Marginal Impacts of a High Reliability Organization on Pest and Disease Entry Risk at U.S. Ports

Abstract

Reducing the risk of animal or plant disease entry at U.S. ports is a major function performed by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service - Plant Protection and Quarantine (APHIS-PPQ). However, limited resources and heightened concerns following the September 11 terrorist attack pose several risk-reducing challenges. Investment in human capital as in a high reliability organization (HRO) provides cost-effective prospects on how hazard can be minimized in a high risk environment. This study uses a two-level nested logit model to analyze the marginal impacts of an HRO on the risk of plant and animal disease entering the United States. Results indicate that APHIS-PPQ ports are an HRO with Cronbach's Alpha of 0.815. Screening tools as a stand-alone variable is not perceived to reduce risk. However, effective risk communication in conjuncture with tools can be used to mitigate risk of pest and disease entry through U.S. ports.

Key words: APHIS-PPQ, nested logit model, plant and animal disease, high reliability organization, U.S. ports

JEL Classifications: Q18, O19, D73

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Introduction

The focus of American food production and agriculture is becoming increasingly international. Borders, while becoming less relevant to international trade, remain the focus for preventing pests and diseases from entering the United States. For instance, a single contaminated fruit or animal could severely hinder U.S. industry, hurt foreign trade, and even jeopardize lives (U.S. Newswire).

To facilitate international trade and ensure a safe food supply by reducing risk of disease and pest entry at U.S. ports, the U.S. Department of Agriculture (USDA) established the Animal and Plant Health Inspection Service - Plant Protection and Quarantine (APHIS-PPQ). APHIS-PPQ works closely with other domestic government and non-government agencies and interacts with international organizations. In addition to work performed by APHIS-PPQ, the new U.S. Department of Homeland Security also performs several functions to enhance general port security. For example, the Container Security Initiative (CSI) was begun in early 2002. By coordinating with authorities in charge of foreign ports, CSI is intended to better identify and target “high-risk” containers coming from abroad.

Agreements have been reached with major ports around the world, including most in Europe and some in Asia. Several of these ports, including Rotterdam, Bremerhaven, Antwerp, and Le Havre have U.S. customs officers on site to monitor container traffic. More recently, the CSI program was extended to Dubai in the Middle East, along with Turkey and Malaysia. In June 2003, $170 million in general funding was awarded for port security enhancements across the country. These grants will fund security upgrades like harbor patrols, surveillance equipment, and command and control facilities.

However, limited resources and heightened concerns following the September 11 terrorist attack pose several risk-reducing challenges. For example, only 2% of containers at port of entry in the United States were screened in 2002; even then, they were often screened only after the container had been moved from ocean port to an inland rail yard (*The Economist*). This strategy has limited effectiveness in reducing disease and pest entry and is potentially very costly. Therefore, alternative low cost-effective strategies are continuously being explored.

One strategy used by managers and supervisors working for USDA APHIS-PPQ at ports of entry is risk-based allocations of capital to be used for screening purposes. This approach does not tell managers how many people they need but helps them allocate existing resources, within an activity, based on risk factors unique to that work unit. In addition, using risk-based data, managers decide how to allocate resources at the regional level. If these resources are not used effectively, pest invasions, and the subsequent devastation of agriculture and the economy, are much more likely.

Another strategy that is anticipated to be low cost and complementary to other strategies is to create a high reliability organization (HRO). The HRO is a relatively error-free organization and is contingent upon cost-effective investment in human capital. HROs can be characterized by human redundancy and a highly functional, flexible division of labor, but nevertheless represent an organization in which short-term inefficiencies can be overcome with reliable operation (Clarke and Short). The HRO fosters effective risk communication and training of employees, creating an environment where employees can freely report concerns about potential risks. Babb and Ammons noted that HROs are training-oriented to familiarize workers with every possible scenario, with training and problem simulations at each step. HROs constantly deal with dangers but manage to operate nearly error free because they are able to counteract hazards through planning and leadership. This study was designed to determine whether APHIS-PPQ personnel perceive APHIS-PPQ as an HRO and to analyze the marginal impacts of HROs on the risk of plant and animal diseases entering the United States. Following Slovic, experience with risk that a disease entered through a port, an individual's perception of risk or the extent that a person knows and understands a risk factor, and resources available to reduce risk, generally tend to reduce risk in HROs. It is hypothesized in this study that investment in human capital, characterized by an HRO, in conjunction with screening tools, significantly reduces risks of pest and disease entry at U.S. ports of entry.

This study provides several contributions to the existing literature on risk analysis and understanding risks at U.S. ports of entry. It fills a void in the literature on economics of risk communication and explores the effectiveness of investment in human capital, as a low cost intervention strategy. Also, this research addresses a void in the existing literature concerning how the perception of reliability affects risk estimates. The methodology presents a classic case where the economic impact of firm-level risk communication is included in risk analysis studies.

Review of Relevant Literature

One of the most pressing concerns for organizations such as USDA APHIS-PPQ is dealing with the unexpected. Organizations in high risk environments constantly face unforeseen failure and crisis because something that was expected to happen did not occur or something that was not expected does happen (Weick and Sutcliffe). Of course, some organizations, such as prison transportation services, air traffic controllers, and nuclear power plants, face much greater risks than others. The study of HROs seeks to discover how people organize for high performance in settings where the potential for error and disaster are overwhelming. Weick and Sutcliffe explain that these sorts of organizations face an ‘excess’ of unexpected events because their technologies are complex and their constituencies are varied in their demands and because the people who run these systems have an incomplete understanding of their own systems and what they face. They also noted that HROs have one common overarching characteristic: they have no choice but to function reliably. If reliability is compromised, severe harm may result. HROs constantly deal with dangers but manage to operate nearly error free because they are able to counteract hazards through planning and leadership (Babb and Ammons). For example, nuclear aircraft carriers operate very reliably, because very few accidents occur, considering the number of hazards.

Weick and Sutcliffe highlight several hallmarks of HROs. First, these organizations have a preoccupation with failure, such that the organization is constantly focused on what might go wrong and results in severe consequences. Second, organizations are reluctant to simplify interpretations. These organizations reject simplified accounts in favor of a more complete understanding of their environment and operating conditions. Third, HROs maintain sensitivity to operations. These organizations are continuously paying attention to the unexpected and make corrections to prevent error, especially in frontline defenses. Fourth, HROs are committed to resilience. Errors do not shut down the systems. The goal is to keep errors small while keeping the system working. Fifth, these organizations defer to expertise. Authority and decision making ability tends to be given to workers on the frontline because they have the most expertise. Expert opinion and information are appreciated, regardless of formal rank.

Weick and Roberts explain that high organizational performance can be maintained by establishing a collective mind, controlling information processing, paying mindful attention, and taking heedful action. The collective mind is characterized by patterns of interrelated actions within the system: actors in the system construct their actions, understanding that the system consists of connected actions by themselves and others, and interrelate their actions within the system (Weick and Roberts). Controlling information processing means not all data can be processed within the short operating periods that HROs face. The most important information needed to make a decision must be selected quickly and deliberately. Weick and Sutcliffe note that, over time, individuals within these complicated systems are able to make decisions and confirm them with fewer and fewer data.

A model of how HROs can modify performance is presented in Figure 1. HROs try routine responses to failure, and if those responses are effective, crisis is averted. The effective routine response is thereby reaffirmed as an appropriate solution. If the routine responses are ineffective, the problem may intensify and ultimately can manifest in crisis. HRO members will attempt non-routine solutions when routine responses fail. Again if non-routine steps are ineffective, the problem may continue to intensify. Non-routine approaches that work well are incorporated into the HRO repertoire of responses, and thus the non-routine becomes routine.

Ultimately, the overarching principle most essential to an HRO is risk analysis. Without an ongoing awareness of risk level, organizations cannot function with the attentive and collective mind described by Weick and Sutcliffe. Risk analysis focuses on the assessment of various risk elements, including population size, host range, dispersal potential, economic impact, environmental impact, probability of detection, likelihood of surviving treatment, and the potential of finding suitable habitat and hosts (Charnley; Lindell and Whitney; Putzrath and Wilson). Pidgeon et al. address risk communication as a process of perception. They explain that risk perception involves people's beliefs, attitudes, judgments, and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits. Often, the perception of risk represents a struggle between scientific fact and the individual's beliefs and experiences.

Accurate assessment of the risks associated with an item requires reliable data. Critical information resources within APHIS-PPQ are still relatively new and may not provide requisite data, particularly regarding pests associated with certain commodities. Although tools such as the Port Information Network (PIN-309) database capture some of this information from officers and identifiers, additional facts simply become part of a non-centralized, institutional memory. Experienced individuals at the ports have valuable, experiential information that could influence the risk assessment process.

When surveying experts at the ports, care was taken to differentiate opinion from information. Kaplan makes an important distinction between expert opinion and information. Expert opinions are often summary assessments of a situation (e.g., pest X poses high risk). While such opinions may be useful, even more valuable are the factual bits of information that were used to form the summary opinion. Expert information collected from several individuals can be reanalyzed to form a more complete assessment of risk. In this study, expert information was gathered about pest loads on commodities entering through U.S. ports of entry. The marginal impact of risk communication, as in HROs, was analyzed for APHIS ports in this study.

Methods

A two-level nested model is used to model the impact of an HRO on the risk of entry of disease at U.S. port of entry. The nested logit model has been used extensively in the literature to model multiple/simultaneous decisions (Morey; Morey and Waldman). First, using survey data, the relevant questions relating to whether respondents perceive APHIS-PPQ to be an HRO were evaluated on a Likert scale of 1 to 5, with the range of the index between 10 and 50. From the aggregate index of 10 questions, a score of 10 would represent a low level of agreement that APHIS-PPQ has characteristics of an HRO while a score of 50 would represent a high level of agreement. The aggregate score also represents the HRO index which would be used in the nested logit model. Indices have been used (and their reliability established using Cronbach's Alpha[1]) to study risk by scholars such as Rimal and Schooler et al. The reliability of the HRO index was high (Cronbach's Alpha = 0.8150).

At the lower level of the multinomial logit model, is a set of risk levels which characterize the risk of pest and disease entry into the United States on the watch of APHIS-PPQ personnel. Four risk levels were used to determine risk of pest and disease entry into the United States: 1 in 10,000; 1 in 1,000; 1 in 100; and 1 in 10. These risk levels can be attributed to identifiers' perception of APHIS-PPQ as an HRO. Therefore, if the respondent perceives APHIS-PPQ to be an HRO, the choice of risk-level for (or the probability of) pest or disease entry at this port would lie between 1/1000 and 1/10000. On the other hand, if the respondent perceives APHIS-PPQ not as an HRO, the choice of risk-level for (or the probability of) pest or disease entry at this port would lie between 1/10 and 1/100. Thus, the dichotomy implied by the nesting structure is not necessarily based on a sequential decision making process.

Accordingly, based on the assumption of an extreme value distribution, if the *i*th individual has J=0, 1, 2, 3, choices (which is a coding option), then the following probabilities for a multinomial logit model apply (see Greene):

(1) $$\Pr ob(Y = j) = \frac{e^{\boldsymbol{\beta}'_j \mathbf{x}_i}}{1 + \sum_{k=1}^{J} e^{\boldsymbol{\beta}'_k \mathbf{x}_i}} \text{ for } j = 1, 2, \ldots, J, \text{ and}$$

(2) $$\Pr ob(Y=0)=\frac{1}{1+\sum_{k=1}^{J} e^{\boldsymbol{\beta}_k^{'}\mathbf{x}_i}}.$$

From the above formulations, J odd ratios can be computed, such that $\ln\left[P_{ij}/P_{i0}\right]=\boldsymbol{\beta}_j^{'}\mathbf{x}_i$. This can further be normalized on any other probability, such that $\ln\left[P_{ij}/P_{i0}\right]=\mathbf{x}_i^{'}(\boldsymbol{\beta}_j-\boldsymbol{\beta}_k)$. The assumption of independence of irrelevant alternatives (IIA) is based on whether the odds ratio P_{ij}/P_{i0} does not depend on the other choices. Caution must be employed in testing for IIA based on the tests of Hausman, and Small-Hsiao, because IIA tests sometimes give inconsistent results and provide little guidance to violations thereof.

Due to the complexity of the data type, a Wald-type test was used to test for IIA, by testing the significance of each of the choices. The probability values indicated that each of the choices was significant; therefore, the IIA assumption does not hold. This implies that for this dataset, the multinomial logit model must be rejected in favor of the nested logit model. Hence, if J choices can be divided into m nests, then

(3) $$\Pr ob_{j|m}=\frac{e^{\boldsymbol{\beta}^{'}\mathbf{x}_{j|m}}}{\sum_{j=1}^{J_m} e^{\boldsymbol{\beta}^{'}\mathbf{x}_{j|m}}}, \text{ and}$$

(4) $$\Pr ob_m=\frac{e^{\boldsymbol{\gamma}^{'}z_m+\tau_m I_m}}{\sum_{m=1}^{M} e^{\boldsymbol{\gamma}^{'}z_m+\tau_m I_m}},$$

where z is the model attribute, I_m, the inclusive value for the mth nest, is defined as

$I_m=\ln\sum_{j=1}^{J_m} e^{\beta^{'}x_{j|m}}$, and τ is the inclusive value parameter.

For the nested logit model, the inclusive value parameter is not equal to 1 (i.e. $\tau \neq 1$). For the dataset under consideration, equation 3 estimates the probability of the risk of pest and disease entry given the *m* nest (where $m = 2$), and equation 4 estimates the probability of the *m*th nest structure (HRO and no HRO). The marginal effects in equation 3 with respect to the variable that defines the APHIS-PPQ personnels' perception of APHIS-PPQ as an HRO give the marginal effect of an HRO on the risk of pest and disease entry into the United States.

Survey Design and Data

Surveys have been used effectively in previous research to study risk and risk perception. For example, Barnett and Breakwell, O'Connor, Bord, and Fisher, and Rogers have used surveys to collect risk perception data. Powell, Bodon, and Hickson used a questionnaire administered by telephone to examine public apathy to information about potential crises. The effectiveness of risk mitigation strategies was also studied through surveys by Riley et al. and Jenkins-Smith and Kunreuther.

This research project used the Tailored Design Method to collect data and answer the research question that screening tools, effective communication achieved with investment in human capital, will reduce the risk of pest and disease entry through U.S. ports. Tailored Design, based on social exchange theory, seeks to gain trust from the respondents by persuading them that the benefits of participating in the research outweigh any potential costs (Dillman). This method allows the questionnaire to be adapted to the particular population. Focusing is done by carefully writing questions, formatting the questionnaire to aid its ease of use, implementing the survey in a manner that reduces errors, and following steps to maximize response rates. The Tailored Design Method has been used previously when studying risk communication (O'Connor, Bord, and Fisher).

After interviewing several APHIS-PPQ experts, a survey was constructed using a panel approach. The panel approach entails using a group of USDA, university, and context experts to critique the content of the instrument to ensure its validity. In this case, eight experts evaluated the survey and made suggestions before its implementation.

For this phase of the project, participants were asked to complete the instrument while being facilitated during face-to-face interviews. This method was selected because the participants provided technical information, and recording the answers accurately was potentially problematic. Also, clarification of survey questions could be provided to respondents to minimize response errors. The combination of written and oral data collection worked well in this context. The survey instrument was administered to 32 of the 62 identifiers (individuals trained to determine whether pest is actionable, using taxonomical references) throughout the nation, representing 51.6% of the population and 107 other port employees. Of the 32 identifiers, 18 were entomologists, 6 were botanists, and 8 were plant pathologists. Of the 107 other employees, 30 were port directors, 36 were state and regional health directors, and 41 were supervising officers.

Data Description

HRO Index

The variable that identifies APHIS-PPQ personnels' perception on whether or not HRO characteristics are present in the APHIS-PPQ organization is a composite score that derives from the opinions on the following characterizations:

1. Employees perceive that their opinions are taken into account on a daily basis.
2. Employees perceive that their opinions are taken into account for long-term planning within the port.

3. Employees perceive that their actions directly contribute to the prevention of pest introductions.
4. Employees perceive that their actions influence others to prevent pest introduction.
5. Employees perceive that APHIS-PPQ is concerned about the possibly of failing to accomplish its mission.
6. Employees perceive that APHIS-PPQ is committed to correcting shortcomings in its data collection process.
7. Employees perceive that APHIS-PPQ emphasizes maintaining effective operations.
8. Employees perceive that APHIS-PPQ is committed to correcting shortcomings in its inspection process.
9. Employees perceive that APHIS-PPQ managers defer to opinions of internal experts about risks.
10. Employees perceive that APHIS-PPQ does not try to present complex issues about pest risk in overly simplistic terms.

The opinions were evaluated based on a five-point Likert scale (5=strongly agree; 4=agree; 3=neutral; 2=disagree; 1=strongly disagree). For this project, all 139 employees were interviewed. Identifiers have direct knowledge of what is being discovered in their jurisdiction. Also, these individuals have the most sophisticated training about potential hazards in their region. They, in turn, share information with officers and technicians within the port involving areas of concern. Therefore, identifiers, port directors, state and regional health directors, and supervising officers have hands-on experience with all aspects of the high reliability index. The schematic in figure 1 illustrates this very well.

Factors Influencing Risk Perception within APHIS-PPQ

APHIS-PPQ employees' perceptions of reliability are based on many variables. Adu-Nyako and Thompson's analysis of food safety risk perceptions discovered that perception is influenced by personal experience with the risk, social and cultural characteristics, and perceived locus of control. Personal experience in this study is represented by employees' previous participation in an outbreak and years employed by APHIS-PPQ. Social and cultural characteristics are captured through the HRO index, which describes APHIS-PPQ's organizational culture. Perceived locus of control is represented by the employees' belief that they receive enough training and have adequate tools to perform their duties.

While the employees were asked to provide expert information, their opinions are also influenced by their predispositions. These opinions, while useful, are not free from bias that might distort employees' perception of reality. Similar to the potential distortion of information caused by risk aversion, an individual who has little experience may underestimate the numbers of pests that he/she believes to exist on a pathway or, out of fear for the unknown, may perceive the hazard to be greater than it is. Conversely, someone with a high level of experience may underestimate the potential hazard because it is believed to be commonplace or may overestimate the danger because the threat appears to be ever-present. Table 1 presents means and standard deviations for some of the variables from the survey. Data were collected for specific commodities and diseases, but due to the sensitive nature of such information, only aggregate risk perception at each port is reported in this paper.

Results

The nested logit model was estimated using the LIMDEP econometrics software. LIMDEP allows for direct specification of the two-level tree and the utility functions for each level. Level 2's utility function characterized the risk of disease entry via the ports as low (1 in 10,000), medium (1 in 1,000), high (1 in 100), and very high (1 in 10). Level 1's utility function characterized whether a particular port was an HRO or was not an HRO. It was assumed that an HRO operates in a manner that expects low and medium risk of disease entry, while organizations that are not HROs operate in a high and very high risk environment in which effective risk communication is not utilized as a counter-effort.

With an average HRO index of 32.17 (range=10 to 50, median=30) and Cronbach's Alpha of 0.815, respondents agree that APHIS-PPQ is an HRO. Therefore, the effect of this perception of APHIS-PPQ on the risk of disease entry into the United States was evaluated. The model involved evaluating the effect on nest 1, the case where respondents perceive APHIS-PPQ as an HRO, but not on nest 2, the case where respondents do not believe that APHIS-PPQ is an HRO. Thus, the variables for the utility functions in nest 1 are the HRO index (measure of perception) and personal experience, while the variables for the utility functions in nest 2 are training/tools, a cross effect variable (training was defined as APHIS-PPQ provides adequate training to support my scientific and pest identification skills and abilities), and tools (I work in an environment that provides me with adequate taxonomic tools and equipment), both of which are measured on the basis of a 5-point Likert scale. At this point, parameter estimates from nest 1 which measures the impact of perceiving APHIS-PPQ as an HRO on the risk of pest and disease entry into the United States is more important. Also, training/tools (the cross effect variable) significantly decrease the risk of disease entry at U.S. Ports.

The full information maximum likelihood (FIML) parameter estimates for the nested multinomial logit model are presented in Table 2. Parameter estimates for the utility of the nests were not presented; they would be meaningless because the nesting structure was not based on a sequential decision making process in which respondents would be first asked about their choice of nest, before they are asked about their choice of alternative risk levels. Instead the nesting structure presents a more robust econometric model.

The inclusive value parameters were estimated for the different nests. At 5% probability level, both inclusive value parameters are not significantly different from zero, but at 10% only one (not HRO) is significantly different. When the inclusive value parameter ϕ is significantly different from zero, intuition suggests a breakdown in the nesting structure because of the apparent absence of perfect correlation (as measured by 1-ϕ) between unobserved factors. In this case, the nesting structure holds at the 1% and 5% probability levels and marginally at the 10% probability level.

High Reliability Organization and Risk of Disease Entry

The results in Table 2 show that the HRO index for AHPIS ports was negative and significant at the 5% level. Therefore, respondents' perception of APHIS-PPQ as an HRO was an important determinant of their perception of the risk of disease entry. Thus, the higher the perception of APHIS-PPQ as an HRO, the lower the perceived risk level for pest and disease entry into the United States. Effective risk communication and investment in human capital play a significant role in reducing the risk of pest and disease entry through U.S. ports. Promoting HRO culture at U.S. ports may play an important role in reducing the risk of disease entering the United States, especially when available resources to screen all containers and cargo entering the country are limited.

Table 2 also shows that personal experience would be significant. Like the case of the HRO index, there is an inverse relationship between personal experience and risk of pest and disease entry into U.S. ports, so that as experience level increases, the perception of risk for pest and disease entry decreases. If employees have experiences that make them familiar with risk, safety concerns that arise from imported pests and diseases may be handled by following known procedures and practices. These results validate our assumption that HROs can reduce risk of disease entry to low or medium risk.

For analytical purposes alone, tools and training/tools were used as variables in the utility functions for the nest where APHIS-PPQ is not thought of as an HRO. The availability of effective tools for screening significantly could affect employees' perception of the safety of their ports, but only when combined with effective training. Therefore, tools as a stand-alone variable is not expected to be a significant variable in this analysis. The training variable could be important because employees may perceive APHIS-PPQ ports to be HROs when they receive various forms of training by simulating possible risk scenarios and knowing what corrective measures to take.

Survey data indicate that some employees who reported their ports have effective tools to mitigate disease entry risk also pointed out that their ports were somewhat unsafe. This result could be explained by the idea that risk can never be completely eliminated, especially with high tech tools only. However, it will be interesting to analyze how port employees rate the reliability of their organization to partially understand some potential reasons why high tech tools alone might not reduce disease entry risk to manageable levels.

Marginal Impacts of the HRO Index on Risk of Disease Entry

Table 3 presents the marginal effects of the HRO index on risk of pests and diseases entering through a port. The probability values in Table 3 suggest that a unit change in the HRO index decreases the probability that an employee perceives a low risk of pest and disease entry by 0.319, but increases the probability that the employee perceives a medium risk of pest and disease entry by 0.073. When the branch effects of -0.540 are added to the choice effects, the total marginal effects for low risk and medium risk are -0.859 and -0.467, respectively.

The HRO index was not a variable in the utility functions for high risk and very high risk; therefore, only branch effects were calculated and both show probability values of 0.370. These results show that the marginal impact of the HRO index is larger with respect to low risk levels than it is with respect to high risk levels. Employees attribute high and medium risk levels to ineffective communications. Effective risk communication plays a major role in reducing the risk of pest or animal disease entry into the United States, especially when complimented with high tech tools.

Conclusions and Implications for Cost-Effective Mitigation Strategies

Reducing the risk of animal or plant disease entry at U.S. ports by APHIS-PPQ requires a good understanding of the interaction between risk assessment, risk communication, and risk management. Because of the complexity involved in modeling the impact of risk communication on risk-reducing strategies, this component has mostly been left out in empirical analysis. Characterizing risk communication and investment in human capital in an HRO framework provides interesting prospects on how hazard can be minimized in high risk environments. This study uses a two-level nested logit model to determine how HROs affect APHIS-PPQ personnels' perception of risk levels for pest and disease entry into U.S. ports.

The results show that the higher the employees' perception of APHIS-PPQ as an HRO, the lower the perceived risk level for pest and disease entry into the United States. The impact of this risk perception variable, the HRO index, is higher at low risk than it is at higher risk. This implies a policy role not only to create an HRO with APHIS-PPQ by increasing investment in human capital, but also effectively reiterating the role of risk communicating within the organization. Therefore, effective risk communication and investment in human capital are important in reducing the risk of pest and disease entry through U.S. ports. Promoting HRO culture at U.S. ports may play an important role in reducing the risk of disease entering the United States, especially when available resources to screen all containers and cargo entering the country are limited.

Traditional references to HROs have been limited to cutting-edge technological units such as aircraft carriers and submarines, nuclear power plants, and the U.S. shuttle program. Such organizations are known to rely on tight control, micro-management, and sometimes an authoritarian approach which keeps decisions in the hands of experts, but no doubt ensures safety. On the other hand, the case for APHIS-PPQ as an HRO is based less on technology or complexity of organization, and more on the argument in favor of decision migration, safety culture, and a cooperative approach to achieving an almost error-free status. HRO characteristics identified by Grabrowski and Roberts and Roberts and Bea which states that the APHIS-PPQ profile include organizational factors, managerial factors, and adaptive factors. Organizational factors deal with rewards and systems that recognize costs of failures and benefits of reliability; managerial factors concern effective risk communication strategies; and adaptive factors enable the organization become a learning organization. Strategies designed to achieve these goals and reduce risk in the HRO must, therefore, be cost-effective and sustainable.

The results presented in this study may be affected by the decision to apply this model only to those respondents described as identifiers, port directors, state and regional directors, and supervising officers. These employees are generally highly experienced, knowledgeable, and technically well-equipped to enable us to define risk perception categories. Unfortunately, the number of these employees is limited. A future study could extend this model to include port technicians, although caution must be taken to educate technicians about risk.

End Notes

[1] Cronbach's Alpha is a measure of consistency used to judge reliability. To calculate Cronbach's Alpha, the number of items in the index is multiplied by the average inter-item correlation. That product is divided by one, plus the number of items minus one, multiplied by the average inter-item correlation.

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Table 1. Descriptive Variables from Survey Group

Variable Name	Description	Mean	Standard Deviation
Experience	Years associated w/PPQ	15.94	8.636
Training	Perception that PPQ provides adequate training (1 to 5 scale)	2.69	1.257
Tools	Perception that PPQ provides adequate tools (1 to 5 scale)	3.72	1.066
HRO index	The level of perception that PPQ is an HRO	32.16	6.910
Outbreak	Identifier had participated in one or more pest outbreaks	0.66	0.483
RiskAss	Average proportion of infested items on a 1 to 4 scale	2.76	0.786

Source: Aggregated survey data.

Table 2. Parameter Estimates for Nested Logit Model

Variable Name	Coefficient	p-value
	Utility Function Attributes	
HRO		
Constant (medium risk fn)	0.1656	0.7693
	(0.5645)	
HRO index	-0.0122	0.0293
	(0.0056)	
Experience	-0.1149	0.0647
	(0.0622	
Non HRO		
Constant (high risk fn)	0.1098	0.8112
	(0.4595)	
Training/tools	-16.6300	0.0862
	(10.3160)	
Tools	10.4597	0.9076
	(90.1538)	
Inclusive value parameters		
HRO (low, medium)	12.4591	0.0850
	(7.2340)	
Not HRO (high, very high)	-0.0084	0.8815
	(0.0566)	

Standard errors are presented in parenthesis.

Table 3. Marginal Effects of the HRO Index on Risk of Disease Entry in an HRO

Effect	HRO Index			
	Risk of Pest/Disease Entering Through a Port	Branch	Choice	Total Effect
HRO	Low Risk	-0.540	-0.319	-0.859
	Medium Risk	-0.540	0.073	-0.467
NO HRO	High Risk	0.370	0.000	0.370
	Very high Risk	0.370	0.000	0.370

Figure 1. High Reliability Risk Communication Model