International Food and Agribusiness Management Review
Volume 14, Issue 4, 2011

Approaches for Selecting Product Innovation Projects in U.S. Food and Agribusiness Companies

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Abstract

Although executives acknowledge the strong link between innovations and performance, they are still challenged by crossing the bridge from great ideas to revenue. The objective of this paper is to understand better the approaches used by the food and agricultural sector to select product innovation projects, and to draw a picture of an innovation portfolio of a food and agribusiness company. This paper adds to the management literature by studying a different sector, the U.S. agricultural sector and focusing on the implementation of theoretical models. The survey of about 100 companies, indicate that the food and agribusiness sector tends to use cross-functional teams and several selection methods when they select product innovation projects. This selection process yields to a diversified portfolio in terms of potential for return, time to market, and costs already incurred. However, companies tend to be biased towards in-house and low risk projects. Company and industry characteristics' effects on the results are present but limited. It is important to note that this dissertation does not study the effect of these practices on performance, which is a necessary follow-up.

Keywords: food, agribusiness, innovation, selection method, portfolio, functional area, cluster analysis

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Introduction

Innovation is critical to the long-term success of a firm as well as the economic health of an industry and the overall economy (Gertner 2004). Brown and Teisberg (2003, p1) stated that "Innovation is the lifeblood of successful businesses. […] [It] has become every firm's imperative as the pace of change accelerates". Indeed, innovations are one strategy to develop and maintain a sustainable competitive advantage (Kirwin et al. 2008; Shanahan et al. 2008; Mikkola 2001; Bard et al. 1988) and to grow (Boehlje and Roucan-Kane 2009). Innovation is also essential to respond to the critical concerns of society such as climate change and global warming, food/energy scarcity and security, environmental challenges or resource use/sustainability.

McKinsey found that more than 70% of top business executives consider that innovation will be at least one of the top three drivers of growth for their company in the next three to five years (Barsh et al. 2008). Although executives acknowledge the strong link between innovation and performance, they are still challenged to cross the bridge from great ideas to revenue. Delivering on the promise of innovation is further complicated by shareholders' need for predictable and sustainable growth. Generating sustainable short-term and long-term growth through the selection of the right innovation projects is the main challenge facing companies in today's dynamic business environment. Most organizations find that they have several good ideas but lack the strategy, frameworks, processes, and funding required to select and convert the best ideas into new revenue (Anthony et al. 2006; Huurinainen 2007).

The literature on innovation management combines numerous different terminologies. In the resource-based view (RBV) of strategy and firm behavior and decision-making, innovations are defined as new combinations of existing and/or new resources and competencies (Penrose 1959, 85). There is a distinction between invention and innovation. Invention consists of the development of an idea for a new product, process, or business model. The innovation term goes further and includes both the invention process but also the use of that idea (Roberts 1988). An important part of the product innovation process is the selection of innovation projects to include in an innovation portfolio.

Empirical studies of the innovation process are limited (Cooper et al. 1997; Cooper et al. 2001; Cooper et al. 2004a, b, c; Huurinainen 2007; and Killen et al. 2007). In addition, although the agribusiness sector is no stranger to innovation, even less has been done on the innovation practices of agribusiness companies. Even though in terms of Research and Development (R&D) spending as a percentage of sales, the food and agricultural industries are not perceived as a high tech industry, there has been significant new product development in food products and agricultural production inputs. Over the last 150 years, there have been several waves of innovation related to agricultural machinery, chemistry, seed, and information management as well as new food products at the retail level (Graff et al. 2003; Gray et al. 2004). Therefore, using descriptive statistics and cluster analysis, the focus of this article is the study of the selection of product innovation projects by food and agribusiness companies through the analysis of survey data.

The selection of product innovation projects by food and agribusiness companies is only part of the entire innovation process. The innovation process starts with developing and maintaining a culture of innovation within the company. Many authors have developed and studied frameworks that stimulate innovation ideas (e.g., Roth and Sneader 2006; Brown 2005; Barsh et al. 2008; Huurinainen 2007). In addition, the selection is a continuous process that happens all throughout the development of innovation projects. Cooper's stage-gate process (Cooper 2001) proposes a structure to continuously analyze the portfolio of innovations and increase the likelihood of success in an uncertain world. His structure encompasses five innovation stages: scoping, building a business case, developing the idea/prototyping, testing and validating, launching). At the end of each stage (and sometimes within a stage), the resource allocation and the prioritization of projects is reviewed and changed if needed. This prioritization is Cooper's "gate". This paper focuses on the selection of product innovation projects at each gate of Cooper's stage-gate process.

There are a myriad of innovations that can be organized into several categories: product, service, process and business model innovations. The scope of this paper is limited to product innovations for three principal reasons: 1) product innovation is quite different from the other aspects of innovation, 2) the increasing pressure on the agricultural industry to produce more food with less resources will require agribusiness firms to continuously improve their product innovation processes, and 3) it simplifies the survey process to allow for better clarity in responses. This is not to say that other aspects of innovation are any less important.

This article presents findings of a survey of 109 top executives of U.S. agricultural and food companies regarding their selection of product innovation projects and the portfolio of projects resulting from these practices. The survey instrument is available from the authors upon request. Given the lack of consensus on how to measure the success of innovation (e.g., Subramanian and Nilakanta 1996; Sampson 2007; Ahuja and Katila 2001) and the lack of previous literature on the ag sector, this paper does not attempt to study which selection approaches lead to the best innovators[1]. This paper focuses on indicating what previous research has shown to be the selection process of the best innovators across industries, and whether food and agribusiness companies are implementing those approaches. Specifically, to help executives who struggle at selecting innovation projects the literature has developed and shows that involving several functional areas in the selection process and using several selection methods will yield to better innovation performance and a more diversified portfolio. Therefore, the main research questions posed in the survey are:

1) Who is involved in the process of selecting product innovation projects in food and agribusiness companies?
2) What are the most common selection methods used by food and agribusiness companies when selecting product innovation projects?
3) What are the key characteristics of food and agribusiness companies' product innovation portfolios?
4) Does the selection of product innovation projects for food and agribusiness companies vary with company and industry characteristics?

The rest of the paper is organized as follows. We start with a presentation of the survey used to answer the research questions. The results are then presented with a focus on cross-functional teams, followed by the selection methods, and then a focus on product innovation portfolios. The

[1] Cooper et al. (2001) define best innovators/performers as companies that have high value projects, the right balance of projects, a portfolio that fits the strategy of the firm, the right number of projects, and etc.

difference across various company characteristics and industry characteristics is discussed in each results section. The data is then analyzed using cluster analysis to draw additional insights. The last section of this paper concludes the discussion.

The Survey

The survey was created and administered online in December 2009. The use of the Internet media for data collection presents advantages and disadvantages. Web-based surveys allows accessing an audience that are otherwise hard to reach and often travelling, while at the same time may create sampling issues by not reaching audiences that do not have access or are not comfortable with the technology (Wright 2005; Llieva et al. 2002). Using web-based surveys avoid paper, postage, and transcription costs and even costs associated with the collection of data with the use of some online survey software (Wright 2005; Llieva et al. 2002). Web-based surveys have also been associated with longer answers to open-ended questions than paper surveys (Llieva et al. 2002).

The software Qualtrics was used to generate and implement the survey. The online survey allowed randomization of questions and answer categories to control for some answer bias. Question branching was also automated to reduce respondent fatigue and increase response rates. Finally, the online format allowed for more timely responses and a more controlled environment to improve response rates. The survey link was sent via email to 849 top executives of food and agribusiness companies using the contact database supplied by the Center for Food and Agricultural Business (CAB) and the Purdue University Food Science department. These 849 executives represented all executives included in the database working for companies expected to be doing some form of product innovation. The survey included a number of questions within each of three areas:

1) The approaches used by companies when selecting product innovation projects (the functional areas involved in the selection and the top three selection methods used).
2) The company's portfolio of product innovation projects (percentage of projects with different return distributions, percentage of short-term versus long-term projects, percentage of projects using primarily in-house capability versus projects using partners capability, percentage of projects with low costs already incurred versus projects with a large proportion of costs already incurred, and percentage of projects with low risk versus high risk of technical/regulatory failure).
3) The company's descriptive profile (2008 fiscal revenue, scope, governance structure, primary sub-industry; and whether innovation is part of the company's core strategy).

A total of 136 surveys were returned out of the 849 recruitment emails. Of the 136 surveys, 109 surveys were usable; resulting in a 12.8 percent response rate. An examination of responses from surveys answered after the reminder email versus those responding to the initial email showed no statistically significant differences across time. This would suggest non-response bias is minimal; nonetheless a low response rate suggests using caution about broad implications from these results. The respondents were all involved in the selection of product innovations with 60 percent involved at the corporate level and 40 percent involved at the division/Strategic Business Unit (SBU) level. As to management responsibilities, 36 percent indicated they were a member of the executive management team (CEO, COO, etc.), 21 percent had primarily marketing responsibility, 21 percent were involved in R&D, 8 percent had primarily sales management responsibility, and 14 percent indicated other responsibilities (e.g., finance, human resource, production, public relations, etc.).

These respondents represented several agricultural sub-industries, revenue ranges, governance structure, and scope. Regarding sub-industries, 23% of the respondents belong to the food sector, 20% to animal nutrition, 18% to crop protection, 12% to seed companies, 9% to capital equipment, 6% to animal health, 1% to biotechnology, and 10% to other. As for firm's revenue, 18% of the respondents worked for companies with a revenue of less than $100 million, 24% with revenues between $100 and $499 million, 5% in the revenue range of $500 to $999 million, 20% with revenues between $1 and $10 billion, and 33% with revenues over $10 billion. In terms of governance structure, 47%, 40%, and 13% of the respondents come from private firms, public firms, and cooperatives respectively. Regarding company scope, global companies make up most of the sample (67%), followed by multi-state firms (18%) and national firms (15%). Finally, given the importance of innovation in the growth and even survival of the companies, it is not surprising to see that most respondents (79%) state that innovation is part of their company's core strategy which shows a large commitment to innovation by agribusiness companies. Nonetheless, 18% report that innovation is not part of their company's core strategy and 2% have doubts ("do not know") despite their involvement in the innovation process of their company.

The Results

Responsibility and Cross-Functional Teams

The innovation literature has advocated the use of cross-functional teams to allow for a smoother and higher performing innovation process (e.g., Cooper et al. 2004b; Christensen et al. 2004; and Christensen and Raynor 2003). Cross-functional teams have been defined in the literature as a group of people with different functional specialties or skills that are responsible for carrying out all phases of the innovation process. Research on non-ag industries has shown that innovation processes use only a few functional areas (e.g., Huurinainen 2007; Cooper et al. 2004b; and Kelley 2005). It is hypothesized that food and agribusiness companies are no different than companies in other industries in regards to the implementation of cross-functional teams, i.e., a few functional areas are involved. It is also hypothesized that industry and company characteristics will affect the number of functional areas and the type of functional areas being used.

Respondents were asked to select all the functional areas involved in the selection of product innovation projects for their company. The categories offered to them were Executives, Marketing, Research and Development (R&D), Sales, and Other. The functional area the most likely to be involved was Research and Development (R&D) (with 90% of the respondents selecting it) followed by executives (89%), marketing (77%), sales (61.5%), and other (18%)[2]. Of the respondents who selected other and gave an explanation, 7 specified manufacturing/operations, and two listed finance. These are interesting numbers that show that sales and marketing were selected by

[2] Note that many companies use more than one functional area so the percentages of functional areas sum to well over 100%.

statistically significantly fewer firms. This suggests some firms rely less on functional areas close to the customer in the selection of product innovation projects.

On average, respondents selected 3.36 functional areas (out of 5) suggesting the existence of cross-functional teams. Seven respondents reported just one functional area (R&D or executives) involved in the selection of product innovation projects. In addition, the pair marketing and sales was never selected by itself. Future research should examine if excluding sales and marketing people from the selection process impacts a firm's innovation performance.

Based on results from past studies (Henderson 2007; Herath et al. 2010; Van Moorsel et al. 2005), it is hypothesized that industry and company characteristics will impact the number of functional areas and the type of functional areas included in the selection of product innovation projects. For example, it may be physically easier for smaller firms (e.g., firms with revenue <$1 billion or multi-state companies) to assemble cross-functional teams because of physical proximity. The data show that that there are indeed significant differences by company and industry characteristics (see Table 1). As expected, the size of the firm has some effect. Specifically, the sales department is more likely to be involved in smaller firms (in terms of revenue, scope, and governance structure) possibly because smaller firms are less likely to have a clear separation between functional areas. Firms committed to innovation are less likely to involve the sales department. A possible explanation is that salespersons tend to be too biased towards short-term projects, failing to see the potential of longer term projects.

As for sub-industry differences, the crop input sub-industry (crop protection, fertilizer, seed, and biotechnology) tends to use more functional areas and is more likely to involve marketing than the other sub-industries (animal nutrition, animal health, capital equipment, and food). Finally, the type of governance structure did not have a significant effect on the number of functional areas and the type of functional areas involved.

Selection Methods

Numerous R&D project selection methods (informal methods, graphical analyses, structured assessments, economic models, and complex models) have been proposed to help organizations make better decisions regarding innovation. Table 2 presents a definition of each of those methods.

No single selection method presents only advantages. They all have drawbacks and are actually extremely complementary of each other leading many such as Cooper et al. (2001) to find that the best innovators/performers (i.e., the companies that have high value projects, the right balance of projects, a portfolio that fits the strategy of the firm, the right number of projects, etc.) are using several selection methods. This leads to the question: Which and how many selection methods are used in the food and agribusiness industry for product innovation projects?

According to the findings from other industries (Cooper et al. 2001; Kester et al. 2009) and discussions with agribusiness companies, economic models are expected to be the most common selection method used for product innovation projects. Respondents were asked to answer the question: “Which of the following portfolio management selection methods best describe your

Table 1. Differences in the Use of Functional Areas across Company and Industry Characteristics

Functional Area Variable	Revenue <$1 billion	Revenue ≥ $1 billion	Multi-state	Global	Private	Public	Committed to innovation	Others	Crop inputs	Livestock inputs	Food
	Percentage of respondents reporting the use of:										
Executives	90%	88%	95%	92%	94%	93%	88%	95%	94%	89%	84%
Marketing	75%	79%	85%	73%	77%	73%	80%	70%	89%*	68%	72%
Sales	73%**[a]	52%**	80%*	55%*	75%**	50%**	57%*	80%*	69%	75%	52%
Mean of functional areas selected	3.47 (1.05)[b]	3.26 (1.04)	3.65 (0.88)	3.30 (1.08)	3.55 (1.03)	3.27 (1.11)	3.35 (1.06)	3.50 (0.89)	3.63* (0.94)	3.43 (0.96)	3.24 (1.16)

[a] *, **, and *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.
[b] Standard deviations are indicated in parenthesis.

Table 2. Definition of R&D Project Selection Methods

Informal methods	Graphical analyses	Structured assessments	Economic models	Complex models
Opportunistic: Take on projects as opportunities arise *Gut feeling:* Choose projects that sound successful *Scientist driven "genius" award:* Let (successful) researchers choose their innovation projects *Unstructured peer review:* Two or more referees (such as expert, peer, …) comment on the same innovation project	Provide a visual picture of the portfolio of innovation project over a few dimensions used as determinants of success: reward; probability of risk; ease of undertaking; newness; project attractiveness; competitive advantage and benefits to customers; time to market; strategic fit; protectability with patents, secrets, copyright, …; synergy between projects; relative market share and industry growth rate; company's business strength and industry attractiveness.	Decision makers score each project on a series of criteria that are each given a weight. Projects are then compared based on their weighted score	These models attempt to calculate a financial value for each project	*Mathematical programming:* select the projects that will optimize some objective function(s) subject to a set of constraints *Game theory:* Evaluate strategies with explicit consideration of competitors' actions *Cognitive modeling / Artificial intelligence:* model previous decisions to automatically make decisions regarding a new project that has comparable circumstances

company's primary selection process? (Please check the 3 most important methods)". As hypothesized, economic models are the most popular methods by being selected by 73% of the respondents, followed by informal (which is a bit surprising) checked by 63% of respondents, and structured assessments chosen by 51% of respondents. Graphical analyses are not used as much (only 33% of the respondents) which differs from Cooper et al.'s findings that they were the second most popular method after economic models. The lack of popularity of the complex models (only 3% of the responses) is not surprising given the significant costs associated with their implementation and their requirement for specific skills.

Respondents were allowed to report up to three selection methods, focusing on the most important methods used in their company's selection process of product innovation projects. The majority of the respondents (53%) selected 3 methods, 23% selected 2 methods, and 24% selected 1; resulting in an average of 2.27 selection methods per company (similar to the 2.34 average reported in Cooper et al. 2001; p16).

Table 3 shows that there are significant differences by company and industry characteristics in selection methods. It is interesting to note that company size has no impact on the number of methods used. However, smaller firms (in terms of revenue) use more informal methods while larger firms use more economic and structured methods. A possible explanation for this result is that larger firms may have more resources to develop more formal selection methods.

Publicly traded firms are expected to be more likely to use economic models because of the pressure to generate returns for stockholders. This hypothesis is confirmed in Table 3. Publicly traded firms are also less likely to use informal methods and more likely to use structured methods for the selection of product innovation projects. This may again be a result of stockholders' pressure or a size effect as discussed earlier.

Table 3. Differences in the Use of Selection Methods across Company Characteristics

Selection Method Variable	Revenue <$1 billion	Revenue ≥ $1 billion	Multi-state	Global	Private	Public
Economic models	65%	79%	55%**[a]	80%**	63%**	82%**
Informal methods	84%***	43%***	80%	59%	75%**	48%**
Structured assessments	37%**	62%**	40%	55%	39%**	61%**
Graphical analyses	33%	33%	35%	32%	29%	36%
Average number of selection methods	2.27 (0.85)[b]	2.26 (0.87)	2.2 (0.89)	2.32 (0.83)	2.16 (0.88)	2.36 (0.84)

a *, **, and *** represent 0.10, 0.05, and 0.01 levels of statistical significance, respectively.
b Standard deviations are indicated in parenthesis.

Innovation Portfolio

Most strategy experts suggest investing in a diversified portfolio to limit risk (McGrath and MacMillan 2000). The innovation literature is no different given the risk embedded in innovation projects (Cooper 2004b). In this study, the diversification of the portfolio of product innovation projects is analyzed over five selection criteria dimensions. These five dimensions and their levels were chosen based on an extensive review of the innovation literature (e.g., DePiante Henriksen and Traynor 1999; Ringuest et al. 1999; Day 2007; Bard et al. 1988) as well as intensive phone interviews (using Yin's suggestions, 2003) with top executives of eight food and agribusiness companies in different sub-industries and of different size.

The five dimensions used were: distribution of potential return/market risk, risk of technical/regulatory failure, time to market, capability, and costs already incurred. Distribution of potential return/market risk indicates the probability that the product innovation's potential return will be below, near, or significantly above the average return of the firm's innovation projects which will depend on consumer acceptance. Risk of technical/regulatory failure specified whether the product innovation project is expected to have some significant technical/regulatory hurdles or not. Time to market defines whether the product innovation will reach the market and generate revenue in the short or long term. The capability criterion indicates whether or not the product innovation project will require working with other firms to have access to all the capabilities (financial resources, technological skills, infrastructure, capital equipment, and access to customers). Finally, costs already incurred refers to the amount of the product innovation project's total budget that has already been spent.

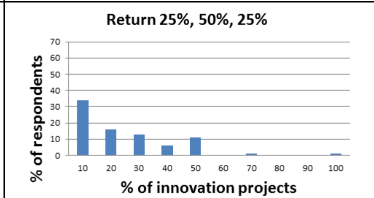
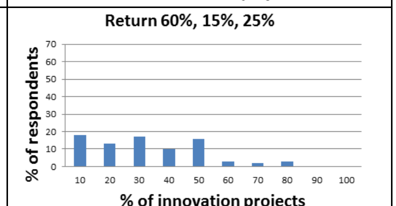
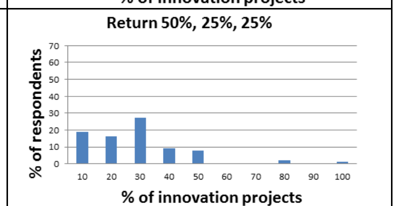
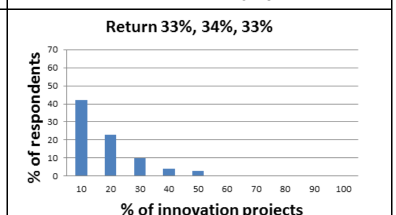
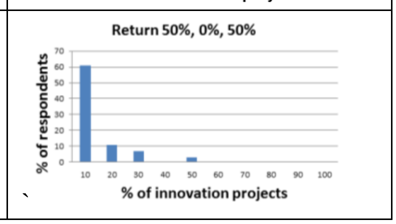
Table 4 summarizes the survey results in regards to the firm's portfolio of product innovation projects across a spectrum of risk/return distributions. The mean of the portfolios across respondents suggests that companies have a diversified set of product innovation projects with regards to return. They however maintain some bias towards distributions with high percentages for the probabilities near and above the hurdle rate (e.g., Return 60%, 25%, 15% and Return 50%, 25%, 25%), i.e., with low relative market risk. The distribution of individual firm responses indicates that the variable return (50%, 0%, 50%) is the most skewed to the left which indicates that the smallest portion of the companies' product innovation portfolio is made of projects with high potential return but also high potential unacceptable returns. The second distribution the most skewed to the left is (33%, 34%, 33%), followed by (25%, 50%, 25%), (50%, 25%, 25%), and (60%, 15%, 25%). These distributions suggest again that respondents prefer product innovation projects with low relative market risk.

As for risk of technical/regulatory failure, on average, the product innovation portfolio of companies presents a majority of projects with low-risk of technical/regulatory failure. The distribution of individual firm responses for this variable is bi-modal with a slightly greater percentage of companies with a portfolio heavily rich in product innovation projects with low risk of technical failure. The bi-modal distribution suggests a fairly heterogeneous group when it comes to investments in low or high technically/regulatory risky product innovation projects.

As for the capability characteristics, portfolios include a majority of in-house product innovation projects on average. However, the distribution of the in-house variable suggests that companies are again fairly heterogeneous in their portfolio regarding capability. Finally, on average, companies have diversified their product innovation projects when it comes to costs already incurred and time to market. However, the distributions suggest heterogeneity in those characteristics from one company portfolio to another.

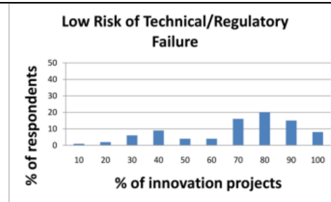
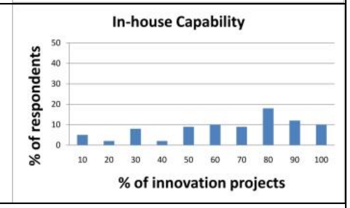
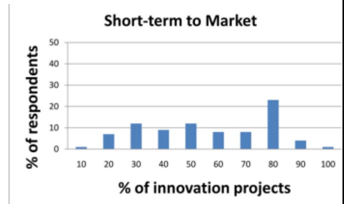
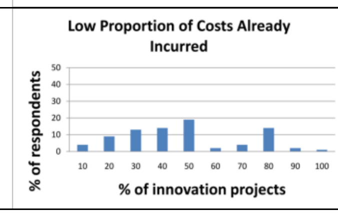
Table 4. Innovation Portfolio of Food and Agribusiness Companies[3]

<table>
<tr><th>Question</th><th>Variable</th><th>(Mean) Standard Deviation</th><th>Distribution of Individual Firm Responses</th></tr>
<tr><td rowspan="5">The table below provides five different levels of uncertainty in the potential return of innovation projects. What is your estimate of the proportion of your company's R&D budget that is invested in projects at each level of uncertainty?

<table>
<tr><th colspan="3">Probability of potential return relative to the Hurdle Rate</th><th rowspan="2">Percentage of your R&D Budget</th></tr>
<tr><td>Above</td><td>Near</td><td>Below</td></tr>
<tr><td>25%</td><td>50%</td><td>25%</td><td></td></tr>
<tr><td>60%</td><td>15%</td><td>25%</td><td></td></tr>
<tr><td>50%</td><td>25%</td><td>25%</td><td></td></tr>
<tr><td>33%</td><td>34%</td><td>33%</td><td></td></tr>
<tr><td>50%</td><td>0%</td><td>50%</td><td></td></tr>
</table></td>
<td>Return 25%, 50%, 25%</td><td>20.96% (18.88%)</td><td>
</td></tr>
<tr><td>Return 60%, 15%, 25%</td><td>29.91% (20.69%)</td><td>
</td></tr>
<tr><td>Return 50%, 25%, 25%</td><td>26.16% (18.00%)</td><td>
</td></tr>
<tr><td>Return 33%, 34%, 33%</td><td>13.82% (12.51%)</td><td>
</td></tr>
<tr><td>Return 50%, 0%, 50%</td><td>9.15% (11.91%)</td><td>
</td></tr>
</table>

[3] Please note that the y axes for all the graphs/histograms have a maximum of 50% (except the y axis for Return 50%, 0%, 50% which goes up to 70%) to allow for comparison and an easy read of the table.

Table 4[4]. Continued

Questions	Variable	(Mean) Standard Deviation	Distribution of Individual Firm Responses
What are the percentages of your company's product innovation projects with: Low risk of technical failure: Exclusively or primarily in-house capability: Short-term to market: Low proportion of the total budget already committed:	Low risk of technical failure	23.69% (67.87%)	
	Exclusively or primarily in-house capability	26.34% (64.33%)	
	Short-term to market	23.07% (55.34%)	
	Low costs already incurred	22.35% (46.94%)	

Some industry and company characteristics were found to impact the characteristics of the product innovation portfolio. For example, the data indicate that smaller firms (lower revenues and firms of small scope) choose fewer risky product innovation projects: they have more short-term projects and fewer technically risky projects. Meanwhile, larger firms are more likely to have product innovation projects with the return distributions (60%, 15%, 25%) and (50%, 25%, 25%), i.e., projects with lower relative market risk. As for industries, the food sub-industry differs significantly from the other sub-industries in terms of product innovation with more short-term projects, more in-house projects, and slightly higher acceptance of low returns distributions which increases the relative market risk. On the other hand, the results indicate that the crop inputs sub-industry chooses product innovation projects with higher probabilities of high returns, i.e., low relative market risk. Finally, the number of functional areas involved in the selection of product innovation projects does not make the portfolio more diversified and does not significantly change the portfolio. Nonetheless, companies involving the sales department in the selection process of product innovation are likely to have more short-term projects and fewer technically risky projects.

[4] Please note that the y axes for all the graphs/histograms (except the y axis for Return 50%, 0%, 50% which goes up to 70%) all have a maximum of 50% to allow for comparison and an easy read of the table.

Cluster Analysis

A review of the distribution of the characteristics of the innovation portfolio suggests that logical clusters of businesses exist with regard to their product innovation portfolio. It was of interest to identify these different clusters, search for differences between them, and, in so doing, gain more insights into the innovation practices of food and agribusiness companies. Cluster analysis was used to define these logical groupings of businesses in terms of four dimensions[5]: technical/regulatory risk, time to market, capability, and costs already incurred. We used the two-step clustering algorithm discussed in details in Roucan-Kane et al. (2010) which resulted in five distinct clusters (see Table 5). The first step is the use of a hierarchical clustering algorithm (Ward's Minimum Variance) to identify the appropriate number of clusters and obtain seed values that are being used in the second step, the non-hierarchical clustering algorithm (k-means). This two-step method yields more stable and reliable results than a hierarchical clustering algorithm (Larson 1993).

The five clusters identified in the cluster analysis were next characterized and labeled using McGrath and MacMillan's classification (2000) and described as follows:

- Platform launchers do not take too much risk: the majority of their product innovation projects has a low technical/regulatory risk and is short-term to market. These portfolios are also in line with tradition and status quo with a dominance of product innovation projects with in-house capabilities and high proportion of costs already incurred. This cluster includes the largest number of respondents.
- Enhancers take on slightly more technical risk and less market risk than platform launchers when it comes to product innovation projects. This cluster is also the cluster with the lowest percentage of product innovation projects with high costs already incurred and long-term to market.
- Scouters differ from the previous two groups by having a majority of long-term product innovation projects and slightly more technically risky projects. This is the cluster with the largest percentage of long-term projects and the lowest percentage of projects using partner capabilities.
- Positioners represent the only cluster with a majority of product innovation projects in the high technical risk category. It is also the cluster with the second largest percentage of long-term product innovation projects behind the scouters.
- The partner oriented cluster is the only cluster reporting a majority of its product innovation projects using partner capability. This cluster is also more diversified than the others in terms of time to market and costs already incurred. This cluster is the second largest.

Table 5 shows that the platform launchers and the enhancers, which are the two clusters that take the least amount of risk, represent about half of the sample - - indicating that the food and agribusiness industry is a fairly conservative industry in terms of product innovation. Yet, this research shows that despite the challenges associated with open innovation, (i.e., generating and producing ideas with other companies), a significant amount of product innovation projects are done with open innovation in the food and agribusiness sector. Indeed, the partner oriented cluster, which is primarily focused on open innovation, represents the second largest cluster in this

[5] The dimension return did not reveal any likely clusters.

data with 22% of companies. In addition, the other clusters have a non negligible percentage of projects using partner capabilities.

Table 5. Cluster Analysis for Innovation Portfolio

	Portfolio Clusters				
Factor	*Platform Launchers*	*Enhancers*	*Scouters*	*Positioners*	*Partner Oriented*
High technical/ regulatory risk	21% (14%)*	26% (14%)	31% (22%)	73% (12%)	30% (21%)
Partner capability	23% (14%)	31% (19%)	17% (13%)	33% (19%)	75% (16%)
Long-term projects	28% (10%)	21% (12%)	72% (7%)	68% (13%)	56% (19%)
High costs already incurred	65% (13%)	19% (8%)	39% (18%)	70% (13%)	56% (20%)
Percent of sample	35%	14%	15%	13%	23%

Significant additional differences in the selection of product innovation projects can be seen within this industry by cluster. More conservative clusters (platform launchers and enhancers) tend to be smaller in revenue, scope, and governance structure. The scouters and positioners, both representing the clusters with the larger share of long-term product innovation projects, are less likely to involve the sales department - - suggesting again that sales representatives may favor short-term product innovations. These two clusters also represent firms with larger revenues suggesting a relationship between revenue and long-term commitment. As for selection method, scouters are significantly more likely to use graphical analyses. Although we have no apparent justification for it, the partner oriented cluster has a significant smaller proportions of firms committed to innovation. This cluster is also the third cluster with a majority of its product innovation projects being long-term to market. Along with the other two clusters committed to long-term projects, this cluster represents firms that are global—confirming the significant effect of scope on the time to market dimension of the portfolio.

The analysis of the clusters by company and industry characteristics did not yield additional differences and implications. For example, the different sub-industries did not fall into specific clusters suggesting that an innovation portfolio may be a function of company but not industry characteristics. In addition, the number of functional areas did not significantly vary across clusters and the use of specific functional areas (besides the sales department) was not descriptive of specific clusters. Besides graphical analysis, the same held true for the use of selection methods. This lack of significant results suggests that belonging to a specific cluster may not be so much a question of which innovation selection management approaches are being used but potentially how enhanced or structured those approaches might be which was not tested. Alternatively, there might be details within the use of a functional area or selection method that could impact the portfolio of innovation projects and therefore its location in a specific cluster.

Conclusion

This study focuses on the approaches used by U.S. food and agribusiness companies when selecting product innovation projects. The innovation management literature suggests the use of cross-functional teams and selection methods for companies to be more successful[6] at selecting innovation projects. The results of this study show that managers are implementing these theories: they involve several departments and use several selection methods when selecting innovation projects. Specifically, food and agribusiness companies usually involve more than three departments/functional areas in the selection of product innovation projects. The results also suggest that sales representatives potentially because of their bias for shorter-term projects are less likely to be involved in the selection of product innovation projects. A variety of selection methods are being used in the selection of product innovation projects; the selection methods the most often cited are economic models, followed by informal methods, structured assessments, and graphical analyses. Yet, 24% of the companies in the sample do rely exclusively on one method, with half and a fourth relying on informal methods and economic models, respectively. Cooper et al. (2001) found that companies relying heavily on economic models or on one selection method in general may not generate portfolios of innovation projects that perform as well as companies incorporating more qualitative analyses.

In terms of portfolios, companies tend to diversify their product innovation projects in terms of time to market and cost already incurred. However, in general, companies favor product innovation projects that are done in-house, are not characterized by large risk of failure or high relative market risk. This suggests a conservative U.S. food and agribusiness industry in terms of innovation strategies. Yet, the cluster analysis indicates that at least half the companies surveyed are not that conservative. For example, about 13% of the companies in the sample are willing to initiate highly technically and regulatory risky product innovation projects. Approximately 23% of the sampled companies are highly willing to share capabilities with partners to embark in their innovation endeavor. And over 37% of the companies are willing to invest in long-term product innovation projects.

This research clearly indicates that company characteristics (such as revenues, scope, governance structure) and industry differences do affect the product innovation portfolios and innovation practices of firms. For example, larger firms and publicly traded firms tend to have a more structured selection process (more structured assessment, more economic models, more long-term projects that carry high risk of technical/regulatory failure) maybe because of their larger pool of resources, and in the case of publicly traded firms, because of shareholders' pressure to generate satisfactory results. As for industry differences, the crop input sub-industry (crop protection, fertilizer, seed, and biotechnology) tends to use more functional areas and is more likely to use marketing executives in the selection process than the other sub-industries (animal nutrition, animal health, capital equipment, and food). Meanwhile, the food sub-industry differs significantly from the other sub-industries with a focus on more short-term projects, more in-house projects, and slightly higher probability of accepting low returns which increases the relative market risk.

[6] Cooper et al. (2001) define best innovators/performers as companies that have high value projects, the right balance of projects, a portfolio that fits the strategy of the firm, the right number of projects, etc.

What can managers learn from these results and this paper? Before answering this question, it is important to mention that given the lack of consensus on how to measure the success of innovation (e.g., Subramanian and Nilakanta 1996; Sampson 2007; Ahuja and Katila 2001) and the limited previous work on innovation in the agricultural sector, we did not attempt to study which selection approaches lead to the best innovators. This paper focuses on indicating what previous research has shown to be the selection process of the best innovators across industries, and whether food and agribusiness companies are implementing those approaches. Researchers indicate that it is critical for managers to form cross-functional teams that use a variety of selection methods to successfully assess product innovation projects. They also suggest that this assessment should be done frequently to continuously evaluate the potential success of the innovations, reduce the risk of potential failure, and limit the research and development costs. This study shows that food and agribusiness companies are, on average, following these characteristics of best innovators, and do involve several departments and selection methods when assessing their product innovation projects. Based on interviews with executives, the authors list potential return, market uncertainty, technical/regulatory uncertainty, time to market, access to capabilities, and costs already incurred as criteria to include in the selection methods. It will also be important for executives to give guidelines to their cross-functional teams particularly when it comes to the direction the company wishes to take regarding market risk, technical/regulatory risk, and open innovation. The industry the company is in, as well as the company characteristics, will likely play a role in the sophistication of the selection process but the frameworks to follow should be the same.

This study opens the door to many more studies on the selection of product innovation projects by food and agribusiness companies. First, this paper focuses on product innovation and could be a starting point for a study on service innovation, which is an area of growing importance (Killen et al. 2007). Second, one of the limitations of this study is that the sample was a sample of convenience focusing on food and agribusiness companies. A larger study with more industries and more respondents would allow for more generalization and the testing of more hypotheses. A similar study could also be implemented in other countries which would provide a greater wealth of knowledge and show the effect of differences in institutional constraints (Lin et al., 2008) or cultural differences (Kogut and Singh 1988). The cluster analysis in this paper also reveals significant heterogeneity in the sample regarding companies' portfolio characteristics indicating that some food and agribusiness companies are willing to take on risk and are on the path to true disruptive innovations while others are being more conservative. It is necessary to study these true innovators further and determine their characteristics as this will help create guidelines to increase innovation in the food and agribusiness sector.

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