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Security-Preparedness of Firms in U.S. Food Supply Chain

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Abstract

The growing interdependence of firms across the globe with seeming rise in the incidence of both intentional and unintentional security events (terrorism, food contamination, etc.), has exposed, and often contributed to, the vulnerabilities of many firms and their supply chain partners.

It is increasingly imperative that the firms be prepared to be able to protect and defend themseleves against such security threats. With this paper we attempt to understand this preparedness, which we consider an ex ante construct, specifically for the firms in the food industry, and find a way to measure it. The highlights of this paper are (1) the unique dataset on firms in the food supply chain across U.S. detailing their security practices, (2) a novel approach to analyzing this dataset using Latent Trait Analysis that allows us to uncover the underlying strength and weakness of firms in their security practices and (3) analysis with which we are able to relate firms' security practices with firm characteristics, such as market area, supply chain scope and firm size. Our preliminary analyses reveal some interesting results on what firms do and how firm characteristics bring about differences in firms' security preparedness, ex ante. We find four distinct latent factors for explaining different facets of security preparedness, two of which are supply chain collaboration and physical security preparedness. We then also analyze the influence of firm and respondent demographics on each of the dimensions of preparedness. Firm size, supply chain scope, market area and tax status of the firm are some of the variables that emerge as as important characteristics that impact security preparedness in supply chains.

Keywords: security, supply chain, latent trait analysis
JEL classification: L100, L800

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1 Introduction

1.1 Risks in U.S. Food Supply Chain

While there are several pressing issues facing the U.S. food sector, such as, climate change, nutrition and obesity, genetic tinkering, carbon footprinting, agro-terrorism, changes in consumer food preferences to name a few, the two important questions that have garnered much attention of late are: (1) Is the food safe?; (2) Is the supply chain secure? Food safety events in the recent past have resulted in increased concerns over the food on the plate. A recent study (Degeneffe et al., 2007) conducted in three waves (July 2005, March 2007, May 2007) on consumer perceptions of bioterrorism and food safety risks shows increasing concern over food safety and corresponding decreasing confidence in safety of the food supply. The findings also suggest an increasing concern over potential terrorist events in the food supply, although post 9/11 no such incident of national significance has been reported. However, there have been widely publicized food recalls and food safety incidents. According to World Health Organization (WHO, 2002) many of the contamination agents in the case of intentional events are the same pathogens that have been linked to significant outbreaks of foodborne illness due to unintentional contamination. Thus, outbreaks not linked to criminal intent can actually expose the vulnerabilities in food supply and increase the threat of a terrorist act. All this is suggestive of a significant confounding between food safety and food terrorism incidents in the U.S. consumers. In effect. food contamination and security incidents have a similar impact on the well being of the entire food supply chain, and often with global repercussions.

The food supply chain is one of the most important supply chain networks in the U.S. economy. However, this highly critical "farm-to-table" chain has also been exposed to many extreme events entailing safety and security scenarios. Though supply chains are often faced with various risks of supply disruptions for the U.S. food supply, which includes crops, livestock, distribution, processing, retail, transportation and storage and accounts for about 13 percent of the U.S. GDP and around 18 percent of domestic employment (FDA report, 2003), such events pose risks that are above and beyond the comprehensible levels. As a result, it is increasingly important for supply chain managers, not limited to the food sector, to strive to achieve not only competitive and efficient supply chains (Christopher and Towill, 2002), but also ones with sufficient flexibility and redundancy to enable them to respond to extreme circumstances (Sheffi 2005).

1.2 Regulatory Initiatives

There are various security initiatives that have been implemented by the U.S. government in an effort to reduce supply chain risks and contain the threats that arise from it. These measures are directed at ensuring security of not just the U.S. food supply chain but supply chains at large. U.S. Customs has instituted

an Advanced Manifest Rule (AMR) in February, 2003, which requires detailed cargo data be submitted to US Customs at least 24 hours in advance. They have also launched the Container Security Initiative (CSI) and the Customs-Trade Partnership Against Terrorism (C-TPAT) in January and April of 2002, respectively. The C-TPAT program involves multiple countries, and promotes the use of best security practices. Manufacturers, importers, carriers, and third party logistics service providers can all participate in the C-TPAT by submitting detailed questionnaires and self-appraisals of their supply chain security practices, while Customs would perform periodic audits and verifications of such practices (Lee and Whang, 2003). In summer of 2002, the Bioterrorism Preparedness and Response Act came into force, which now governs the efforts of Federal Drug Administration (FDA) and several other agencies in protecting the U.S. from food-borne threats from foreign and domestic sources. The various provisions of this legislation are for improving the capacity to prevent, detect and respond to such threats, which consequentially will add to the security level of firms and supply chains. These regulatory policies are directed towards not just imports or addressing food terrorism and defense concerns but also provide mandates on firm security practices, for example- procedures like PR/ HACCP(Pathogen Reduction/ Hazard Analysis and Critical Control Point), develop a framework for vulnerability analysis such as CARVERShock+, and set voluntary guidelines such as those set in good agricultural practices (GAP), good manufacturing practices(GMP) to ensure that the processes are functioning efficiently and securely.

While some security practices are mandated most others are only recommendations or guidelines, which the individual firms may not follow or implement under various cost considerations. Most such guidelines often lay excessive emphasis on maintaining records and documentation that provide easy tractability in case of an untoward incident but may not directly and immediately improve the firm's ability to prevent security incidents. Compliance procedures are largely directed at improving visibility in the supply chain, like tracking one supplier up and one customer down or AMRs. However, these require extensive documentation which can often be burdensome and costly for firms to implement. The argument for undertaking such investments is that it increases the competitiveness and improves efficiency of the firms that undertake such investments (Peleg-Gillai et al. 2006, Sheffi, 2005). Though such guidelines may be burdensome and may not be implemented with fully within a firm, it is important to note that such measures enhance prevention and detection capabilities of the firm and hence the supply chain. After all, a chain is as strong as its weakest link.

1.3 Outline

In this paper we lay out some evolving ideas on supply chain security preparedness, and develop a measure for such preparedness that is indicative of the preparedness of different constituents of the food supply chains such as suppliers and manufacturers, retailer and grocery wholesalers, and foodservice operators

to avert and/or deal with security incidents of both intentional and unintentional nature. The approach of investigation is an empirical one that attempts to capture the underlying factors that influence the firm responses on different security practices. The dataset used here is unique in that (1) it has an exhaustive set of questions on all conceivable food industry security practices (2) ranked responses on a 5-point Likert scale on the perceived level of confidence with which these practices are followed, and (3) it encompasses a large number of suppliers and manufacturers, retail and grocery wholesalers, and foodservice operators across U.S., both big and small in terms of their annual revenues, number of employees, market area, and supply chain scope. We investigate the dataset from Supply Chain Security Benchmarking and Assessment Survey developed and administered by the Universities of Minnesota, Michigan State and Georgia Institute of Technology [1]to firms in U.S. food sector. The expected results of this exercise is to analyze if firm preparedness is unidimensional or a multi-dimensional construct and then develop a score for each firm based on these identified dimensions. We use factor analysis to explore the different dimensions of firm preparedness levels and then use latent trait models to construct a measure for each firm on each of the dimensions identified, as well as determine the effectiveness of each of the security practices questioned in the survey. We also attempt to analyze the influence of firm characteristics such as annual revenues, market area and supply chain scope, number of employees, primary activity of the firms (manufacturing, foodservice etc.), and also respondent characteristics from each responding firm, such as organizational responsibility and title and experience within the firm and industry in explaining the preparedness levels of the firms. Another aspect that we also summarize here is the impact of security investments in firm's security outcomes (such as increase or decrease in number of security incidents, risk profile, etc.) and business performance (such as increase or decrease in operating costs, insurance, loss, etc.) and examine if any relation exists between preparedness levels and outcomes for the responding firms.

2 Previous Studies

There is ample empirical research that highlights the importance of emergency planning on reducing the impact of disruption risks (Sheffi, 2005). Hendricks and Singhal (2003,2005) analyzed announced shipping delays and other supply chain disruptions reported in the Wall Street Journal during 1990s and showed based on matching sample comparisons, that firms experiencing disruptions under-perform their peers significantly in stock performance as well as operating performance as reflected in costs, sales, and profits (c.f. Kleindorfer and Saad, 2005). The globalization of the supply chain with suppliers, manufacturers, retailers and consumers spread far and wide for most of the products makes the supply chain more vulnerable. Hence when thinking about reducing

[1]We have access to data collected by University of Minnesota and Michigan State University only. We will limit our analyses to the firms covered by these universities only.

firm's vulnerability to disruptive events, Sheffi and Rice (2005) advocates that managers need to look into increasing not just safety measures but also safety awareness and a proactive safety culture thereby making firms and supply chains more resilient.

Managing disruption risks for firms and their supply chains is an extensively researched area in management and decision sciences, operation research, logistics with models for optimum decision. Snyder, Scaparra, Daskin and Church (2006) in their tutorial in operations research have presented a broad range of models for designing and fortifying supply chains that are resilient to disruptions. These models are based on stochastic linear programming models each focused on a particular characteristics of the supply chain and their problems under study. Kleindorfer and Saad (2005) also provide a conceptual framework for risk assessment and risk mitigation that arise from disruptions in a supply chain. However, there is very limited experential literature on the firm-level analysis of security practices and procedures followed and the cost and security outcomes. there are four major studies that are relevant and informative for this research. We focus for the rest of the survey on these four works. Sheffi (2001, 2005) addresses this gap by providing case study approach to security and resileince issues. This work reiterates the measures for reducing vulnerability through better collaboration for security, improved detection ability and building in redundancy in the system, beyond the regular measure of reducing likelihood of disruptions. It also highlights the importance of investing in people and culture through effective communication strategies, employee training and education programs, and imbibing a culture of security and resilience.

Though Sheffi (2005) does not focus on any particular industry the inferences from the research concur with similar research in this area by Peck(2006) on U.K. food and drink industry. In this second study, Peck (2006) aims to ascertain the current state of Business Continuity Management(BCM), or resilience, in the food and drink industry. Her exhaustive report "Resilience in the Food Chain"(July 2006) on the state of continuity planning and management and identification of operational failures, near misses, and known weaknesses, together with questions on approaches to risk and supply chain management, is a summary of findings from a qualitative case-study of 61 senior managers from 28 organizations comprising both small and large food supply chain constituents. The research design involved looking at the entire U.K. food and drink industry as opposed to individual firms. The relevant findings suggested that:

1. All organizations interviewed had some form of IT-related continuity planning/disaster recovery in place although BCM was still in its early stages but a growing concern.
2. Most companies were pursing wider operational risk management plans for compliance reasons.
3. Few companies had moved from reactive crisis management to a proactive culture.
4. Emphasis of BCM changes between sectors, that is, large retailers are inherently resilient (as most of their networks can withstand the loss of a store

or a product supplier without significant disruptions) but small retailers look to their wholesalers for supply chain continuity.

5. Logistic service providers engage in BCM on an ad hoc basis, depending on whether their clients are willing to pay for continuity planning.

6. Food processors' and packagers' efforts center around protection of key assets because their operations are dependent on a few capital intensive facilities. As a result some made no distinction between everyday operations, risk management and BCM. The manufacturers' tend to have certain amount of "flexibility" in production (as proposed by Sheffi, 2005) which is their basis for resilience-building. However, this flexibility is steadily eroded due to cost and optimization concerns.

These findings provide important insights on the perceptions of resilience-preparedness in the business. The important aspect of this work is that it incorporates multiple responses from a single firm by interviewing more than one senior manager. While Peck (2006) provides some understanding of how traditional profitability concerns can over ride the importance of building in resilience, the third work cited here details the benefits of security investments and initiatives on business value. This research on security initiatives by manufacturers and logistic service providers was undertaken by The Manufacturing Institute in collaboration with Stanford University's Global Supply Chain Management Forum with a cross-industry sample of 11 manufacturers and 3 ocean carriers/logistic service providers. (Peleg-Gillai et al., 2006). The sample selection was deliberate based on identifying companies that were "innovators" in the efforts made by them to strengthen the security of their own supply chain. The survey had about 56 questions detailing impacts of security initiatives undertaken by the company. To highlight some relevant findings of how security initiatives improved business performance: Sample firms of manufacturers reported close to 30% reduction in problem identification time, response time and resolution time achieving greater resilience; 50% increase in supply chain data, 30% increase in timeliness of shipping information thereby greater supply chain visibility; 30% reduction in process deviations, 38% reduction in theft/loss/pilferage, 37% reduction in tampering, 43% increase in automated handling of goods all leading to increased product safety and process improvement. While Sheffi(2005) justifies security investments by their contribution to avoiding disruption and resilience investments primarily due to the flexibility they provide creating a competitive advantage for the company, Peleg-Gillai et al. (2006) helps in providing quantifiable estimates to the benefits companies can potentially realize. While the results of these studies (Peck 2006, Peleg-Gillai et al. 2006) cannot be considered as industry averages they attempt to provide insights into industry practices and contribute to the hitherto limited literature in this area.

The fourth study is an ongoing work on The Supply Chain Security Benchmarking and Assessment Survey for firms in the U.S. food sector conducted by three institutes of Michigan State University, University of Minnesota and Georgia Tech in 2006-2007. It is focused on providing industry with in-depth understanding of competencies and performance measures that make them ready

to defend the food they handle, their physical assets and employees and business reputation and brand name. The on-going research on this survey is aimed at defining practices & competencies and their relative contributions to security performance and creating a benchmark and a diagnostic tool to assist in extended and future comparison and evaluation of defense readiness. The security competencies used in this research are arrived at by using existing literature on performance improvements and also through extensive interviews with over 50 supply chain, security, and food quality managers representing over 20 firms. These competencies include: process strategy, process management, infrastructure management, communication management, technology management, process technology, metrics and relationship management, service provider collaboration management, and public interface management (Closs 2005, 2008). According to the above study these competencies have been often used to describe best-practice frameworks in logistics research. A similar effort has been carried out at University of Minnesota (different from this research) where new a set of competencies is defined for use in their study. The competencies are re-organized around people, partners, products, and practices (Kinsey et al., 2007). The new set of competencies derived from this study are physical security, audits and metrics, strategy/security protocols, communication, training, supply chain collaboration, supply chain verification, tracking/monitoring. Results from this study show that foodservice is the best performing sector with respect to security practices and that large companies across all sectors do better in all competencies. A recent study on food security practices in food service operations in Kansas (Yoon and Shanklin, 2007) indicated the need for training programs on food security to further motivate food and nutrition professionals to implement preventive measures. However, the scope of this study was limited to Kansas schools and health care facilities only. We compile the dataset from Michigan State University and University of Minnesota and used this combined dataset for the purposes of this paper to investigate the question of preparedness of a supply chain and the different dimensions of the construct of firm-preparedness. The data used in the research has a comparatively larger sample size and focuses on not just the impacts of security investments but also on how well the various security practices are followed within the firm (similar to Closs, 2005 and Kinsey et al., 2007). Also, we introduce the concept of security-preparedness and it is our attempt to arrive at the "competencies" or what we call the dimensions of preparedness empirically.

The existing research on supply chain security and resilience either have narrowly focused dataset (food service operations in schools and hospital in Kansas, though larger) or only qualitative case-study approach (detailed interviews conducted with only 25-30 organizations in the U.K. food and drink industry, Survey of 14 companies by Peleg-Gillai et al. 2006). With this paper we attempt to utilize empirical investigation techniques on a larger and broader firm-level survey response dataset to complement and hopefully advance the research in this area.

3 Empirical Methods

3.1 Data Description

Our empirical investigation into firm security practices is based on the received on the "Supply Chain Security Benchmarking and Assessment Survey Questionnaire" for constituents of the U.S. food supply chain. This survey project was supported through a grant by the Department of Homeland Security (DHS) and the National Center for Food Defense and Protection (NCFPD). The primary focus of this survey was to collate firm level responses on various security practices followed and security performance. Though this survey was designed with security incidents of intentional nature in mind the questions asked are on practices and procedures that are helpful for both intentional as well as unintentional security incidents. The survey questionnaires were sent out to each of the three major constituent groups in the U.S. food supply chain, namely, (1) suppliers, manufacturers and distributors, (2) retailers, wholesalers and foodservice operators, and (3) logistic service providers. The survey questionnaire was developed jointly by the three institutions - Michigan State University (MSU), University of Minnesota (UMN), and Georgia Institute of Technology (GT). However, all the three institutions focused on administering the survey to only one of the three supply chain constituents each. Michigan State University was responsible for administering the survey to suppliers, manufacturers and distributors, University of Minnesota conducted similar efforts for retailers, wholesalers and foodservice operators and Georgia Tech carried out this survey for the logistics service providers to the food industry. The data collection for this survey began in 2006. UMN freezed its efforts in April 2007. MSU received most of its responses by April 2007 too. We have used the dataset from UMN and MSU last updated on July 12, 2007.

Although this survey was jointly developed the number and nature of certain questions varied from institution to institution and hence from retailers/wholesalers/foodservice to suppliers/manufacturers and logistics providers. Also, the questionnaire dissemination was done differently by each institution. We believe all these factors have added to the variable response rates for each of the constituents of the supply chain. The Survey was mailed to the firm's corporate headquarters or manufacturing plant. The responsibility of filling out the survey lay with the Operations, Supply chain, Quality Assurance, Security, Risk Management departments. In some cases where none of the above mentioned departments could be identified dealing with supply chain security issues the respondent could be classified as belonging to Other category. This is a cross-sectional dataset with a total of 207 firm responses on about 131 questions. Of the 207 firms represented there were 136 responses came from MSU data and 71 responses came from UMN data. Although some firms in the UMN survey have stated manufacturing as their primary activity and some firms in MSU survey have listed operations other than manufacturing as their primary activity, no firm has responded more than once and there has been no double counting of firms in the dataset. However, in the data received from MSU and

UMN two firms have identified themselves as logistic service providers. Out of this total number of observations four were deleted for the lack of response to a substantial number of questions (40 questions or more in section I out of total 87 questions used), resulting in a total of 203 observations under study. The response rate for UMN survey was about 8%, which though low captures about half to two-thirds of the market by sales. The response rate for the MSU is a strong 58% for the the survey administered through Food Products Association, which primarily consists of large food manufacturers.

The survey questionnaire is divided into three distinct sections. Of the two independent questionnaires that were sent out to two different firm types, we use only the overlapping 87 questions from section I, 13 questions from section II, and 31 questions from section III. The first section (I) asks various questions with respect to the security practices that the firms follow as prevention, detection, recovery and responsiveness measures to build and enhance security within the firms as well as along the supply chain. Summary of section I questions on security practices and measures –with response rates from 1 (strongly disagree) to 5 (strongly agree) are shown in Table 1.

Insert Table 1 about here

The mean, standard deviation, median and modal categories of responses for each of the respective questions shows that firms strongly comply with government and U.S. Department of Agriculture (USDA) guidelines (questions 9, 51), have Hazard and Critical Control Point (HACCP) systems in place (question 59) and have defined procedures for product recalls as well as tracing products one supplier up and one customer down (now mandatory by law) (questions 31, 21). However the collaboration and cooperation with their supply chain partners is still quite weak (questions 10, 17, 30, 41, 42, 69, 83, 84). This could be indicative of a tendency to lay importance only on documentation and satisfying compliance requirements but not being proactive about security issues that face the supply chain as a whole thereby impacting individual firms too. Another concerning fact that emerges from the descriptive statistics is that firm responses do not exhibit confident prevention (question 74), recovery (question 77) and continuity plans under events of catastrophic nature (question 80).

The second section (II) focuses on firm characteristics with respect to annual revenues, market size, supply chain scope, number of employees nationally and internationally, and also the employment profile of the employee primarily responsible for filling out this questionnaire (respondent).

Insert Table 2 about here

Table 2 shows that about 42% of the firms in the sample are large (in terms of annual revenues) and global (with respect to their market area and supply chain scope) and only 2 firms have annual revenues less than $20million and local market area as well as supply chain scope. Description of the firm and

respondent characteristics and their mean responses are described in Tables 3 and 4, respectively.

Insert Table 3 about here

Table 3 provides the averages of responses across all section I questions for each firm based on their firm characteristics such as annual revenues, number of employees, market area and supply chain scope.

Insert Table 4 about here

Table 4 provides the averages of responses across all section I questions for each firm based on their respondent profile such as respondent title, organizational responsibility, number of years in the same industry, employer and position. Table 3 shows that the mean response to section I question on various security practices are also the highest for firms that are large (revenues), global in market area and supply chain scope, have large number of employees both domestic and internationally. We see that the average responses are higher as the firms increase their market areas and expand the scope of their supply chain. For firm size based on annual revenues the trend is less clear. However, not-for-profit/cooperatives show higher category response on questions of security practices than for-profit firms. Foodservice retail has shown greater confidence with respect to security practices in a parallel study using the UMN data only (Kinsey et al., 2007) against other retailers and wholesalers but it also is better than suppliers/manufacturers too. Simple means of responses to section I questions by respondent characteristics, in Table 4, shows that as title of the respondent rises the mean response to security practice questions actually goes down . Experience with either the industry or the current employment/position do not seem to systematically bias the response. Respondent responsibility within the organization shows a similar pattern as the respondent title in the organization. Respondents with corporate level responsibility have lowest confidence in the security practices carried out within their firms and this confidence increases as the respondent gets closer to the shop-floor level, except for respondents with warehouse responsibility .

The third section (III) aims to capture the impact of changes in security investments of the firms on measures like resilience, risk profile, number of security incidents, both within the firm and across the supply chain.

Insert Table 5 about here

Similar to Table1, a summary of firm responses on a 5 point Likert scale, this one labeled as significantly reduced (category 1) to significantly increased (category 5) with no change (category 3) for most questions, is given in Table 5.

Insert Figure1 and Figure 2 about here

Figures 1 and 2 illustrate through graphs the percentage of respondents who reported increase (categories 4 and 5), decrease (categories 1 and 2) or no change (category 3) due to security investments on various security and business outcomes. While 9.5% respondents replied that the operating costs within their firm reduced close to half (about 48%) of the respondents replied that these costs had actually gone up (categories 4, 5) and the remaining replied with no change in such costs. Also, though 26.5% responded with lowered insurance costs, close to 66% responded with no change in insurance costs or even higher insurance costs (7.3%).

The descriptive statistics of the dataset provide an overview of the different security practices and procedures carried out by the firms in the U.S. food supply chain as well as the effect of security investments carried out by the firms on various security and business performance indicators. However, there still remains the need to understand whether the different security practices followed by firms are just practices carried out in isolation or they are followed with varying levels of conviction (from strongly agree to strongly disagree) depending on how prepared they actually are. This preparedness of firms to be able to cope with security incidents, that is, security-preparedness (or preparedness), is the construct that we analyze here. It manifests itself through various prevention, detection, response, recovery and other security measures that the firms have in place or practice. There are several questions that such a construct poses: Is it unidimensional or multi-dimensional? If multi-dimensional what are the different dimensions? How to measure such a construct? How do firms differ on this construct? How would firm characteristics affect, if at all, this construct? What is the influence, if any, of this construct on security performance and business outcomes?

3.2 Factor Analysis

We begin by addressing the question of dimensionality of this construct. It may be argued that there are different facets or dimensions to preparedness and each such facet needs to be measured differently as it may be captured differently by the response pattern of the firms. For example, some firms may stringently monitor their own assets and their premises but may not lay emphasis on supply chain collaborative measures. To address this issue we utilize principal factor analysis approach. Specifically, we investigate whether different responses load onto one or more underlying factors for this dataset, using all the 87 questions and all the 203 firm responses using the method of principal factor analysis. In the unrotated factor model most of the questions loaded reasonably well (>0.4) on the first factor. To be sure, there were 7 questions that loaded better on the second factor. Of these, 5 questions were based on use of advanced technology and monitoring, for example, use of Radio Frequency Identification (RFID), Global Positioning Systems (GPS), X-ray, Closed Circuit Television (CCTV) to track products. These are questions on use of frontier

technology, which does not have very high market penetration. The average response on these questions was reasonably low across firms. The reliability measure for this one factor model implying a unidimensional construct were high (Cronbach's α being 0.9782). However, there are several problems with this unrotated factor solution: we find that the first factor has wide range of loadings, from a minimum of 0.15 to a maximum of 0.8; all questions that load on the second factor do not have a consistent interpretation although they have about the same loadings; only one question loads on the third factor. Hence we rotate the factors to, hopefully, obtain a more clearer pattern of loadings and hence a more interpretable solution.

Using rotation[2] on the retained factors and from the scree test we find that two strong factors emerge; factor 1 details firm centric practices, and factor 2 largely consists of supply chain collaboration efforts by the firm. Further decomposing the factor solution[3] we arrive at four distinct factors, namely, factor 1: firm systems/strategies/processes, factor 2: supply chain collaboration, factor 3: firm security emergency preparedness, and factor 4: tracking products and people on firm premises. We find the four-factor model as best describing the data and with a clearer interpretation of the factors as compared to one factor model or other multiple factor models. The reliability measure Crobach's α is greater than 0.85 for all the 4 factors. We then segregate the questions based on the factor they belong to and construct independent measurement models for each factor using the more appropriate latent trait analysis for categorical data and continuous latent factor/trait.

3.3 Latent Trait Analysis

We have argued that the notion of firm's security preparedness is manifest in the varying levels of confidence with which a firm follows security practices and procedures, which are essentially the responses to section I questions. From preliminary results of the factor analysis we find four dimensions to this notion or construct. We then use Latent Trait Analysis(LTA) for the continuum latent trait, for each of the dimensions or traits separately. LTA analyzes the relation between latent (unobserved) continuous variables and the observed categorical variables. These models are frequently used in education and now also in health and risk assessment and analysis. One such model called the Rasch model, in the area of Psychometrics, has been used to understand the food safety behavior of consumers (Arnout et al., 2006) from a survey questionnaire. In the present context, the Security Benchmarking Survey also embodies the perceptions of managers and professionals on their respective firms' following of various security practices and hence it is reasonable to apply this method in this context. If the firms have a higher amount of the latent trait or dimension of preparedness, then they are more likely to endorse the higher ordered categories of response for

[2]We used varimax and promax rotation, both giving the same factor solution

[3]Scree test is a thumb rule that often retains smaller number of factors. Hence we also look at solutions with larger number of factors.

each of the questions. We use Graded Response Model(GRM), which is better suited to data with polychotomous responses(Samejima, 1969).

To arrive at an appropriate form of the latent trait model to use, we first assume that the underlying variable of interest (one particular dimension of preparedness), is a continuous latent variable following standard normal distribution (with mean 0 and variance 1). The questionnaire has questions, which require responses in ordered categories. The basic tenets of latent trait analysis are that response on a given question can be explained by a set of factors called latent traits and that the relationship between responses and the set of traits can be described by a monotonically increasing function (Hambleton et al., 1991). We use the framework laid out by Rabe-Hesketh, Skrondal and Pickles (2004) in developing the method here. Suppose that this latent trait for a firm j, θ_j , is a continuous variable. Let $\Theta = \theta_1, \theta_2, ...\theta_J$ be $1xJ$ vector of latent traits for all J firms; let y^*_{ij}be the true latent response given the latent trait for firm j, that is, θ_j on the question/item number i for a total of I such questions/items. Here the latent response y^*_{ij} is a continuous variable too. Let y_{ij}be a categorical measure of the true latent response y^*_{ij}. The response categories are ordered from low to high with higher ordered categories signifying greater presence of the latent trait. Thus, as θ_j increases so does y^*_{ij} (monotonically) and also y_{ij} (stepwise).

Imagine cut-points or thresholds α_1, $\alpha_2...\alpha_k...\alpha_{K-1}$ such that $\alpha_1 < \alpha_2 <.. < \alpha_k <.< \alpha_{K-1}$ Here $k = 1, ...5$ for the 5 categories of responses to each question (from "strongly disagree" $=s_1 =1$ to "strongly agree"$= s_5 = 5$). Then , the true latent response y^*_{ij} will be manifest through category k, that is, s_k if the latent response is lower than the threshold α_k but higher than the threshold α_{k-1}. Thus we have,

$$y_{ij}=\begin{cases} s_1 & if \quad y^*_{ij}<\alpha_1 \\ s_2 & if \quad \alpha_1 \leq y^*_{ij}<\alpha_2 \\ . & . \quad . \\ . & . \quad . \\ s_5 & if \quad \alpha_4 \leq y^*_{ij} \end{cases}$$

for question i, firm j will respond in category 2, that is $y_{ij} = s_2$ if the true continuous latent response y^*_{ij} lies between thresholds α_1 and α_2 on the latent response continuum.

Let ν_{ij} be the linear predictor for the latent response y^*_{ij} for question or item i, with

$y^*_{ij} = \nu_{ij} + \epsilon_{ij}$

where the error term ϵ_{ij} of the true latent response y^*_{ij} is assumed to have standard normal distribution. With the assumption of normality such latent response models are called the Graded Response Models (Samejima, 1969, 1996).The linear predictor ν_{ij} is itself an increasing function of the unobserved explanatory variable, that is, the latent trait θ_j.

Let Φ be the cumulative standard normal distribution of ϵ_{ij}. Then, the probability that the response takes any value less than or equal to category s_k (conditional on the latent and observed explanatory variables) is given by:

$P(y_{ij} \leq s_k) = \Phi(\alpha_k - \nu_{ij})$
or equivalently

$$\Phi^{-1}(P(y_{ij} \leq s_k)) = \alpha_k - \nu_{ij}1.1 \tag{1}$$

The probability of the jth response category is then given by:

$$P((y_{ij} = s_k) = P(\alpha_{k-1} \leq y^*_{ij} < \alpha_k) = \Phi(\alpha_k - \nu_{ij}) - \Phi(\alpha_{k-1} - \nu_{ij})1.2 \tag{2}$$

In effect, equation(1.1) conveys that, if the thresholds are placed higher then the probability that the firm is able to overcome those thresholds will be lower and hence the probability that the firm would respond in the categories below the threshold will be higher. To understand the relationships established in equation (1.1) further consider an example: for a given firm j the categorical latent response to question i, that is, y_{ij} would be equal to or lower than category 3, that is, s_3 if the true latent response y^*_{ij} is less than the threshold α_3. Thus, the firm would respond in category 1 or 2. However, if the true latent response is lower than even threshold for category 2, that is, α_2 then the firm will only respond in category 1. By construction the true latent response y^*_{ij} is an increasing function of v_{ij} and so is the measured latent response y_{ij} an increasing function of v_{ij}. The predictor v_{ij} is assumed to be a linear function of item and firm characteristics such that,

$$\nu_{ij} = \beta_i + \theta_j 1.3 \tag{3}$$

where β_i denotes the easiness of answering question i. Easiness here implying the ability to answer a particular item i in higher order categories[4]. Alternatively, $-\beta_i$ denotes the difficulty of the item. This item parameter accounts for the fact that some questions are such that a large proportion of the firms will answer them in the higher order categories (and hence are easy) and some questions are such that only a small proportion of firms can answer in higher order categories (and hence are difficult). Thus, it helps to distinguish between firms that answer a large number of "easy" questions in the higher order categories and those who answer a large number of "difficult" questions in the higher order categories. In essence, it controls for the question/item fixed effects. As the easiness of the question increases the prediction of response in higher order categories also increases. One important assumption here is that the item parameters β_i 's do not influence or are influenced by the firms' trait distribution θ_j 's.

Substituting equation(1.3) in equation(1.1) gives:

$$\Phi^{-1}(P(y_{ij} \leq s_k)) = \alpha_k - (\beta_i + \theta_j)1.4 \tag{4}$$

[4]If a security practice is identified as "easy" it does not automatically imply that the practice is easy to follow but that more number of firms follow that practice. This could be due to mandatory regulations or possibly because the practice is not costly to the firms.

Equation(1.3) describes the latent response model that we fit to the dataset with an ordinal probit link. This simple item response model for ordinal items assumes that the latent response has different means for the different items but the same residual variance $Var(\epsilon)$. Also, the effect of the latent variable θ_j is the same for all items and the thresholds are constant across items i. The above model is fitted using the generalized liner latent and mixed models (GLLAMM) program in Stata. This program uses the approach of maximum likelihood estimation specifically for fitting latent response models of the above type. There are other software such as M+, R, WINSTEPS that are used to fit such latent models. We have used GLLAMM primarily due to easy availability and familiarity with Stata.

The output of this model fitting are the threshold estimates α_k, the item parameters β_i, and the firm scores θ_j, which give the location of the latent trait of the firm j on the trait, continuum. As Θ is assumed to follow standard normal distribution most of its mass lies between the -3 to $+3$ continuum. The higher the value of θ_j, the more positive the location of latent trait on this continuum. θ_j can also be thought of as the amount of latent trait present in firm j. Equation (1.1) can then be used to estimate the probabilities of a firm with a given amount of latent trait endorsing a particular item category. The thresholds are the model intercepts. They increase as the response category increases, implying that the firm needs to cross a higher threshold to reach higher order categories for any given question or item. For example, for a firm to respond in category 2 (disagree) rather than category 1 (strongly disagree) it must have latent trait location greater than α_1. The item parameters are a measure of "difficulty"/"ease" of each of the items, and are, like thresholds, invariant over firms. Since $-\beta_i$ represents the difficulty level in answering item i we see that question with low value of β_i will be more difficult to answer while question j with high value of β_j will be easier to answer. "Difficult" basically implies that a large proportion of firms do not agree, or do not follow confidently the practice stated in the question i while "easiness" implies that a large proportion of firms agree, or follow confidently the practice stated in question j. The probability estimates for firms with a given firm score to endorse a particular response category for a given item can be obtained by plugging in the estimates from the model into equation (1.2).

Results from this analysis provide item coefficients which suggest if a particular item is "difficult" or "easier" to practice compared to the base item that has the coefficient equal to zero. Thus items with lower values are perceived to be "difficult" or that less firms practice it while those with higher values are "easier" or that more firms practice it with greater confidence. The last two columns of Table 1 show the coefficients and their standard errors for the items. While between-factor items are not comparable but comparisons of the within-factor items shows that for the first factor that deals with firm centric systems/strategies/processes, larger number of firms comply with government regulations such as required record keeping, tracking one supplier up and one customer down and also following HACCP but very few firms have recovery or continuity plans in place. The base question for factor 2 is use of RFID, a

frontier technology, which has very little following in this dataset and hence all other items show positive coefficients as compared to use of RFID, except the item on confidence in supplier's information systems. We consider this anomaly considering that the item does not show extremely low mean, median or modal response and does not have a high standard deviation either. This item needs further investigation at this point in time. The items in factors 3 and 4 on security emergency preparedness and tracking people and products on firm premises can be interpreted similarly. The coefficient values suggest that firms do not show confidence in engaging in security emergency preparedness planning or establishing communication protocols for security incidents. However, firms do have access protocols in place and generally seal their assets than lock them while in transit. While firms follow the mandatory requirements quite confidently security procedures that can be important but not mandated are not followed sincerely.

3.4 Regression Results

Using latent trait analysis we arrive at preparedness scores, for each of the factors for each firm, which we now use in our regressions on firm characteristics such as number of employees in U.S., number of employees internationally, annual revenues, market area, supply chain scope, tax status, primary activity, as well as on respondent characteristics such as work experience in the industry/company/position, title and organizational responsibility to see how firm characteristics such as size and scope and respondent characteristics such as position and experience can influence the security preparedness. We find that employees in U.S. and annual revenues are highly correlated (0.77). Thus including both in the independent variables would lead to multicollinearity and reduce the size of the coefficients. Also, number of employees in US and number of employees internationally is highly correlated (0.66). Hence we drop revenues and employees internationally as independent variables and find statistical significance for employees in US in explaining the firm scores for each of the factors. Market area and supply chain scope too show high degree of correlation (0.59) however the correlation though significant at 1% level is weaker compared to the above variables. Both these variables are show some degree of significance when used exclusively in the regressions.

Insert Table 6 about here

Summarizing the results from Table 6, we find number of employees in US, market area, and supply chain scope as important explanatory variables in explaining firm scores and hence firm response pattern. Retailers, especially in foodservice, seem to be better performers compared to wholesalers (as also documented in earlier report by Kinsey et al.) as well as manufacturers and logistic providers. For firm centric systems/strategies/processes factor, that is, factor 1, number of employees in the U.S., supply chain scope of the firm and whether the

firm's primary activity is foodservice retail are important explanatory variables. For supply chain collaboration factor 2, number of employees in the U.S., foodservice retail business and both market area and supply chain scope of the firm are important explanatory variables while for profit tax status is marginally important. For security emergency preparedness factor 3, employees in US, supply chain scope and for profit tax status are important explanatory variables. For firm's ability to track people and products on its premises as captured by factor 4, employees in US, market area and supply chain scope and grocery retail business are important explanatory variables. The dummy for tax status is negative and significant suggesting that for-profit firms have lower prepparedness levels. However, the case for factor 1, that is firm centric measures, this effect is not significant. Regressing firm scores on respondent characteristics suggests that the respondent is from operations or risk management area has a significant but negative impact on the firm security preparedness scores across all dimensions. However, it is interesting to note that years of work experience in the industry or the job do have a significant impact on the respondent's perception of security preparedness. See Table 7.

Insert Table 7 about here

4 Discussion and Conclusion

The notion of preparedness, which we argue as a latent construct in this research, needs to be reflected upon a bit. What this research advocates is that preparedness is the propensity of the firm to be proactive, organized, armed and able, and flexible under an impending threat of any extreme event. The main objective of the survey, the results from which we use for the analysis here, was to capture these various capabilities of firms with respect to security measures. We acknowledge that there is a need to further refine the understanding of this concept and its analysis. Our analyses presently suggest multiple dimensions to the construct of security preparedness. This concurs with the hypotheses of various research studies in the area of resilient and secure supply chains (Kinsey et al. 2007,Closs et al. 2008). However, the formulation and interpretation of these dimensions has not been empirically validated in the literature.

It was also our aim to analyze the influence of certain characteristics of the firm such as size (number of employees), scope of operations (market area, supply chain scope, manufacturing or retail, etc.), as well as profile of the respondent from the firms on preparedness levels. We find in our investigation that a large number of firms complete all the regulatory compliance procedures, have information systems, senior management attention, and prevention, detection and response capabilities in place. However, there is very little collaboration along the supply chain apart from what is prescribed by regulation. Thus, the culture of security and shared concern across the supply chain is yet to be imbibed. This analysis points out to the importance of organizational culture in preparedness,

which can have important implications for businesses in improving their security profile. We find that number of employees as a measure for size of the firm is important explanatory variable for firm response in higher ordered categories, that is, showing more confidence in following security practices. Thus, larger firms appear to better follow security practices, which maybe a result of greater cost effectiveness. Smaller firms on the other hand may derive benefits from the positive externalities generated from investments made by larger firms. Also, supply chain scope and market area are important in explaining prepparedness. The primary activity of the firm is important in determining the stakes of the firm in the event of a security incident. Foodservice firms have brand reputation to protect and hence higher stakes than a manufacturing firm that does not have a brand recognition in a security event.

Thus, large firms with considerable global exposure appear to have greater security consciousness and investments in security procedures and practices, which can be rationalized with the arguments of security spillover effects for large firms across their supply chains. Small firms, on the other hand, may lack the economic incentives in investing in security measures and hence may turn out to be lower on the security preparedness scores for their supply chains. For such smaller firms, dedicating resources to increasing security would be an expense not an investment. However, increasing the scope of operations to the global arena will necessitate firms to consider security building in their supply chains and could be viewed as vigilant cost to avoid international embargoes. Also, it is easy to argue that firms will behave rationally by being more self-centric in their security metrics (as product recall procedures may have liability issues for which, the firm is solely responsible) than a ready collaborator in improving the overall supply chain resilience (as a firm is not directly responsible for the employees of its service provider, but it is a practice in the interest of the supply chain). The weakest answers were on questions of supply chain collaboration and particularly on the getting more information of supplier's security levels while the stronger ones were on firm centric security practices. However, there is positive and significant correlation between getting more supplier information and following rest of the security practices suggesting some degree of complementarities between the two types of practices.

The conclusions of this research have important policy implications in what needs to be done further for achieving secure supply chains and thereby strengthening the economy. The results provide pointers to the various practices followed with different levels of conviction and can consult policymakers on the needful areas of attention, as well as, commend the success of certain measures. They could provide the necessary mandate for introducing new security regulations. The methodological approach used in this paper can also help design security assessment questionnaires better by flagging questions that are not significant for inclusion, thereby providing an improvement in technique and implementation.

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Legend 1: Response Categories for section I

Response Category	Rank
Strongly Disagree	1
	2
	3
	4
Strongly Agree	5

Legend 2: Response Categories for section III

Response Category	Rank
Significantly Reduced	1
	2
No Change	3
	4
Significantly Increased	5

Table 1: Summary Statistics of Section I Question Responses by factors

Questn No.	Question	Mean	Sd	Median	Mode	No. of firms	Factor^	Coef.		Sd
5	Our firm's information systems provide managers the *timely* information they need to respond to contamination/security incidents.	4.00	1.02	4	4	203	1	0.00		
6	Our firm's information systems provide managers *valid* information they need to respond to contamination/security incidents.	3.99	1.01	4	4	201	1	-0.03		0.11
7	Our firm utilizes food and material security audit/certification programs.	3.83	1.27	4	5	197	1	-0.18		0.11
9	Our firm complies with government-required record keeping regulations in the event of a potential terrorist threat or actual terrorist incident.	4.33	1.04	5	5	200	1	0.57	***	0.12
11	Our firm's senior management views supply chain security as necessary for protecting our brand or reputation.	3.98	1.13	4	5	201	1	0.01		0.11
12	Our firm has the ability to track and trace products one supplier up and one customer down the supply chain.	4.38	1.09	5	5	203	1	0.67	***	0.12
18	Please use for Questions 18 through 21 Our firm's supply chain security metrics were developed based on _____.	3.76	1.26	4	5	184	1	-0.33	***	0.12
19	*Industry* guidelines	3.76	1.24	4	5	184	1	-0.30	***	0.12
20	*Internal* guidelines	3.89	1.24	4	5	186	1	-0.12		0.12
21	*Key supply chain partner* guidelines	3.29	1.31	4	4	180	1	-0.88	***	0.11
25	Our firm's information systems allow us to quickly share appropriate information to all firm employees in case of contamination/security incidents.	4.03	1.10	4	5	202	1	0.06		0.11
26	Please use for Questions 26 through 28 Our firm has established a communication strategy for providing information about contamination/security incidents to _____.									
	Appropriate government/public agencies	4.04	1.20	4	5	202	1	0.14		0.12
27	*The media/public*	3.95	1.27	4	5	202	1	0.01		0.12
28	*Our supply chain partners*	4.00	1.18	4	5	202	1	0.04		0.12
31	Our firm has defined procedures to complete product recalls.	4.65	0.91	5	5	201	1	1.31	***	0.14
32	Our firm's senior management actively supports food supply chain security initiatives.	4.06	1.07	4	5	201	1	0.12		0.12
34	Our firm uses an enterprise-wide strategy to address security concerns.	3.57	1.27	4	5	195	1	-0.50	***	0.11
35	Our *firm's* information systems are secure.	4.21	1.00	4	5	202	1	0.31	***	0.12

Table 1: Summary Statistics of Section I Question Responses by factors (cont.)

Questn No.	Question	Mean	Sd	Median	Mode	No. of firms	Factor^	Coef.		Sd
38	Our firm's information systems allow us to provide any and all of the following information within 24 hours, if requested by the FDA, for each food item transported within the past year: • The name of the immediate previous source and immediate subsequent	4.24	1.10	5	5	202	1	0.38	***	0.12
45	Our firm's information systems provide our supply chain partners with the *timely* information they need to respond to contamination/security incidents.	3.95	1.09	4	5	199	1	-0.07		0.11
46	Our firm's information systems provide our supply chain partners with *valid* information they need to respond to contamination/security incidents.	3.96	1.10	4	5	199	1	-0.04		0.11
48	Our firm maintains a database containing emergency contact information for all of our service providers.	3.62	1.25	4	4	195	1	-0.46	***	0.11
53	Our firm has established consequences for employees who fail to comply with internal security procedures.	3.62	1.24	4	4	199	1	-0.45	***	0.11
59	Our firm utilizes the Hazard Analysis and Critical Control Point (HACCP) system.	4.49	1.10	5	5	191	1	0.90	***	0.13
61	Please use for Questions 61 through 64 Our firm incorporates information on _____ a contamination/security incident into employee food protection training. Preventing	4.04	1.07	4	5	199	1	0.09		0.12
62	Detecting	3.81	1.20	4	5	199	1	-0.20	*	0.11
63	Responding to	3.90	1.13	4	5	198	1	-0.09		0.11
64	Recovering from	3.36	1.28	3	3	196	1	-0.74	***	0.11
65	Our firm has defined internal *communication* protocols in case of a contamination/security incident.	4.13	1.05	4	5	198	1	0.21	*	0.12
66	Our firm has defined internal *reporting* protocols for contamination/security incidents.	3.99	1.12	4	5	199	1	0.03		0.12
71	Our firm only uses those service providers with whom we have an established relationship.	3.67	1.13	4	4	195	1	-0.43	***	0.11
73	Our firm's senior management views supply chain security initiatives as a necessary cost of doing business.	3.76	1.17	4	5	193	1	-0.25	**	0.11

Table 1: Summary Statistics of Section I Question Responses by factors (cont.)

Questn No.	Question	Mean	Sd	Median	Mode	No. of firms	Factor^	Coef.		Sd
74	Please use for Questions 74 through 77 Our firm has processes in place to _____ a contamination/security event in our supply chain.									
	Prevent	3.78	1.13	4	5	199	1	-0.26	**	0.11
75	Detect	3.77	1.15	4	5	198	1	-0.27	**	0.11
76	Respond to	4.03	1.10	4	5	200	1	0.07		0.12
77	Recover from	3.77	1.18	4	4	198	1	-0.29	***	0.11
78	Our firm has implemented procedures to monitor receipt of products at our facilities.	4.42	0.93	5	5	192	1	0.70	***	0.12
80	Our firm's continuity plans consider the potential lack of availability of critical public resources (e.g. transportation, power, water, communications, fire, emergency management) in the event of a crisis.	3.27	1.35	3	4	202	1	-0.89	***	0.11
8	Our firm has specific education programs for our supply chain partners regarding supply chain security procedures.	2.85	1.28	3	3	193	2	1.58	***	0.13
10	Our firm verifies that our service providers' use government or industry security guidelines.	3.29	1.19	3	3	196	2	2.04	***	0.13
13	Our firm uses an external audit team (as opposed to self-audits) to verify the security procedures of our supply chain partners.	2.84	1.51	3	1	192	2	1.56	***	0.13
14	Our firm collaborates with service providers to improve their security programs.	2.86	1.33	3	3	194	2	1.59	***	0.13
16	Our firm utilizes security metrics as part of an overall brand protection program.	2.95	1.39	3	3	188	2	1.66	***	0.13
17	Our firm has defined consequences for supply chain partners who fail to comply with supply chain security procedures.	2.76	1.36	3	1	192	2	1.46	***	0.13
23	Our firm monitors security metrics across the supply chain.	2.75	1.36	3	1	193	2	1.43	***	0.13
30	Our firm verifies that service providers perform security background checks on their employees.	2.55	1.37	2	1	190	2	1.24	***	0.13
36	Our *supply chain partners'* information systems are secure.	3.25	1.01	3	3	182	2	-0.69	***	0.11
37	Our firm uses radio frequency identification (RFID) to effectively track the products in our control.	1.78	1.28	1	1	189	2	0.25	*	0.13

Table 1: Summary Statistics of Section I Question Responses by factors (cont.)

Questn No.	Question	Mean	Sd	Median	Mode	No. of firms	Factor^	Coef.		Sd
40	Our firm verifies that service providers monitor transportation assets.	2.92	1.30	3	3	191	2	1.65	***	0.13
41	Our firm has strategically assessed our supply chain protection capabilities for *domestic* supply chain partners.	2.97	1.31	3	4	190	2	1.70	***	0.13
42	Our firm has strategically assessed our supply chain protection capabilities for *international* supply chain partners.	2.79	1.32	3	2	171	2	1.47	***	0.13
47	Our firm's supply chain partners collaborate in the use of radio frequency identification (RFID) to track products throughout the supply chain.	1.79	1.19	1	1	176	2	0.25	*	0.13
50	Our firm has identified transportation vulnerabilities from point of origin to final destination (including shipping modes/routes).	2.83	1.29	3	3	193	2	1.55	***	0.13
52	Our firm's senior management views supply chain security as a competitive advantage.	3.24	1.28	3	3	196	2	1.97	***	0.13
54	Our firm uses global positioning systems (GPS) to track containers of product for which we are responsible.	1.93	1.37	1	1	181	2	0.47	***	0.13
67	Our firm uses closed circuit television (CCTV) to monitor activities on loading docks.	3.03	1.59	3	1	193	2	1.76	***	0.13
68	Our supply chain partners can provide us the actionable information we need to respond to contamination/security incidents.	3.57	0.92	4	4	197	2	2.30	***	0.13
69	Our firm uses security assessments to determine if relationships should be maintained with *suppliers.*	2.75	1.31	3	1	195	2	1.45	***	0.13
70	Our firm uses security assessments to determine if relationships should be maintained with *customers.*	2.50	1.33	2	1	184	2	1.22	***	0.13
79	Our firm conducts drills to test our supply chain protection capabilities.	2.61	1.36	2	1	196	2	1.31	***	0.13
81	Our firm requires transportation providers to provide advanced shipment notices [e.g. Advanced Shipment Notices (ASN's) or Advanced Manifest Requirements (AMR's)] before delivery.	3.23	1.33	4	4	187	2	1.95	***	0.13
82	Our firm audits the security procedures of *contract manufacturers.*	2.88	1.37	3	4	177	2	1.54	***	0.13

Table 1: Summary Statistics of Section I Question Responses by factors (cont.)

Questn No.	Question	Mean	Sd	Median	Mode	No. of	Factor^	Coef.		Sd
83	*Please Use for questions 83 to 85: Our firm sudits security procedures of : Frequently*	2.61	1.30	3	1	193	2	1.28	***	0.13
84	*Infrequently used suppliers* (e.g. employee/driver background checks, origination and ownership, ingredients, and packaging procedures).	2.20	1.17	2	1	191	2	0.86	***	0.13
85	*Our customers* (e.g. employee/driver	2.08	1.14	2	1	186	2	0.69	***	0.13
87	Our firm uses technology (e.g. X-ray, RFID, etc…) to verify trailer or container contents.	1.61	1.05	1	1	184	2	0.00		
4	Our firm has defined communication protocols consistent with the National Incident Management System (NIMS) (i.e. federal protocol to handle security incidents).	3.25	1.35	3	4	186	3	-0.27	**	0.11
15	Our firm has decision trigger points and/or automated response actions in the event of a contamination/security incident.	3.49	1.32	4	4	200	3	-0.03		0.11
22	Our firm has a senior management position focusing on security (e.g., Director of Security, Chief Security Officer).	3.43	1.55	4	5	199	3	-0.04		0.11
29	Our firm participates with external public health groups (e.g. U.S. Public Health Service, Center for Disease Control).	3.21	1.44	3	5	197	3	-0.30	***	0.11
33	Our firm regularly conducts internal security audits to determine weaknesses in physical security.	3.50	1.25	4	5	199	3	-0.01		0.11
39	Our firm participates in emergency-preparedness planning with appropriate government agencies.	3.22	1.40	3	5	196	3	-0.30	***	0.11
44	Our *empty* trailers and containers are stored in a secure environment.	3.57	1.32	4	5	197	3	0.06		0.11
49	Our firm participates in emergency-preparedness testing (table top, field exercises, etc…) of plans with appropriate government agencies.	2.66	1.47	2	1	195	3	-0.87	***	0.12
60	Our firm regularly assesses the qualifications and credentials of security personnel.	3.57	1.29	4	5	186	3	0.00		
1	Our firm has established access control for *employees* to ensure the integrity of facilities and operations.	4.09	1.09	4	5	203	4	0.29	***	0.12
2	Our firm has established access control for *non-employees* to ensure the integrity of facilities and operations.	4.09	1.14	4	5	203	4	0.31	***	0.12

Table 1: Summary Statistics of Section I Question Responses by factors (cont.)

Questn No.	Question	Mean	Sd	Median	Mode	No. of firms	Factor^	Coef.		Sd
3	Our firm has established restrictive controls (restriction of personal items in sensitive areas, restriction of non-essential chemicals in sensitive areas, etc…) to ensure the integrity of facilities, operations, and food products.	4.00	1.09	4	4	202	4	0.14		0.11
24	Our firm has the technology to track food products including salvage, reworked, and returned products.	4.01	1.17	4	5	202	4	0.21	*	0.12
43	Our *loaded* trailers and containers are stored in a secure environment.	3.86	1.24	4	5	197	4	0.04		0.12
51	Our firm employs guidelines from the U.S. Department of Agriculture (USDA) or its divisions (e.g. FSIS).	3.31	1.34	4	4	188	4	-0.59	***	0.11
55	Our *firm's* transportation assets are *locked* while in transit.	3.60	1.45	4	5	197	4	-0.25	**	0.11
56	Our *firm's* transportation assets are *sealed* while in transit.	4.04	1.35	5	5	198	4	0.29	***	0.12
57	Our *service providers'* transportation assets are *locked* while in transit.	3.44	1.27	4	4	195	4	-0.46	***	0.11
58	Our *service providers'* transportation assets are *sealed* while in transit.	3.85	1.22	4	5	194	4	0.00		
72`	Our firm performs background checks on all employees.	3.62	1.52	4	5	200				
86`	Our firm generates routine exception reports (e.g. noncompliance reports, corrective action reports, potential incident reporting, and actual incident reporting).	3.35	1.38	3	5	195				

` These questions have very low factor loadings (less than 0.4) and are not consistent with interpretation of the factor on which they load the highest

***, **, * imply 1%, 5%, 10% level of significance respectively

^ Factor Interpretation
factor1: firm systems/procedures/strategies
factor2: supply chain collaboration
factor3: security emergency preparedness
factor4: tracking people and products on firm premises

Table 2: % number of Firms by Annual Revenues, Market Area and Supply Chain Scope

	Market Area				
	Local	Regional	National	Global	Total
Revenues					
<20M	0.99	2.96	4.43	1.97	10.34
20M-100M	0.99	5.91	5.42	7.39	19.70
100M-500M	1.48	4.93	8.37	4.43	19.21
500M-1B	0.00	2.96	0.99	4.43	8.37
>1B	0.00	8.37	7.88	26.11	42.36
Total	3.45	25.12	27.09	44.33	100.00

	Supply Chain Scope				
	Local	Regional	National	Global	Total
Revenues					
<20M	0.99	3.45	3.45	2.46	10.34
20M-100M	0.99	3.94	6.90	7.88	19.70
100M-500M	0.99	3.45	9.85	4.93	19.21
500M-1B	0.00	1.48	2.96	3.94	8.37
>1B	0.00	4.93	10.34	27.09	42.36
Total	2.96	17.24	33.50	46.31	100.00

Table 3: %number of Firms and Mean response* by firm characteristics

Annual Revenue ($)	Mean	sd	%N	Market Area	Mean	sd	%N	Supplier Base	Mean	sd	%N	Number of Employees U.S.	Mean	sd	%N
<20M	3.42	0.95	10.3	Local	3.18	1.28	3.4	Local	2.92	1.10	3.0	0-100	3.18	0.89	12.3
20M-100M	3.11	0.69	19.7	Regional	3.28	0.60	25.1	Regional	3.27	0.61	17.2	101-500	3.27	0.66	19.7
100M-500M	3.18	0.66	19.2	National	3.26	0.78	27.1	National	3.32	0.70	33.5	501-1000	3.23	0.58	10.3
500M-1B	3.51	0.63	8.4	Global	3.75	0.64	44.3	Global	3.70	0.72	46.3	1001-5000	3.23	0.64	18.7
>1B	3.79	0.62	42.4									5001-20000	3.80	0.66	18.7
												20001-50000	3.98	0.72	9.9
												50000+	3.87	0.49	10.3

Table 3(cont.): %number of Firms and Mean response* by firm characteristics

Number of Employees Internationally	Mean	sd	%N	Tax Status	Mean	sd	%N	Primary Activity	Mean	sd	%N
0-100	3.24	0.74	49.8	For profit	3.48	0.73	90.6	Manufacturing	3.52	0.77	59.6
101-500	3.40	0.55	8.9	Not-for-profit	3.52	0.73	6.9	Retail Wholesaler	3.28	0.55	11.3
501-1000	3.48	0.74	6.9	Other	3.35	1.03	2.5	FS Wholesaler	3.59	0.68	9.4
1001-5000	3.68	0.84	7.4					Grocery Retailer	3.08	0.71	9.9
5001-20000	3.67	0.66	9.4					FS Retailer	4.03	0.48	4.4
20001-50000	3.94	0.47	8.9					Logistics	3.80	0.20	1.0
50000+	4.02	0.50	8.9					Other	3.37	0.77	4.4

FS: Foodservice
*mean response to section I questions only
%N: Percentage of the total number of respondents
M: Million
B:Billion

Table 4: %number of Firms and mean response* by respondent characteristics

Title	Mean	sd	%N	Organizational Responsibility	Mean	sd	%N	Industry Experience (years)	Mean	sd	%N	Position Experience (years)	Mean	sd	%N
President(owner)	3.24	1.10	4.9	Corporate	3.30	0.75	52.2	0-1	2.75	1.77	1.5	0-1	3.42	0.93	13.8
Vice-President	3.41	0.76	9.9	Divisional	3.56	0.73	10.8	2-4	3.40	0.58	7.4	2-4	3.54	0.62	24.6
Director	3.33	0.72	28.1	Plant	3.75	0.65	29.6	5-9	3.65	0.70	11.8	5-9	3.58	0.68	23.2
Manager	3.52	0.68	31.5	Warehouse	3.38	0.65	6.4	10-14	3.66	0.67	13.3	10-14	3.41	0.66	17.2
Supervisor	3.69	0.68	15.8	Store	4.00	0.79	1.0	15-19	3.55	0.76	21.2	15-19	3.53	1.11	8.9
Other	3.58	0.77	9.9					20+	3.38	0.72	44.8	20+	3.28	0.60	12.3

*mean response to section I questions only

%N: Percentage of the total number of respondents

Table 4(cont.): %number of Firms and mean response* by respondent characteristics

Position Experience	Mean	sd	%N	Company Experience	Mean	sd	%N	Employees at Facility	Mean	sd	%N
0-1	3.42	0.93	13.8	0-1	3.31	0.94	9.9	<50	3.56	0.68	39.90
2-4	3.54	0.62	24.6	2-4	3.52	0.66	19.2	50-99	3.47	0.69	25.12
5-9	3.58	0.68	23.2	5-9	3.40	0.76	23.2	100-199	3.64	0.70	12.81
10-14	3.41	0.66	17.2	10-14	3.68	0.52	14.8	200-499	3.01	0.75	9.36
15-19	3.53	1.11	8.9	15-19	3.41	0.80	12.8	500+	3.38	0.94	12.81
20+	3.28	0.60	12.3	20+	3.49	0.76	20.2				

*mean response to section I questions only

%N: Percentage of the total number of respondents

Table 5: Summary Statistics for some Section III Question Responses

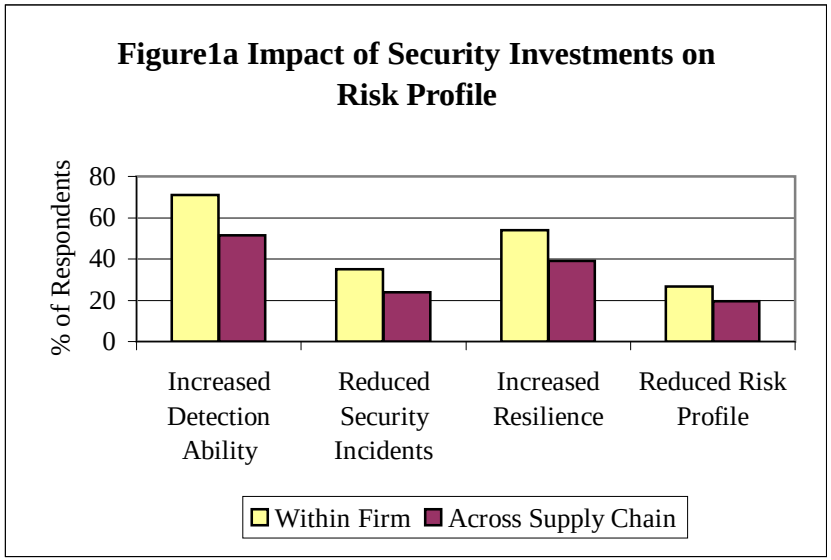
Question Number	Question	Mean	Sd	Median	Mode	Number of responding firms
	Our firm's security investment has _____ our ability to detect security incidents:					
1	(a) Inside our firm	3.89	0.85	4	4	194
	(b) Across the supply chain	3.53	0.83	4	3	187
	Our firm's security investment has resulted in _____ security incidents:					
2	(a) Inside our firm	2.70	0.84	3	3	183
	(b) Across the supply chain	2.81	0.76	3	3	175
	Our firm's security investment has _____ our resilience in recovering from security incidents:					
3	(a) Inside our firm	3.63	0.86	4	3	182
	(b) Across the supply chain	3.44	0.80	3	3	177
	Our firm's security investment has _____ our risk profile with respect to insurability and operations integrity:					
4	(a) Inside our firm	3.08	1.04	3	3	179
	(b) Across the supply chain	3.03	0.85	3	3	174
	Within my firm, our security investment has led to:					
5	(a) _____ operating costs	3.39	0.78	3	4	189
	(b) _____ loss/ shrink	2.71	0.79	3	3	185
	(c) _____ insurance costs	2.79	0.67	3	3	177
	(d) _____ personal injury incidents	2.69	0.66	3	3	183
	(e) _____ employee turnover	2.92	0.59	3	3	182
	Within my supply chain, our security investment has led to:					
6	(a) _____ operating costs	3.35	0.75	3	3	173
	(b) _____ loss/ shrink	2.85	0.69	3	3	171
	(c) _____ insurance costs	2.88	0.65	3	3	164
	(d) _____ personal injury incidents	2.82	0.59	3	3	164
	(e) _____ employee turnover	2.92	0.51	3	3	161
	Relative to our major competitors, our security investment has:					
7	(a) _____ cost to a greater extent	3.20	0.71	3	3	162
	(b) _____ customer service to a greater extent	3.38	0.65	3	3	164
	(c) _____ productivity to a greater extent	3.20	0.69	3	3	165
	(d) _____ product quality to a greater extent	3.43	0.69	3	3	167
	Relative to our major competitors, our firm has been able to more effectively:					
8	(a) _____ supply chain costs as a percentage of total costs	3.03	0.63	3	3	156
	(b) _____ service levels to customers	3.42	0.67	3	3	165
	(c) _____ our supply chain assets	3.18	0.58	3	3	157

Table 6: Regression Results for Firm Characteristics

Dependent Variable	Preparedness Score							
	factor 1		factor 2		factor 3		factor 4	
Adj R^2	0.11	0.12	0.23	0.21	0.17	0.19	0.12	0.08
RMSE	0.95	0.95	0.83	0.84	0.82	0.81	0.81	0.83
Number of employees in U.S.	**0.13** ***	**0.13** ***	**0.15** ***	**0.17** ***	**0.19** ***	**0.18** ***	**0.09** ***	**0.10** ***
	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
Market area	**0.15** *		**0.28** ***		**0.12**		**0.16** **	
	0.09		0.08		0.08		0.08	
Supply chain scope		**0.18** **		**0.21** ***		**0.17** **		**0.15** *
		0.09		0.08		0.08		0.08
Dummies for primary activity:								
Manufacturer	**0.48**	**0.47**	**0.32**	**0.32**	**0.17**	**0.15**	**0.14**	**0.14**
	0.33	0.33	0.29	0.29	0.29	0.28	0.28	0.28
Retail Wholesaler	**0.01**	**-0.01**	**0.18**	**0.11**	**0.02**	**0.02**	**-0.12**	**-0.15**
	0.38	0.38	0.33	0.34	0.33	0.32	0.33	0.33
Foodservice Wholesaler	**0.70** *	**0.67** *	**0.52**	**0.41**	**0.29**	**0.28**	**0.01**	**-0.04**
	0.39	0.39	0.34	0.35	0.34	0.33	0.34	0.33
Foodservice Retailer	**0.57**	**0.58**	**0.90** **	**0.87** **	**0.31**	**0.33**	**0.27**	**0.26**
	0.45	0.45	0.39	0.40	0.39	0.39	0.39	0.39
Grocery Retailer	**-0.17**	**-0.20**	**-0.17**	**-0.31**	**0.02**	**0.02**	**-0.53**	**-0.60** *
	0.39	0.38	0.34	0.34	0.34	0.33	0.34	0.33
Logistics	**0.80**	**0.73**	**1.11** *	**0.96**	**0.39**	**0.34**	**1.14** *	**1.05**
	0.75	0.75	0.66	0.66	0.65	0.64	0.64	0.64
Dummy for tax status:								
For-Profit	**-0.22**	**-0.19**	**-0.45** **	**-0.35**	**-0.53** **	**-0.52** **	**-0.37** *	**-0.32**
	0.25	0.24	0.22	0.22	0.21	0.21	0.21	0.21

Table 7: Regression Results for Respondent Characteristics

Dependent Variable	Preparedness Score			
	factor 1	factor 2	factor 3	factor 4
Adj R^2	0.07	0.06	0.07	0.11
RMSE	0.97	0.92	0.87	0.82
Title dummies:				
President	**0.20**	**-0.09**	**-0.05**	**0.49**
	0.42	0.39	0.37	0.35
Vice-President	**0.35**	**-0.18**	**-0.41**	**0.37**
	0.33	0.31	0.29	0.28
Director	**0.05**	**-0.31**	**-0.07**	**0.06**
	0.26	0.25	0.23	0.22
Manager	**-0.08**	**-0.06**	**-0.21**	**-0.02**
	0.76	0.81	0.35	0.92
Supervisor	**0.25**	**0.05**	**-0.12**	**0.03**
	0.29	0.27	0.26	0.24
Responsibility dummies:				
corporate	**-0.74**	**-0.55**	**-0.05**	**-0.28**
	0.73	0.69	0.65	0.61
divisional	**-0.21**	**-0.40**	**0.22**	**0.26**
	0.76	0.71	0.67	0.64
plant	**-0.17**	**-0.27**	**0.34**	**0.43**
	0.74	0.70	0.66	0.62
warehouse	**0.06**	**0.09**	**0.57**	**0.43**
	0.81	0.77	0.73	0.69
Role Dummies:				
quality assurance	**0.09**	**0.17**	**-0.01**	**-0.20**
	0.21	0.20	0.19	0.18
supply chain	**-0.25**	**0.07**	**0.03**	**0.00**
	0.30	0.29	0.27	0.25
security	**-0.12**	**0.20**	**0.39 ***	**-0.03**
	0.25	0.23	0.22	0.21
risk management	**-0.64 ***	**-0.49**	**-0.60 ***	**-0.77 ****
	0.39	0.37	0.35	0.33
operations	**-0.97 *****	**-0.70 ****	**-0.67 ****	**-1.01 *****
	0.36	0.34	0.32	0.30
Number of employees at facility:	**-0.04**	**-0.12 ****	**-0.12**	**-0.09**
	0.05	0.05	0.05	0.05
Experience:				
Years in Industry	**0.02**	**-0.09**	**-0.07**	**-0.04**
	0.07	0.07	0.06	0.06
Years in position	**0.03**	**0.07**	**0.05**	**0.02**
	0.06	0.05	0.05	0.05
Years with employer	**-0.02**	**0.04**	**0.05**	**0.00**
	0.05	0.05	0.05	0.05



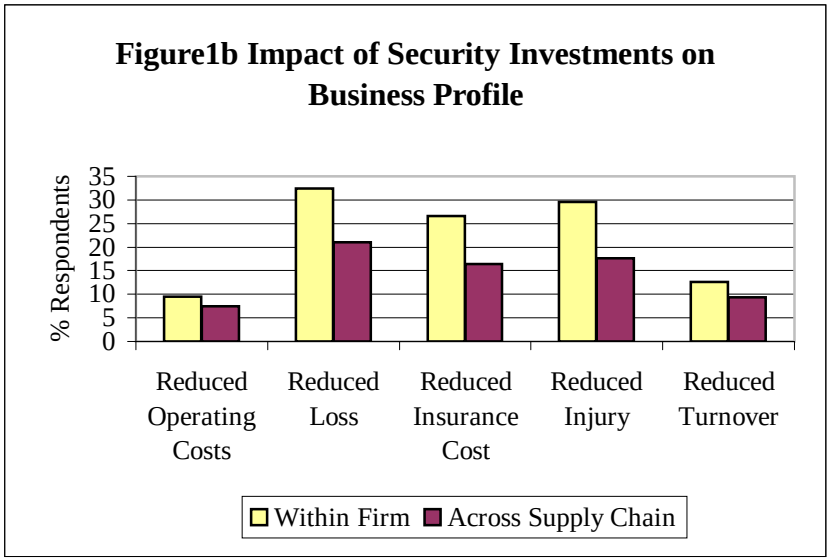


Figure 2: Scree plot From Exploratory Factor Analysis