when the state of Ei changes from $False$ to $True$. This indicates that these events occur much easily, and have a considerable impact on A1 that we should not ignore.

Table 2. The result of $P(A_1 = True \mid E_i = True)$ and $P(A1 = True \mid Ei = False)$

No.	$P(A_1 = True \mid E_i = True)$	$P(A1 = True \mid Ei = False)$
E1	0.121	0.056
E2	0.101	0.058
E3	0.091	0.058
E4	0.068	0.058
E5	0.076	0.058
E6	0.077	0.058
E7	0.124	0.058
E8	0.114	0.058
E9	0.072	0.058
E10	0.064	0.058
E11	0.075	0.057
E12	0.080	0.054
E13	0.082	0.054
E14	0.083	0.055
E15	0.071	0.058
E16	0.102	0.055
E17	0.066	0.058
E18	0.067	0.058
E19	0.069	0.058
E20	0.070	0.058
E21	0.066	0.058
E22	0.069	0.058
E23	0.112	0.058
E24	0.101	0.054
E25	0.080	0.058

It is worth focusing on the root nodes in upper left area because they may be more vulnerable than the other ones. That is because their failure probabilities are lower, but they have a higher conditional probability of A1 failure occurrence. Problems with system scheduling (E_7), unusual information system errors or breakdown (E_8), CS is temporarily closed (E_{23}), POS system errors (E_3), technical personnel operational errors (E_2), and no goods information (E_{14}) are included in this area. In addition, their circles have the largest radiuses on average. This means they have greatest impact on A_1, although their failure probabilities are lower. If any of these events happen, it is more likely that buyers will not receive their goods on the third day.

5.4 Diagnostic analysis of conditional probability of Ei

A diagnostic analysis was done to compute the posterior probability of any given set of

variables given some evidence. It was represented as instantiation of some of the variables to one of their acceptable values. This study computed the conditional probability of failure occurrence of each root node given $Al = False$, which represents buyers do not receive goods on the third day does not happen ($P(Ei = True \mid Al = False)$). Therefore, we can figure out the conditional probabilities of the failure occurrence of any event that we should maintain to ensure that buyers to receive their goods on time. $P(Ei = True \mid Al = True)$ was also calculated in order to find variations. Table 3 lists the results.

Table 3. The result of $P(Ei = True \mid Al = False)$ and $P(Ei = True \mid Al = True)$

No.	$P(Ei = True \mid Al = True)$	$P(Ei = True \mid Al = False)$
E1	0.01146	0.00449
E2	0.00459	0.00230
E3	0.00257	0.00124
E4	0.00188	0.00158
E5	0.00322	0.00289
E6	0.00505	0.00447
E7	0.18205	0.10903
E8	0.00467	0.00177
E9	0.00375	0.00160
E10	0.00425	0.00336
E11	0.00139	0.00130
E12	0.00901	0.00670
E13	0.13571	0.11728
E14	0.13865	0.11711
E15	0.00139	0.00119
E16	0.01365	0.00763
E17	0.12155	0.11572
E18	0.00578	0.00549
E19	0.11810	0.11273
E20	0.00170	0.00149
E21	0.00254	0.00208
E22	0.00901	0.00534
E23	0.00366	0.00161
E24	0.01998	0.00954
E25	0.16475	0.11373

The conditional probabilities of the root nodes given that $Al = False$ and $Al = True$ are illustrated in Figure 6. The horizontal axis is represented as $P(Ei = True)$ and the vertical one is $P(Ei = True \mid Al)$. The curve with the diamond is the result of $P(Ei = True \mid Al = True)$ and the one with the square is the result of $P(Ei = True \mid Al = False)$. The variation in the conditional probability of failure occurrence in each root node when the state of A1 changes from $False$ to $True$ can then be seen.

Our study also separated the root nodes into four areas with mean values represented by the black lines shown in Figure 6. The events in the lower area are considered the vulnerable

parts of the system because we have to keep these events at low conditional probabilities if we don't want A_1 to occur. In the lower right area, it can be seen that the root nodes have higher failure probabilities and little change in their conditional probabilities of failure occurrence will cause the event, buyers do not receive goods on the third day. Problems from shift changes (E_{24}), Problems from shift changes (DC) (E_{16}), Senders send goods to a specific CS (E_{11}), clerk errors (E_{22}), goods sent to the wrong store (E_{18}), e-map information is not updated in time (E_1), unusual errors during delivery (E_6), and wrong labels attached to goods (E_9) are included in this area.

We also observed that the root nodes in the lower left area had lower failure probabilities, but only a small increase in their conditional probabilities of failure occurrence would cause the event, buyers do not receive goods on the third day. Articles have the same barcode information (E_{15}), POS system errors (E_3), goods provisionally returned (E_{10}), courier errors (E_{20}), CS is temporarily closed (E_{23}), unusual information system errors or breakdown (E_8), problems with system scheduling (E_7), time difference between different batches of goods (E_4), Sorter errors (E_{21}), technical personnel operational errors (E_2), and arrival notice sent in advance (E_5) are in this area.

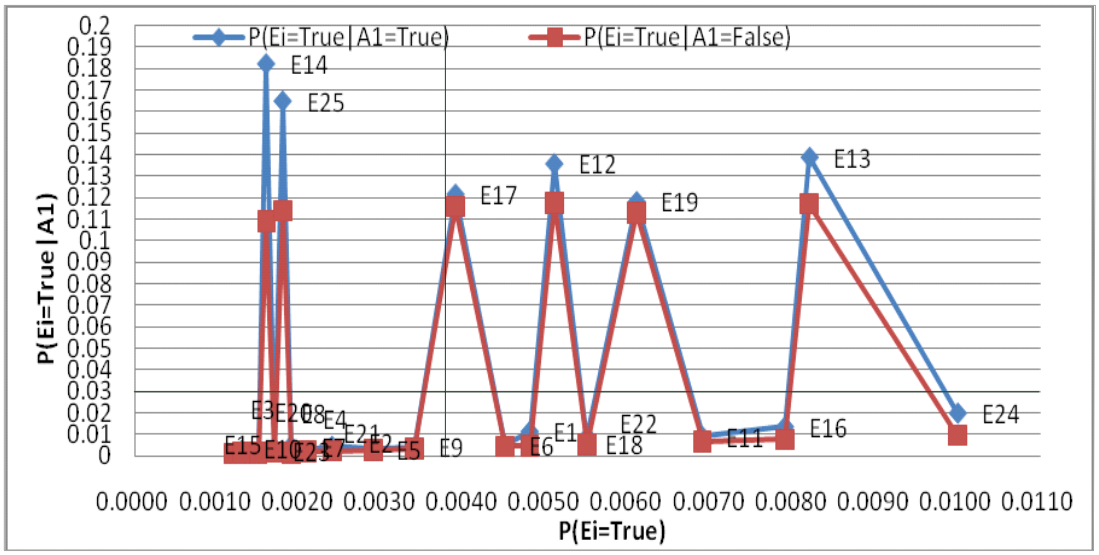

Figure 6 The result of $P(Ei = True \mid Al = False)$ and $P(Ei = True \mid Al = True)$

6. DISCUSSION

The real failure probability of buyers do not receive goods on the third day, 5.94%, is the average rate of problematic cases from August to October in 2010. It is apparent that the failure probability of A_1 in the FTA was a little higher than that of the real data. This is acceptable because the states of the gates are deterministic, working and not-working, do not include inherent uncertainty in the system. The conditional probability of failure occurrence of A_1 in BN is a little lower than that in the real data. This can be attributed to the time period of our data collection. Our real data was the average of problematic cases from three months. There may be bias caused by small amount of data. In addition, the probabilities were based on experts' long-term experience, so they are more stable and closer to a normal situation compared to the data we collected. Therefore, we consider this result valid, which is better than that of the FTA.

In accordance with the result of BN from predictive analysis and diagnosis analysis, we

can find out the most vulnerable root nodes. Our study classifies the result into four categories by the level of failure probability and two main causes of vulnerability in ezShip. e-map information is not updated in time (E_1) was categorized as information failure, and problems from shift changes (DC) (E_{16}), clerk errors (E_{22}), and problems from shift changes (E_{24}) were categorized as physical logistics failure. They all have higher failure probabilities and contribute to a higher conditional probability of failure occurrence of A1. Additionally, just small change in their conditional probabilities of failure occurrence, given the evidence of A_1, will lead to an occurrence of A_1. To sum up, these events have high failure probabilities and a great effect on A_1 occurrence.

These events are the most vulnerable parts in the ezShip delivery process, and most of them are caused by physical logistics failures, especially human mistakes, so ezShip managers should pay more attention to improving staff's skills and implementing SOP intensively in order to reduce their failure probabilities.

The events that have lower failure probabilities are worth mentioning. Technical personnel operational errors (E_2), POS system errors (E_3), problems with system scheduling (E_7), and information systems have unusual errors or breakdown (E_8) belong to information failure, and CS is temporary closed (E_{23}) belongs to physical logistics failure. All of them had low failure probabilities, but they all greatly increase the conditional probability of A_1 occurrence than those that have higher failure probabilities. In addition, only a small change in their conditional probabilities of failure occurrence gives evidence that A_1 will occur. In brief, although these events do not happen easily, when any of these events happens they have a great impact on A_1 occurrence. They have a strong influence on buyers do not receive goods on the third day. Therefore, these events are also the most vulnerable parts in the ezShip delivery process.

These events are the most vulnerable in ezShip delivery system and most of them belong to information failure, so it is so important that managers of ezShip allocate more resources to maintaining the reliability and stability of information systems. With respect to CS is temporary closed, the ezShip website should provide this information in advance, or close this option to avoid customers choosing it.

7. CONCLUSSION AND SUGGESTIONS

Supply chain vulnerability is a new concept in risk management. There have been few studies that measure the vulnerability of local supply chains. Consequently, our study is aimed at discussing the vulnerability of the ezShip delivery process, which is part of a supply chain. FTA is a very popular technique for safety-critical systems. It provides a logical expression of casual relationships to construct a framework from TE to basic events. However, it has some limitations in practice. BN have become a widely used for representing uncertain knowledge in probabilistic systems. It expresses casual relationships based on a set of conditional probabilities. It can include uncertainty and be carried out in predictive and diagnostic analysis, but it is not easy to construct BN and obtain all probabilities directly from experts' domain knowledge. Therefore, our study combined the two methodologies. We first constructed the FT logically, and then converted it into BN.

We consider researching the vulnerability of a system using both FT and BN to be feasible because FT provides a logical and simple way to construct a framework for a large, complicated system, and the results of the BN are reasonable and close to real data. Through predictive and diagnostic analyses, e-map information is not updated in time, problems from shift changes (DC), clerk errors, and problems from shift changes are the most vulnerable

parts, with high failure probabilities in the ezShip delivery process. It was also found that technical personnel have operational errors, POS system errors, problems with system scheduling, has unusual information system errors or breakdown, and CS is temporarily closed were the most vulnerable parts with lower failure probabilities in the ezShip delivery process. Once any of them occurs, there will be a great impact on buyers do not receive goods on the third day. Moreover, little change in their conditional probabilities of failure occurrence will cause A1 to occur.

To summarize, it was found that most of the vulnerable parts with higher failure probabilities belonged to physical logistics failure. On the other hand, most of the vulnerable parts with lower failure probabilities belonged to information failure. This analytical result favors to CVS.com managers finding solutions. Then, ezShip can achieve good performance. For those vulnerable events that have higher failure probabilities, ezShip managers should pay more attention to improving staff's skills and implementing SOP intensively. We suggest that analyst should try to accumulate statistical data to evaluate the BN in order to achieve more objective results. In addition, BN allows events to include multiple states. Considering multiple states can increase the depth of the study. In our research, we only analyzed the relationship between A1 and each event. In the further research, we can consider events jointly to infer posterior probabilities and observe the relationships.

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Appendix 1 Functions of each member in ezShip

Member		Description of Function
Information Technology Corporations	1.	Receive logistics information
	2.	Maintain and update e-map information
	3.	Set logistics information schedules
	4.	Transmit logistics information
	5.	Send arrival notices to receivers
	6.	Plan daily delivery routes in DC
	7.	CVS provide the new, deleted, and corrected information for stores
Senders	1.	Enter the required delivery information into the platform
	2.	Print barcode labels online
	3.	Attach the label to the corresponding article
	4.	Send goods to LF
Hi-Life	1.	Scan the barcode of each article
	2.	Store goods
	3.	Help sender attach barcode label
	4.	Print the waybill when an LF courier comes to receive goods
	5.	Take goods to the LF courier
Distribution Center	1.	Scan the barcode of each article in LF DC
	2.	Sort goods into different CVSs (goods to FM are gathered)
	3.	Send Goods which destinations are to FM stores to FM DC
	4.	Switch barcode labels from the sending side to the receiving side
	5.	Package goods with specific package bags
	6.	Sort goods into different logistics boxes according to their destinations
	7.	Send goods to FM stores via courier
Family Mart	1.	Receive and store goods
	2.	Scan barcodes
	3.	Give goods to receivers
Receivers	1.	Choose the store where they want pick up their goods
	2.	Pick up their goods after receiving the arrival notice