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U.S. Agribusiness Companies and Product Innovation: Insights from a Choice Experiment Conducted with Agribusiness Executives

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Abstract

Product innovation generates short and long-term growth by attracting new customers while satisfying existing customers. This paper identifies factors influencing the selection of innovation projects and quantifies the tradeoffs which agribusiness managers make when selecting product innovations. A choice experiment approach is used to provide insight into agribusiness executive behavior. Our results indicate that executives prefer (in decreasing order of importance) projects with low risk of technical/regulatory failure, low relative market risk, short-term to market, in-house capability, and high sunk costs. Our results suggest that policy makers could stimulate open innovation with programs such as government sponsored research and cost-sharing.

Keywords: innovation, agribusiness, executive behavior, willingness-to-trade

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Introduction

Innovation generates short and long-term growth by attracting new customers while continuously satisfying current customers. "Innovation is critical to the success of a firm as well as the economic health of an industry and the overall economy" (Roucan-Kane, Gray and Boehlje; p.52). Various researchers have developed frameworks which stimulate, measure and determine governance structures that enhance innovation ideas (Roth and Sneader 2006; Brown 2005; Barsh et al. 2008; Huurinainen 2007; Christensen and Raynor 2003; Christensen et al. 2004; Dacin et al. 2007; Sampson 2007; Ahuja and Katila 2001). Companies are faced with many potential innovation projects to choose from and must allocate a limited research and development (R&D) budget to selected projects. "The selection of the right innovation project is the main challenge facing companies in today's dynamic business environment" (Roucan-Kane, Gray and Boehlje; p.52). Several frameworks and criteria have been developed to assist companies with this difficult task (Day 2007; Graves, Ringuest, and Case 2000).

Various studies have been conducted to identify important project attributes that are considered when making innovation project investments. A review of the literature revealed that companies focus primarily on financial criteria such as project net present value, internal rate of return, and return on investment when selecting innovation projects. Additional research has found that companies that also incorporate qualitative criteria into their decision-making are the most successful innovators (Cooper et al. 1999; Coldrick et al. 2005). A summary of the criteria that have been proposed in the literature are provided in Table 1 (see Appendix).

The goal of this paper is to identify factors influencing the selection of innovation projects, quantify the tradeoffs which agribusiness managers make when selecting product innovations, and address the difficulties companies face in making these decisions. Several attributes have been highlighted by previous research as important for project selection. However, the preferences by agribusinesses for projects with bundles of these various attributes, especially when compared across multiple projects, are largely unknown. This research fills a gap in the empirical literature by providing insight into agribusiness executive behavior using a choice experiment (CE) approach. This framework enables the identification of preferences for project attributes by agribusiness companies and allows for the estimation of tradeoffs between the various innovation projects' characteristics.

Methods

To complement the findings from the prior literature, semi-structured phone interviews were conducted with executives from eight diverse food and agriculture companies. Phone interviews were conducted to identify important project attributes to be evaluated in the CE. The detailed structure and process used to conduct the interviews is discussed in Roucan-Kane (2010). The objective of the interviews was to obtain direct information from decision makers regarding project characteristics that they take into account when choosing their company's innovation portfolio (Roucan-Kane 2010). All of the criteria from the literature in Table 1 (see Appendix) were mentioned by at least one of the respondents.

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It was found that financial return, time to market, risk, strategic fit, access to capability and competitive advantage considerations were particularly important. In the interviews, respondents mentioned that other qualitative criteria were usually considered as being embedded in financial return, particularly as more information was gathered about the project through time. As such, return to research, product demand, competition and market share were included in their financial calculations.

Various types of risk were identified by respondents, specifically regulatory, technical and market risk. Regulatory risk refers to the uncertainty associated with the regulatory approval process and whether the project will receive some kind of intellectual property rights protection (patent, copyright, etc.). Technical risk originates primarily from a lack of information from a technology standpoint (McGrath and MacMillan 2000). This type of risk was particularly important for technology intensive companies such as those in the seed sub-industry compared to companies in the food sub-industry. Market risk refers to the lack of certainty about consumer demand. It was found that firms usually take this into account by conducting sensitivity analysis on their financial return given various market assumptions.

In addition to risk, several respondents discussed governance structure and their search for partners to obtain knowledge in basic research as a factor in their decision making. Previous commitment (Hammond 1999) was a factor not widely covered in the literature but raised in the phone interviews. One respondent indicated that earlier investments in a project biased the "go/kill" decision in subsequent stages.

Econometric Modeling

Food and agribusiness executive behavior is analyzed using a choice experiment based on random utility theory. Random utility theory assumes individuals seek to maximize their expected utility subject to the choice set that they are given. This individual's utility is considered a random variable because the researcher has incomplete information (Manski 1977). Let utility be the sum of observable and unobservable components:

$$(1) \qquad U_{jt} = V_{jt} + \varepsilon_{jt}$$

where U_{jt} is the latent, unobservable utility for the jth alternative in choice set t; V_{jt} is the observable, systematic portion of utility determined by the attributes; and ε_{jt} is the random component of utility, independently and identically distributed over all alternatives and choice scenarios. The probability that alternative j will be selected is the probability that the added utility from this selection is greater than choosing another alternative presented in the choice experiment:

$$(2) \qquad (V_j - V_k) > (\varepsilon_k - \varepsilon_j) \forall\ j \neq k,\ j \in N$$

where N is the total set of alternatives available to the respondent (Boxall and Adamowicz 2002; Adamowicz et al. 1998) and choice set subscripts t are suppressed for simplicity. We cannot

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observe $(\varepsilon_k - \varepsilon_j)$, so the relationship in equation 2 cannot be determined exactly. But one can make statements about choice outcomes up to a probability of occurrence by calculating the probability that $(\varepsilon_k - \varepsilon_j)$ will be less than $(V_j - V_k)$. Therefore, the probability that an individual will choose alternative *j* is given by (Louviere, Hensher, and Swait 2000):

$$(3) \qquad P_j = P\left[(\varepsilon_k - \varepsilon_j) < (V_j\text{-}V_k)\right] \forall\ j \neq k,\ j \in N\,.$$

Assuming the ε terms are distributed according to the extreme value (type 1) distribution enables statistical estimation of the model parameters by maximum likelihood and yields the multinomial logit (MNL) or conditional logit model (McFadden 1974) for discrete choice modeling. The probability of choosing alternative *j* can then be expressed as:

$$(4) \qquad P_j = \frac{e^{\boldsymbol{\beta}\mathbf{X}_j}}{\sum_{k \in N} e^{\boldsymbol{\beta}\mathbf{X}_k}}$$

where **β** is a vector of parameters that relate the vector **X** of attributes to the utility of the jth alternative (Boxall and Adamowicz 2002; Adamowicz et al. 1998) and V_j is assumed to be linear in parameters according to:

$$(5) \qquad V_j = \boldsymbol{\beta}\mathbf{X}_j = \beta_1 x_{j1} + \beta_2 x_{j2} + \ldots + \beta_n x_{jn}$$

where x_{jn} is the nth attribute for alternative *j*, and β_n is the parameter associated with the nth attribute of the jth alternative. An alternative to the MNL model that allows the coefficient associated with each observed variable to vary randomly from one individual to another is the mixed logit (also called random-parameters logit). This model introduces individual decision maker preference heterogeneity that is not captured by the multinomial logit model, which assumes homogeneous preferences for the attributes contained in the CE. The mixed logit model also relaxes the independence from irrelevant alternatives assumption, and allows efficient estimation when the same individual makes repeated choices, as is the case in this study (Revelt and Train 1998).

The utility of attribute *j* for individual *i* in choice set *t* in the mixed logit model is distinct from equation (1) and is generally presented as (Tonsor et al. 2005):

$$(6) \qquad U_{ijt} = V_{ijt} + (u_{ij} + \varepsilon_{ijt})$$

where V_{ijt} is the systematic portion of the utility function, u_{ij} is an error term normally distributed over individuals and alternatives (but not over *t*, the choice sets), and ε_{ijt} is the stochastic error, independently and identically distributed over all individuals, attributes and choice sets. In a mixed-logit model, the probability of individual *i* choosing alternative *j* in choice set *t* is $P_{ijt}(U_{ijt} \geq U_{ikt})$ over all possible *k* attributes. Assuming V_{ijt} is linear in parameters, as in equation (5), the utility function can be expressed as

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$$U_{ijt} = \boldsymbol{\beta}_{ijt}\mathbf{X}_{ijt} + \left(u_{ij} + \varepsilon_{ijt}\right) \quad (7)$$

where X_{ijt} is a vector of individual-specific and alternative-specific attributes for choice set *t*, and β_{ijt} is a vector of preference parameters that is randomly distributed across individuals (Alfnes 2004; Tonsor et al. 2005).

The Choice Experiment

Choice experiments allow for the evaluation of trade-offs between attributes or characteristics pertinent to a specific decision. We use this approach to examine how agribusiness decision-makers choose among innovation projects. CEs differ from conjoint analysis of stated preferences which typically ask respondents to rate or rank alternatives, by having decision makers choose a single preferred alternative from a choice set made of various attributes and levels (Adamowicz et al. 1998).

Careful analysis of the findings from the literature review and interviews generated five project characteristics to be evaluated: risk of technical/regulatory failure, time to market, access to capabilities, probability of potential return and costs already incurred. These innovation project characteristics were broken down into attributes with varying levels. Table 2 (see Appendix) provides detailed descriptions of each attribute and their corresponding levels. Attributes were standardized to make them comparable across various agricultural sub-industries. For example, no specific length of time was assigned to the levels associated with the attribute "time to market" (*Mkt*) due to various differences in firms' planning horizons given the sub-industry in which they operate. As such, the level 'short-term to market' refers to innovations that could be developed, manufactured, marketed and commercialized in the "short-term", while "long-term" to market refers to innovations that would reach the market over a longer time frame.

The *Return (above average, average, below average)* attributes represent a project's distribution of potential return. For example, Return 50, 25,25, represents an innovation project with a 50% probability of generating an above average rate of return, 25% probability that the project will generate the average rate of return and a 25% probability that the rate of return will be lower than average.

In designing choice sets, it is important that every alternative represents a realistic combination of attributes and levels that characterize an innovation project. It is important for companies to select innovation projects that fit the firms' strategic direction and have potential for competitive advantage. Each choice set, comprised of three alternatives, was framed so that it included plausible choices. An example choice set is presented in Figure 1.

A project/alternative with no potential competitive advantage or strategic fit would never be chosen by the company. Therefore, respondents were asked to make their selection "assuming that all projects fit your organization's mission, strategic focus and have potential for competitive advantage."

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Among the following three innovation projects, which would your organization be most likely to choose?									
Characteristics	**Project 1**			**Project 2**			**Project 3**		
Risk of technical/regulatory failure	low			Low			high		
Time to market	long-term			long-term			short-term		
Access to capabilities	in-house			partner			in-house		
Probability of potential return	Above 25%	Near 50%	Below 25%	Above 50%	Near 25%	Below 25%	Above 50%	Near 0%	Below 50%
Costs already incurred	high proportion			low proportion			low proportion		

Figure 1. Example of a Choices Set Question Used in the Research

Experimental Design

An optimal fractional factorial experimental design was generated using the experimental design and choice modeling macro in SAS 9.2 (SAS 2008) that uses the PROC OPTEX procedure (Kuhfeld 2009). The experimental design constructed was made up of 20 choice sets (unique attribute-level combinations) which were split into two randomly assigned blocks to reduce response fatigue. Thus, each survey respondent was asked to complete a total of 10 choice sets. Following Kuhfeld (2009, 2005) and Pardoe (2006), the experimental design was evaluated with an artificial set of data and found to be amenable to analysis using the workhorse conditional logit model. The order of the attributes presented was randomized to control for order effects. Because innovation projects depicted by the CE are assumed to fit the company's mission and strategic focus and because executive decisions about innovation projects tend to be pre-screened by lower-level management, executives are presented only with the choice of which project in the choice set is best. At this point in a typical stage-gate process all purely dominated strategies have already been eliminated from a firm's choice set. Thus, an "opt-out" alternative was not included in the experimental design.

Data

The data for this study was collected using a survey of agribusiness executives (Roucan-Kane 2010). The survey was pre-tested with individuals in academia and industry, including six executives of food and agribusiness companies. Using a contact database provided by the Purdue Center for Food and Agricultural Business and the Purdue Department of Food Science, the survey was sent to a convenience sample of 849 executives in December 2009. The use of recruitment emails, referral to the correct respondent within a business, financial incentives, and an appealing survey interface were used to increase response rate, consistent with the procedures recommended by Dillman, Smith, and Christian (2009). A response rate cannot be calculated directly because of the inability to know which of the initial contacts were sent directly to a member of the target population and how many referrals to the correct person within each business occurred after recruitment emails were sent to the entire sample frame.

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The survey was composed of three sections that included questions on company characteristics (2008 fiscal revenue, scope, and governance structure), respondent characteristics (company position, education, experience selecting innovation projects, etc.) and the choice experiment. The data revealed that all of the respondents were involved in the selection of product innovations with 58% involved at the corporate level and 42% involved at the division or strategic business unit level. Thirty-seven percent of the respondents indicated they were executives, 21% had primarily marketing responsibility, 22% were involved in R&D, 7% had primarily sales management responsibility, and 13% indicated other responsibilities. The sample is fairly diversified across agricultural sub-industries with 25% of the respondents belonging to the food sector, 20% to animal nutrition, 17% to crop protection, 12% to seed companies, 9% to capital equipment, 7% to animal health, 1% to biotechnology, 1% to fertilizer, and 8% to other: grain handling, additives to seed, etc. Data on executives' firm revenue is shown in Figure 2.

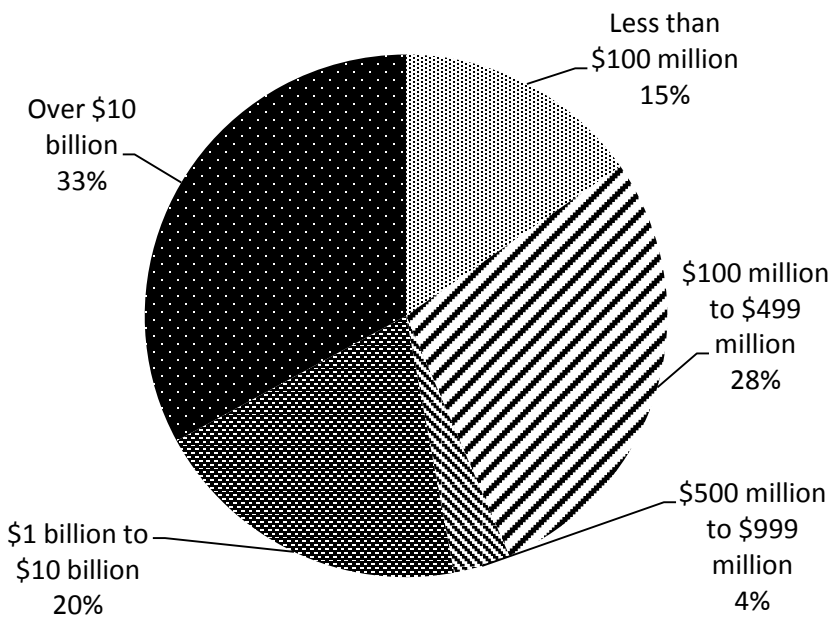

Figure 2. Distribution of Firm Revenue in the Sample

Estimation

The econometric model estimated specifies the observable, systematic portion of utility as:

$$\begin{aligned} V_i = {} & \beta_1(\text{Cost}) + \beta_2(\text{Mkt}) + \beta_3(\text{Technical failure}) + \beta_4(\text{Capability}) + \\ & \beta_5(\text{Return } 50, 25, 25) + \beta_6(\text{Return } 25, 50, 25) \\ & + \beta_7(\text{Return } 50, 0, 50) + \beta_8(\text{Return } 60, 25, 15) \end{aligned} \tag{8}$$

where all variables are dummy variables representing attribute-level combinations in the CE (Table 2, see Appendix). The variable *Cost* represents the level of costs already incurred in a

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given project (either high or low); *Mkt* is a variable capturing the time for the innovation project to reach the market and generate revenue; *Technical Failure* represents the risk of technical/regulatory failure; and C*apability* captures the origin of needed capabilities for the project. The *Return (above average, average, below average)* variables represent a project's distribution of potential return; the reference level for all of the return variables is a 33%, 34%, 33% distribution of returns.

A mixed logit model with the aforementioned utility function specification was estimated using the software NLOGIT 4.0. One thousand Halton draws were used for the simulation and all random variables were specified to vary according to a normal distribution. This variable specification allows for parameters to reflect both positive and negative utility associated with a project attribute.

Results

The mixed logit model estimation results are presented in Table 3. The overall model is highly significant ($\chi 2<0.001$). We find that companies are more likely to choose a project with a high proportion of costs already incurred. It is important to note that the coefficient associated with the variable *cost* is small and is only marginally significant, indicating that previous commitments have a limited practical effect on the decision. *Cost* has the smallest significant coefficient relative to the other parameters, indicating that the other attributes will have a stronger absolute effect on the investment decision.

Table 3. Effect of Project Characteristics on the Choice of Innovation Project

Variable/Attribute	**Mixed Logit Model**			
	Mean Coefficient		**Std. Deviation**	
Cost	0.24 (0.13)	*	0.26 (0.50)	
Market (*Mkt*)	-0.99 (0.23)	***	0.98 (0.60)	
Technical failure	-2.33 (0.44)	***	1.50 (0.52)	***
Access to capability	-0.47 (0.16)	***	1.56 (0.60)	***
Return 50, 25, 25	1.14 (0.31)	***		
Return 25, 50, 25	0.18 (0.21)			
Return 50, 0, 50	-0.52 (0.26)	**		
Return 60, 25, 15	1.63 (0.34)	***		
Goodness of fit				
Prob>chi-square	< 0.001	***		
Number of Simulations	1000			
N	85			

Note: Standard errors in parentheses. *, **, and *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.

Model results indicate that executives prefer projects with a shorter time to market, low risk of technical failure, and in-house capability. The coefficients on these attributes are highly significant, indicating a strong effect on the selection of innovation projects.

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Using the return distribution 33%-34%-33% as the reference level, all but one of the return distributions (*Return 25, 50, 25*) were found to have a significant effect on the choice of innovation projects. The lack of significance of *Return 25, 50, 25* suggests that the preference for this return distribution is not significantly different from the 33%-34%-33% return distribution in terms of market risk. *Return 50, 0, 50* represents the greatest downside risk and, as would be expected at this point in a firm's decision making process, is the only return distribution that is less preferred than the reference level.

Results from the mixed logit allow for examination of the distribution of preferences. Significant standard deviation coefficients around the mean of the variables *Technical failure* and *Capability* provide statistical evidence of preference heterogeneity around those attributes. As such, the mean coefficients of these variables are not representative of the overall sample. One can delve deeper into the analysis of heterogeneity among respondents by studying the magnitude of the standard deviations. The magnitudes of the standard deviations relative to the mean coefficients indicate that 94% prefer projects with low risk of technical/regulatory failure, and 62% prefer projects that require only in-house capability[1].

Respondents' Willingness to Trade-Off between Attributes

The coefficients estimated from a random utility model have little economic interpretation because of the non-cardinal nature of utility. These coefficients are typically used to calculate respondents' willingness to tradeoff (WTT) between attributes allowing for additional insights into executives' preferences. The WTT between two attributes (attribute 1 and attribute 2) is calculated as the total derivative of the systematic portion of the utility function with respect to changes in attributes 1 and 2, $dV_i = \beta_1 dx_1 + \beta_2 dx_2$, setting the result equal to zero, and solving for dx_2/dx_1. This yields the change in attribute 2 that keeps utility constant given a change in attribute 1. The result is the willingness to trade attribute 1 for an incremental increase in attribute 2, and is given by:

$$(9) \qquad WTT_{1,2} = \frac{dx_2}{dx_1} = -\frac{\beta_1}{\beta_2} \ .$$

This ratio is most commonly reported as a willingness to pay measure where x_2 is a cost variable in the marketing literature (Hole 2007b). In the present context, WTT is a non-monetary measure of the willingness to tradeoff one attribute of an innovation project for another attribute.

When the standard deviation coefficients of the attributes are not statistically different from zero in the mixed logit model, the estimated mean WTT can be interpreted as being representative for the entire sample. Where evidence of preference heterogeneity exists (i.e., if the estimated standard deviations are statistically significant), the mean WTT estimates are not representative of the entire sample. Given that WTT is derived as the ratio of two random variables, a method

[1] These figures are given by $100 * \Phi(-\hat{\beta}_k / \hat{S}_k)$, where Φ is the cumulative standard normal distribution function and $\hat{\beta}_k$ and $\hat{S}_k$ are the mean and standard deviation, respectively, of the *k*th coefficient (Hole 2007a).

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capable of calculating the variance of a non-linear function of two or more random variables is needed to evaluate the significance of the WTT measures. A variety of methods exist to determine confidence intervals on the WTT estimates, including the delta, Fieller, Krinsky-Robb, and bootstrap methods; these four methods have all previously been found to be reasonably accurate and yield similar results to one another (Hole 2007b). The delta method was implemented to calculate these variances by a first-order Taylor series expansion around the mean value of the random variables following Hole (2007b):

$$\text{(10)} \qquad \operatorname{var}\left(\hat{\mathrm{WTT}}_1\right)=\left(\left(-1/\hat{\beta}_2\right)^2 \operatorname{var}\left(\hat{\beta}_1\right)+\left(\hat{\beta}_1/\hat{\beta}_2{}^2\right)^2 \operatorname{var}\left(\hat{\beta}_2\right)+2\left(-1/\hat{\beta}_2\right)\left(\hat{\beta}_1/\hat{\beta}_2{}^2\right)\operatorname{covar}\left(\hat{\beta}_1,\hat{\beta}_2\right)\right)$$

Using the delta method estimate of the variance, a confidence interval can then be constructed to evaluate the significance of the WTT measures as $WTT_1 \pm z_{\alpha/2}\sqrt{\operatorname{var}\left(\hat{WTT}_1\right)}$. For 99%, 95%, and 90% confidence intervals, $z_{\alpha/2}$ equals 2.576, 1.96, and 1.645, respectively. The WTT measures are statistically significant for a given confidence interval if the confidence interval does not include zero and the coefficient is contained within the range of the confidence interval.

Table 4 reports the WTT measures and their statistical significance based on the confidence intervals calculated by the delta method. A positive WTT measure indicates respondents' WTT between two attributes, while a negative WTT signifies respondents' unwillingness to tradeoff between two attributes. Using time to market as the reference, the positive figure 0.25 indicates that the respondents are willing to take on a project where more of the costs have already been incurred (so with more previous commitments) by giving up short-term to market and taking on a longer-term project. A negative willingness to trade measure indicates that respondents are not willing to trade or must be compensated in the form of another attribute to take on more of an attribute. For example, the figure -0.47 in the first row of Table 4 can be interpreted as follows: respondents are willing to forgo a project that requires only in-house capability in exchange for a project that will require partnering, if in return they are given a shorter term to market for the project. The figure -2.35 suggests that respondents will take-on more risk of technical/regulatory failure in exchange for a shorter-term project.

The magnitude of the significant WTT figures can be compared across a single row of Table 4 to determine respondents' relative preference for each attribute. When the tradeoffs are estimated with (time to) Market as the reference, respondents' preferences for the attribute risk of technical failure is more than three times greater in absolute value than the next largest WTT estimate. The signs of the WTT measures indicate the individual attribute levels the respondents prefer. For example, if one continues to use time to market as a reference, the negative WTT for capability and risk of technical failure indicate that respondents prefer in-house capability and low risk of technical failure. Similarly, looking at the magnitude of these WTT measures for the reference Capability, one can rank respondents' preferences as follows: low risk of technical/regulatory failure is preferred to the return distribution (60%, 25%, 15%), which is preferred to the return distribution (50%, 25%, 25%), which is preferred to short-term to market, which is preferred to the return distribution (50%, 0%, 50%), which is preferred to low costs already incurred. Alternatively, the magnitude of the tradeoffs for the reference Technical Failure leads to the following descending ranking of preferences: the return distribution (60%, 25%, 15%), return

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distribution (50%, 25%, 25%), short-term to market, in-house capability, and low costs already incurred.

Table 4. Derived Willingness to Tradeoff (WTT) Measures

Cost	Capability	Market	Technical Failure	Return 50, 25, 25	Return 25, 50, 25	Return 50, 0, 50	Return 60, 25, 15
Willingness to tradeoff column attribute *x* with (time to) Market							
0.25**	-0.47***	na	-2.35***	0.49**	0.08	-0.22	0.70**
Willingness to tradeoff column attribute *x* with Capability							
0.54**	na	-2.13***	-5.01***	2.54***	0.4	-1.11*	3.50***
Willingness to tradeoff column attribute *x* with Technical Failure							
0.11**	-0.20***	-0.43***	na	0.49***	0.08	-0.22**	0.70***
Willingness to tradeoff column attribute *x* with Cost (already incurred)							
na	1.87**	3.99**	9.35**	-4.58*	-0.74	2.08	-6.54**

Notes. *, **, and *** indicate the WTT estimate falls within the 90%, 95%, or 99% confidence interval, respectively. All confidence intervals calculated by the delta method following Hole (2007b) are available from authors upon request.

Conclusion

In today's business environment, innovation is critical to firm success. Therefore, understanding and researching how companies select their innovation projects is critical to help develop benchmarks that can be used by companies. A choice experiment was conducted with 85 executives of U.S. food and agribusiness companies. Survey respondents' stated preferences for innovation projects were elicited based on five criteria: distribution of potential return (market risk), risk of technical/regulatory failure, time to market, capability, and costs already incurred.
The results indicate that the magnitude of these considerations vary with companies preferring (in decreasing order of importance) projects with low risk of technical/regulatory failure, low relative market risk, short-term to market, in-house capability, and high costs already incurred. It is surprising to see such a high influence of the risk of technical/regulatory failure and a relatively lower influence of market risk. A possible explanation is that technical/regulatory risk, as distinct from market risk inherent in any new innovation, may be viewed as avoidable and therefore not entirely beyond companies' control when selecting innovation projects.

Global demand for food is expected to increase for at least another 40 years, with continuing population and consumption growth expected (Godfray et al. 2010). Given the need to feed this growing population in the years to come, food and agricultural industries may be able to meet these demands by achieving breakthrough innovations in their supply chains. However, the results of this research suggest that firms avoid choosing projects with a high risk of technical/regulatory failure, likely limiting the probability of achieving breakthrough innovations. It is, therefore, critical for firms to consider strategies to manage the risk of technical/regulatory failure if they cannot avoid it. For example, firms need to make sure they invest enough time monitoring and attempting to influence the regulatory landscape, and should develop formal processes to increase the probability of obtaining regulatory approval.

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From a policy standpoint, governments should consider ways to reduce the technical/regulatory risk facing agricultural companies by clearly communicating the requirements, procedures, expectations, and timelines for regulatory processes. More transparent regulatory processes can reduce uncertainty that may hinder the innovation process within the agricultural sector and may facilitate more open innovation. Policy makers could stimulate open innovation through government sponsored research and cost-sharing programs that require partners (public or private). To address the challenges of open innovation, such as Intellectual Property Rights appropriation, better guidelines could be developed for companies to be more willing to engage in innovation projects with other firms and public research institutions.

Despite the limitations of research based on a small convenience sample of agri-food executives, this study reports results from a population not often surveyed and opens up a wide area of future research to study the innovation selection process of companies. It would be interesting to follow up on this study with a choice experiment designed to characterize market risk in a different fashion that would allow the estimation of tradeoffs between different probabilities of market return outcomes. New respondent demographics that may have an effect on the decision could also be identified. To match the decision-making process with reality, the survey could be done by several respondents from one company discussing and completing the survey together. In addition, several studies dealing with choice experiments (e.g. Revelt and Train 1998) have compared the effect of attributes from both stated and revealed preference data. Although analyzing revealed preferences in the case of innovation projects is likely to be cumbersome and require intense collaboration with companies, the results of such a study could significantly increase our understanding of the innovation process.

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Appendix

Table 1. Criteria Considered by Firms when Making Product Innovation Selection Decisions

Criterion	Definition	Studies
Project Attributes		
Reasonable financial return	Estimation of a reasonable return (revenue minus cost)	DePiante Henriksen and Traynor (1999), Ringuest and Graves (1989)
Time to market	The project's length of time from ideation to product launch	Mikkola (2001), Farrukh et al. (2000), Cooper at al. (1999)
Risk	Scientific/ technical, market uncertainty; probability of failure or success	Bard et al. (1988), Day (2007)
Organizational Attributes		
Relevance	Degree to which the proposed project supports the organization's mission and strategic objectives, and satisfies customers' needs	DePiante Henriksen and Traynor (1999), Day (2007)
Capability and Competitive advantage	Company's capability to produce and market the product compared to competitors	Day (2007)
Return to research	The impact of the project on basic research, synergistic concurrent project(s), and development of new projects or second generation innovation	DePiante Henriksen and Traynor (1999)
Internal competition	Will the project cannibalize firm's current offerings?	Bard et al. (1988)
Market Attributes		
Product demand	Is there a market? Is it big enough?	Day (2007), Ringuest and Graves (1989), Bard et al. (1988)
Competition/ Market share	What will be the number of competitors? How aggressive will they be? How successful will their product be?	Day (2007), Ringuest and Graves (1989), Bard et al. (1988)
Environmental Attributes		
Intellectual Property Rights/ Protection	Ability to achieve sustainable competitive advantage via patents or proprietary knowledge	Cooper at al. (1999)

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Table 2. Attributes and Levels in the Choice Experiment Design

Attribute	Description	Levels	Coding
Cost	Level of cost already incurred in the project	Low High	0 1
Time to Market (Mkt)	Time for the innovation project/alternative to reach the market and generate revenue	Short-term Long-term	0 1
Technical Failure	Level of risk of technical/regulatory failure, i.e., intensity of technical and/or regulatory hurdles	Low High	0 1
Capability	Origin of needed capabilities for the project/alternative	The capabilities are available or will be developed in-house The needed capabilities come from other companies through some form of governance structures	0 1
Return 33, 34, 33	The innovation project/alternative has a (33%, 34%, 33%) distribution of potential return	Reference level for distribution of return dummy variables	-
Return 50, 25, 25	The innovation project/alternative has a (50%, 25%, 25%) distribution of potential return	No Yes	0 1
Return 25, 50, 25	The innovation project/alternative has a (25%, 50%, 25%) distribution of potential return	No Yes	0 1
Return 50, 0, 50	The innovation project/alternative has a (50%, 0%, 50%) distribution of potential return	No Yes	0 1
Return 60, 25, 15	The innovation project/alternative has a (60%, 25%, 15%) distribution of potential return	No Yes	0 1

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