 0.04(0.07) |
| Baseline Utility | -0.00(0.00) | -0.00(0.00) | 0.00(0.00) |
| Farm Size | 0.00(0.00) | 0.00(0.00) | 0.00\*(0.00) |
| Interaction with Entrepreneurial Peers | 0.35\*(0.13) | 0.28\*(0.12) | 0.23(0.14) |
| Interaction with Technical Experts | 0.20(0.20) | 0.17(0.20) | 0.14(0.21) |
| Replications |  | 0.05\*\*(0.02) | 0.06\*\*(0.02) |
| Adaptations |  | 0.02(.03) | 0.04(0.03) |
| Adaptation X Interaction with Entrepreneurial Peers |  |  | 0.02(0.04) |
| Adaptation X Interaction with Technical Experts |  |  | 0.12\*(0.05) |

|  |
| --- |
| n=158 Standard errors in parenthesis\* p <0.05  |
| \*\* p <0.01\*\*\* p <0.001 |
| **Table 3: Examples of Presumptive and Principled Adaptations to the Template**

|  |  |  |
| --- | --- | --- |
| **Introduced Practice** | **Presumptive Adaptation** | **Principled Adaptation** |
| Nitrogen introduced as part of mineral supplement at a ratio of 1 pound Nitrogen per 100 pounds salt | Added more Nitrogen, killing a cow | Add less than required amount of Nitrogen  |
| Cows to be given a salt/mineral supplement of 100 pounds salt with 50 pounds of minerals | Reduced the minerals to 5 pounds per 100 pounds of salt, very little benefit for cows | Focus on providing minerals on animals that targeted for breeding or to those that are pregnant |
| Provide water in all of the pastures in plastic barrels | Provided water in some of the pastures where convenient | Cut tires in half and nail them to trees, providing water in all pastures |
| Construct a shed for milking with a grated concrete floor | Milked in corral, where manure can contaminate milk | Milk in roadway, where there is no manure to contaminate milk |
| Milking shed floor to be made of textured concrete | Milking shed floor was very smooth, causing animals to slip and fall | Milking shed floor is made of compact gravel |
| One person ties the legs of the cow and another person milks | The same person ties up legs and milks the cow, wiping hands with a cloth in between | The same person ties up the legs and milks the cow, but washes hands in soap and water between each process |

 |

**Figure 1: Interaction graphed at +1 and -1 Standard Deviations**

**Appendix A: Abbreviated Adaptation Measure**

The full measure contains 45 items and is available from the authors. This measure has been translated to English from the original Spanish.

**Please mark which best describes how you have carried out each practice over the last year.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **I do this exactly as the poster shows** | **I do this in a different way** | **I don’t do this** |
| **Reproductive management**  |
| Watering **troughs** in all of the pastures |  |  |  |
| Injections of minerals, AD3E, y selenium |  |  |  |

|  |
| --- |
| **Management of newly born calves** |
| Build a shed for the calves |  |  |  |
| Stop milking the cow 2 months before she gives birth |  |  |  |

|  |
| --- |
| **Use of minerals** |
| Mix 100 lbs of salt with 50 lbs of minerals |  |  |  |
| Offer this every day, all that they can eat |  |  |  |

|  |
| --- |
| **Establishing sugar cane** |
| Make trenches 20 cm deep and 1.5 m apart |  |  |  |
| Apply 300 lbs of fertilizer per acre and plant 60 cm cane stems that are 7 months old |  |  |  |

|  |
| --- |
| **Hygienic milking** |
| Use a milking shed |  |  |  |
| Wash the shed before and after milking |  |  |  |

|  |
| --- |
| **Protein banks** |
| Prepare the earth and apply 300 lbs of fertilizer |  |  |  |
| Leave the seeds soaking one day before planting |  |  |  |

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