

Open University Cyprus Hellenic *Open University*

***Master's join degree/post graduate Programme
Enterprises Risk Management (ERM)***

MASTER THESIS



Critical Infrastructures Risk Management

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Nikitas Spiros Koutsoukis**

June 2018

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This thesis submitted for partial fulfillment of the requirements
Master's join degree/post graduate programme
«Enterprises Risk Management (ERM) »
Faculty of Economics and Management

Open University of Cyprus Hellenic Open University

June 2018

Summary

The goal of this thesis is to study the critical infrastructures, their meaning and importance inside of a business. To study also who and how needs to manage those critical infrastructures. In addition, to understand what may be the consequences, as a result of the lack or the malfunction of the critical infrastructures with no replacement of any of them, for an automobile repair workshop and that business sector to be studied, in general.

The methods followed for the development of this essay include the search on the net, especially on the Google scholars and on the Open's University Online Library (my Athens) for articles and books related to this topic in order to better understand and develop this research. Moreover, a visit on a business of a specific automobile repair workshop located in Nicosia, Cyprus and the interview from the business's employer and the employees with whom I remained in continues communication during the development of this study in order to get the most possible feedback from them and their job and the requirements around the critical infrastructures. Finally, the close watches to their job from my part.

The results of this study are achieved. The critical infrastructures are well identified and the case of the automobile repair workshops has been developed and analyzed through the bowtie method in a way that can serve the business's operations and continuity.

Thanks

I would like to express my sincere gratitude to my academic coordinator Dr. Nikitas Spiros Koutsoukis for the continuous support of my study. Especially, I would like to thank Dr. Nikitas Spiros Koutsoukis for the supervision of my study, his assistance, patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis.

I would like to thank the employer and the employees of the automobile repair workshop I visited and developed as a case study for my thesis, for their time and patience from the beginning till the end of my writing.

Last but not least, I would like to thank my family: my parents, my brother and sister for supporting me spiritually throughout writing this thesis and my life in general. And of course, my fiancé who is one of the mechanics working on the workshop I selected to study and who inspired me to select my topic, he gave me tutorial and food for thought and supported me to develop this thesis in the best possible way. Finally, I would like to thank him for his patience for all this time he is next to me.

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Chapter 1

1.1. Introduction

The basic critical Infrastructures are usually the same for all the type of businesses and enterprises, but the importance of a single critical infrastructure and the way to manage it depends on the products and/or services offered by a specific company, where the business is located, the distance between the company and the raw materials needed, the distance between the business and the customers, the workforce and many other factors.

The importance of the critical infrastructures for the business's profit, which's and who's the responsibility to manage the critical infrastructures, why and how to manage them, will be studied in the next chapters.

Why are the critical infrastructures important for a society and for an economy? The basic critical infrastructures are important to cover the basic needs of the humanity. For instance, water is considered as a critical infrastructure and no human being can survive without it. In the term of today's society, the critical infrastructures are required to every individual and to the society as a whole in order to cover some basic needs and to offer conveniences. For example, electricity is required to cover the need of lighting and the use of technology. Nowadays technology has done big steps of advancement and is considered as a big part of our everyday life, and every kind of technology needs electricity to work. For instance, internet needs electricity and nowadays internet covers many societal needs. In terms of the economy, technology is important for the economic advancements of the society. Also, the conveniences offered by the critical infrastructures enable a society to be more economically leisured.

Who is affected by a possible risk of the critical infrastructures? Who needs them to survive? In the society, everybody needs them and everybody is affected by a possible risk of the critical infrastructures. Below I will study further what is meant with the term critical infrastructures and try to understand their importance based on risks within a business. For a deeper study I have selected the case study of an automobile repair shop visited for the scope of this thesis and I will try to see also some general ideas around the critical infrastructures and the risks prone to them, generally in the field of the mechanics.

Who should manage a critical infrastructures' risk? In the society, every government and every organization has the responsibility to manage the critical infrastructures. Within a business, that person is the manager or the management team. However, I will also study the role of every employee in front of the critical infrastructures within a business and specifically an automobile repair shop.

1.2. Define the Critical Infrastructures

The American Heritage Dictionary defines the term “infrastructure” as the basic facilities, services and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices and prisons. (The American Heritage of the English Language, 2000).

According to President’s Clinton E.O. 13010 (Executive Order 13010-Critical Infrastructure Protection, July 17, 1996) signed on July 15, 1996, critical infrastructures are: telecommunications, electrical power systems, gas and oil storage and transportation, banking and finance, transportation, water supply, emergency systems (including medical, police, fire and rescue), and continuity of government.

In terms of an enterprise, critical infrastructures are considered all the facilities, installations, services, workforce and assets (including cyber assets) required for the business to be functional. Critical infrastructures differ among the enterprises based on the business size, the service or product offered by the business to the market, where the business is located in, the distance between the business and the target market segment as well as the distance between the business and the raw material needed for it, the number of manpower and where they are all located.

The critical infrastructures are what an entrepreneur needs to set up a business and then these will be the basics for an enterprise to be functional and running. The critical infrastructures need to be in place first of all the rest. For example, when you enter an office you will firstly need to turn on the lights and then move into it. For the employees these are given and the employer needs to make sure that every single morning and for the whole day all the critical infrastructures are given to the enterprise and so to guarantee the functionality in order to be able to offer the products and/or services to the customers, which will give profit to the business.

What happens if any of the critical infrastructures cannot be given for a day? What will happen if the supplier who needs to bring the raw material to the factory is not able to be there on time because of roadwork on his way? That’s the reason employers need to have in place a plan to manage the critical infrastructures.

1.3. Methodology & scope of the research

To develop the main part of this study, the basic research methodology that has been followed is the semi-structured interviews. After I have defined the term of the critical infrastructures in general, I have selected as the main topic of this research the automobile repair workshops. I have prepared some general questions and I have visited an automobile repair shop located in Nicosia, Cyprus to get some answers. During the on-spot interviews with the employer and the engineers at the workshop, more questions came up and all this discussion enabled me to understand the importance of the critical infrastructures within the business and to develop this dissertation.

Therefore, in the next chapter I will try to list and describe the main critical infrastructures within an automobile repair shop and the market sector of the mechanics in general. In the chapter 3, I will identify the risks prone to those critical infrastructures, as from the main definition of the risk and ERM. Afterwards, I will present a risk analysis of all the above based on some criteria and I will select the bowtie method as a risk analysis and management tool, and I will apply the various risks identified on this study, to the bowtie method. The analysis of every risk will be described through some figures prepared that are easy to understand and followed by the management of the automobile repair shop in order to ensure the business's functionality and continuity.

In the nutshell, I will sum up all the above and come to a conclusion of the study. To achieve the scope of this study means to create in the end an analysis tool that will be adaptable to the business of the automobile repair workshops to better identify the risk events and be in place to eliminate those risks and the consequences that may emerge as a result of them.

Chapter 2

2.1. Critical Infrastructures of Automobile repair shops

Every business sector and every enterprise faces and needs to manage its critical infrastructures. The automobile repair shop is the business sector chosen to be studied in this master's thesis. I have chosen to study the critical infrastructures of a specific automobile repair shop located in Nicosia, Cyprus based on information collected from the holder and the employees of the business and then to broaden the study in the sector of the mechanics in general.

To start with, based on the information provided by the holder and the employees of this specific automobile repair shop, we will study their critical infrastructures. I will study which they are, why they are considered critical for the business and what may be the risk emerging from every specific infrastructure for the business and in the long term for the sector of the mechanics, in general.

2.1.1. Electricity

Firstly, the electricity is a major critical infrastructure, required for the functionality of the enterprise. In a contemporary automobile repair shop, as the one chosen to study, the technology is a basic need for the engineers. Nowadays, every automobile including the cars, are designed to work based on the latest technology, therefore as a mechanic if you need your business to survive you need to follow the technology, and technology needs electricity to work.

First of all, the work of a mechanic is much easier and much faster with the use of an electric automobile elevator. According to the mechanics of this specific workshop, you can work without it and instead of the electric car elevator you may use a manual one. However, the effort and the time spent to have the work done will be much more, the employee will be more tired, thus less productive and at a higher risk to be hurt. And you cannot charge the customer your lack of the basic means. However, there are some kinds of jobs you cannot do without the electric automobile elevator. In fact, only the basic jobs can be done without big issues.

Also, people especially in Cyprus, are using their cars on a daily basis, have limited free time to visit a workshop to repair their cars, thus most of the clients chose the fastest solution. So, to provide fast service is also a must for the workshop if you need to be competitive in the market. Therefore, the holder needs to make sure that the electricity is provided at the workshop.

Moreover, every kind of hardware and tool kits used and especially, the automotive diagnostic service tools are the basic pieces of equipment for every automobile workshop, in our days. Usually,

every car that gets into the workshop is a unique case. Like a unique patient for the doctors! Nowadays, the engineers work with the assistance of the automotive diagnostic service tools as this is what the contemporary cars require. You cannot make a diagnosis for a car only with the sound of the machine or because you had a similar case a year ago. What you have done on one car will not necessarily work on the one you have to fix right now. But the automotive diagnostic service tools can give you a more accurate guidance, and to work, the electricity is required for them.

In addition to the above, electricity is required for the use of the lights. Even during the day, the sunlight is not enough for the mechanics to work. If you need to see and work deep in the car you need to have a lamp with you to have light into the car's machine. However, the alternative to this is a flashlight that works with batteries.

The electricity is also required during the night to protect the workshop as at the specific one, the space is protected by cameras and by an alarm. The capital invested for a business like an automotive repair shop, even for a small enterprise, is usually high, mainly because of the cost of the hardware and the tool kits required to be used on a daily basis. Therefore, the business cannot afford to lose all those tools. Such a case will affect mainly the business's profit.

In the nutshell, the risks that may emerge from the lack of electricity include waste of time, lack of functionality, the workers to be more vulnerable to be hurt, to lose customers, lack of competitiveness, fire, robbery and many others. All these will be better identified and analyzed consequently.

2.1.2. Internet

Secondly, what a mechanic of the workshop claimed is that many times, the internet is necessary for him to work on difficult cases. He claimed that for him is important to have on his hands, during the work, a good and resilient mobile device with which, at any time, he can search usually on the YouTube, videos of engineers who ever faced a similar issue and to see how other colleagues of him, around the globe, have fixed the problem. As he said, this usually works and it's important to get advises from your colleagues around you as well as from the internet before you risk and try something by yourself. You may be on the sector for years and have a lot of experience but you always have something new to learn. You always need to study the new technologies. Even after work, the research is required for everyone. But in order to avoid losing time to wait to come home and search for something on the internet, the use of it on spot during the work is required. The internet is related to the electricity as well.

Also, the majority of the diagnostic services tools the engineers are using are on-line tools. Therefore, the internet is mandatory for them to work. In addition, every diagnostic service tool needs to always be up to date. Usually they need to be updated once a year but even in this one time of the year you cannot afford not to have broadband connection at the workshop to proceed with the required updates. And because the tools used is not just one but multiple, occasionally you have to update one of them.

2.1.3. Water

The water is a critical infrastructure for every human being. Utilities provide essential services to people 24 h a day, 7 days a week, and their services are essential to keeping communities healthy and economically viable. People rely on the constant delivery of drinking water and the collection, conveyance, and treatment of wastewater. People use water for the most basic human needs. Vital networks and businesses, industries, hospitals, other utilities, agriculture, and manufacturing industries are dependent on water systems. (Robert M. Clark, 2011).

Inside of a business, the employer is responsible to provide the essentials, including water, to the employees and sometimes to the customers, too. Especially during the summer period, cool drinking water is essential for the mechanics. The specific workshop I visited, as I said is located in Nicosia, where the running water is not safe drinking water. Therefore, the employer is using distilled water in big bottles that he keeps cool with the use of a fridge that works with electricity or bottled distilled water, as an alternative, that he buys from the nearest supermarket and he keeps it cool in a small fridge in the workshop's kitchen, which also needs electricity to work. Therefore, we see that the critical infrastructures are related between them to serve the society.

Moreover, water is essential in general for the kitchen and for cleaning purposes as well as for the use of the toilette. The sewerage of the shop has to also work properly. In addition, especially for the mechanics water is essentials as they need to clean up their hands just after they finish their work. In this kind of businesses, the employees use a big amount of water and soap to clean up their hands during the day, before their lunch time or after work. Even during the day, after you fix a car you need to do a test drive to be sure that you can now give the car to its holder. "You cannot drive the car with dirty hands", as an engineer said.

Additionally, the water as mentioned above is required for cleaning purposes. The cleaning lady who comes at this specific workshop once a week, at that day of the week, she needs plenty of water to clean up the workshop. If at that specific day she is coming she will not have access to water she will not be able to clean up the workshop properly and maybe the next day she will be able to come again will be the same day next week as per her schedule. In case, the workshop is kept dirty for a whole week, the environment will be unfriendly for the employees and the customers, too.

2.1.4. Road network

The road network is also a critical infrastructure for this business sector for many different reasons. First of all, there is no other way other than the road network to bring a car into the workshop. The customers have to be able to drive at the road network and bring the cars to the mechanics. Even if the car cannot get moving, it will be brought into the workshop with the use of a roadside assistance that is using the road network. At the moment the automobile will arrive at the place it should be accessible to be entered into the workshop through the road network. If for example the town decides to proceed with roadwork just in front of the workshop's entrance and the cars will not be able to enter into the workshop, this fact will definitively affect the enterprise. The specific

workshop I visited is accessible from the road network through 2 sides and this minimizes the risk to be affected by road works.

As I also mentioned in the previous section the mechanics after they repair a car they need to use the road network to do a test drive. That's one more reason why road network is a critical infrastructure for this business. At the moment that the mechanic will have to proceed with his test drive, if there will be traffic in the road network that will affect his work. Usually, you cannot just drive a car you just repaired only till the next corner and in a neighborhood, where usually there is no traffic because you need to have the chance to drive the car as fast as required to have the test completed. "Usually you need to warm up the machine to spot the problem", as an engineer said. So, traffic in the road network may be something that will delay the delivery of the automobile to its holder, who is of course the business's customer. Whatever affects the customer it is a risk for the business and its profit. However, in some cases you cannot postpone this step because as a professional you need to be sure that the work is done properly.

Additionally, the road network may be considered as the basic critical infrastructure for the automobile sector in general. This is because the automobiles are used on the road network, thus whatever affects the road network affects the automobiles as well as the automobile repair shops' work, too. In fact, without the road network, there will be no need to use the automobiles, thus these enterprises may not exist or may exist under a different concept, e.g. to repair mostly other kind of machines and not mostly to repair cars.

2.1.5. Imports: Transportation & Ports & Airports

Usually, the automobile repair workshop's have an amount of stock of raw materials including basically auto parts, filters and oils that are used most of the times and for most of the automobile models. This is the information I got from the specific one I visited in Nicosia. These raw materials are usually obtained from the nearest shops selling these kinds of goods. The employer or an employee can make an order to these shops occasionally and at any time during the day they can visit the shop and obtain the raw materials using the road network. In this case the road network is considered critical infrastructure for that as well, but as this can be done at any time and in case of delay of one to two days, because of any difficulty to go and get the stuff the road network is not really affecting this job, just because at the workshop they usually have the basic raw materials mostly used.

However, the employer cannot have every auto part in stock at the workshop. They do have some auto parts but what usually happens is that as soon as for instance, the workshop accepts a car, the engineers and the mechanics check it and based on what job is needed to be done, they decide what kind of raw materials are required. Usually something that is not in the workshop's stock will be required. At that moment, they should call at all the available shops selling the merchandise to check if they do have what is needed, in their stock.

In Cyprus, this market sector relies if not totally, mostly on the imports. I have asked the engineers if they know factories in Cyprus that manufacture any kind of raw materials they are using. They only thought of the company ALCO Filters Ltd (ALCO Filters Ltd.com) but none of them was sure if

this company has a factory in Cyprus that manufactures the filters. I called at the company and as I have been informed, this company does have a factory and the majority of their goods are manufactured in Cyprus. They also do have some imports of finished goods coming from various countries. However, even for the goods they produce in the factory in Cyprus, they do rely on some raw materials imported from abroad. Nevertheless, the filter is only one of the raw materials used in a workshop.

They also told me to check Prodromos Ttikos & Sons Ltd (Tikkos Racing) , a company that sells tailpipes, exhaust mufflers, diesel particular filters, catalysts, mini folds, air filters and other products accessories. I contacted this business and as they informed me this company is only importer and reseller. They rely on imports 100%.

Finally, they told me that used parts and in general used raw materials can be found in the island from broken cars. However, this part of the market does not cover the whole needs of the business.

In the nutshell, this specific workshop and every workshop in Cyprus and the whole market sector, in general, they all do rely on the imports. These imports are done through transportation: ports and airports. Therefore, ports and airports need to work normally for these businesses to be able to work as well. Also, the transport from the port or the airport to the reseller need to be done and then from the reseller to the workshops. This delivery needs to be on time the raw material is required and any delay because of any malfunction on the transportation of the good to its final destination will affect the workshop.

In the sector of the transportation we can implement the waste collection. This is a critical infrastructure for every business. I don't think there is any one, employer, employee or customer who can afford having the trash in or near the business. Every company needs to have near access to garbage bins and the garbage trucks are needed to have regular and easy access to these bins. Businesses rely on the government for that service.

2.1.6. Fuels

Fuels are what usually make automobiles get moving. I am saying usually because nowadays there are some electric vehicles, too. In Cyprus there are few of them. The fuels that are usually used for the automobiles in Cyprus are mostly the gas and the petroleum and the hydrogen in some cases. If the vehicles machine will have no fuel to move, the employees of the workshop will not be able to work on it. Even if some jobs can be done without the fuels, the work cannot be completed without it, simply because they will not be able to start the machine and check that is working properly. In any workplace, any employee and any employer does not want to leave a job incomplete and pending. Any pending job does not give profit to the business but steals working time.

2.1.7. Workforce

The workforce is not an infrastructure like all the others but for the workshops the workforce is critical for the business's operations. Usually at the jobs where customer relations and experiences do count, the employers need to make sure that they will keep their key staff. In these businesses, worker's safety and health is a really important aspect for the employer. Employees are really

susceptible to injuries. Small injuries are difficult to be avoided, although employers need to make sure that they eliminate at the maximum the probability of a serious accident at the work place. The risks that may emerge from a serious injury are a lot.

Additionally, as a leader of a business, the employer needs to care about his employees. What in my opinion is a good theory to be followed by good leaders, is Maslow's hierarchy of needs. Maslow's hierarchy of needs is a motivational theory in psychology comprising a five-tier model of human needs, often depicted as hierarchical levels within a pyramid. Maslow (1943, 1954) stated that people are motivated to achieve certain needs and that some needs take precedence over others. Our most basic need is for physical survival, and this will be the first thing that motivates our behavior. Once that level is fulfilled the next level up is what motivates us, and so on.

Later, the final model included an eight-stage model:

1. Biological and physiological needs - air, food, drink, shelter, warmth, sex, sleep, etc.
2. Safety needs - protection from elements, security, order, law, stability, etc.
3. Love and belongingness needs - friendship, intimacy, trust, and acceptance, receiving and giving affection and love. Affiliating, being part of a group (family, friends, work).
4. Esteem needs - which Maslow classified into two categories: (i) esteem for oneself (dignity, achievement, mastery, and independence) and (ii) the desire for reputation or respect from others (e.g., status, prestige).
5. Cognitive needs - knowledge and understanding, curiosity, exploration, need for meaning and predictability.
6. Aesthetic needs - appreciation and search for beauty, balance, form, etc.
7. Self-actualization needs - realizing personal potential, self-fulfillment, seeking personal growth and peak experiences.
8. Transcendence needs - A person is motivated by values which transcend beyond the personal self (e.g., mystical experiences and certain experiences with nature, aesthetic experiences, sexual experiences, service to others, the pursuit of science, religious faith, etc.). (McLeod, updated 2017)

It's not necessarily for one stage of the model to be fulfilled hundred per cent for an employee to be able to proceed to the next one but every employer who wants to be considered a good leader of his business needs to have the above in mind. Often, employers think that the employees count only on the salary they get from a job, but as we can notice from Maslow's hierarchy of needs, this is not considered as a personal need. However, it does count in order for a human being to be able to survive in our modern society but it's still not will guarantee to the employer that he will keep his key staff in the business.

2.1.8. Work environment

In addition to the workforce, the work environment needs to be friendly for the employers and the customers who will visit the workshop. Usually, the engineers and the mechanics work under pressure and that is something that makes somebody psychologically and mentally tired and they also easily get physically tired. They may have pains e.g. at the lower back because of the position of their body during the work. As a mechanic explained these kinds of pains cannot be avoided in most of the cases.

Therefore, a friendly working environment and good relations between the staff and the employer are crucial to avoid unneeded nervousness during the working hours or even after work. The work environment is a reason for a good employer to search for another job. The business may face many risks from an often turnover of the employees. For big companies that specific tasks are known by many employees of a team this may not seem a problem, but for small enterprises like the one I am studying that the employees are only 6 in total, this turnover affects the business's operations.

2.1.9. Location & Construction

The infrastructures of the workshop itself are critical for the enterprise. The workshop needs to be well located in an area easily accessible for the customers. The one I visited is well located in an industrial area in Nicosia. The construction of the workshop needs to be foamed-lined. Especially in Cyprus that most time of the year the temperatures are very high you need to work in a cool place and since the workshops in general are not air-conditioned but big spaces with opened doors, the construction need to be as much foamed-lined as possible.

Also, a good workshop needs to be spaciousness and functional. The one I visited was a good one, although it could be more spacious because part of the job was done outside the construction because inside it was full house and during the morning the mechanics were working under the sunlight. I visited the workshop in February; I cannot imagine using that space behind the construction in July and trying to complete a job under the sun in high temperature.

Chapter 3

3.1. Enterprise Risks prone to Critical Infrastructures

3.1.1. Define Risk and ERM

All organizations, regardless of their size, industry, or customer base, have to face some degree of risks. Hence, risk management is seen as a management response to the volatile environment. ERM treats each risk as part of an enterprise's entire risk portfolio rather than a discrete one and is thus considered as a holistic and integrated risk management approach. (Xianbo Zhao, 2015). Risk has different meanings to different people, and the concept of risk varies according to viewpoints, attitudes, and experiences (Walewski J, 2003).

Some scholars emphasized the negative or harmful consequences of risk and considered the risk as synonymous with threat (Baloi D, 2003), (Rescher, 1983), (Rowe, 1977) while some recognized risk as a double-edged sword, encompassing both downside risk (threat) and upside risk (opportunity) (Loosemore, 2006), (Segal, 2011), (Ward S, 2003). In addition, as risk arises from uncertainty (Hillson D, 2007) some definitions have linked risk with uncertainty. Hillson (Hillson, 2006) argued that uncertainty without impact on objectives should not be viewed as risk.

Also, some of the international and regional risk management standards admitted the double-edged nature of risk and linked risk with organization's objectives. For instance, the International Organization for Standardization (ISO) defined risk as "effect of uncertainty on objectives" (p. 1) in ISO 31000:2009, which has been adopted in the British Standards Institution (BSI), and Standards Australia/Standards New Zealand (AS/NZS 4630:2004) defined risk as "the chance of something happening that will have an impact on objectives" (p. 4), which was withdrawn in 2009 in favor of ISO 31000. Given the double-edged nature of risk and its impact on objectives, this research adopts the risk definition provided by ISO 31000:2009 and puts aside the difference between risk and uncertainty in terms of availability of the likelihood of occurrence. Definitions of risk management are also available in risk management standards. ISO 31000:2009 briefly defined risk management as "coordinated activities to direct and control an organization with regard to risk" (p. 2).

ERM is most frequently defined with reference to the 2004 guidance document Enterprise Risk Management—Integrated Framework published by the Committee of Sponsoring Organizations of the Treadway Commission (COSO). The COSO (COSO, 2004) defined ERM as "a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage

risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives”.

3.1.2. The Case of Automobile Repair Shops

In the case of the specific automobile repair shop I visited a risk is considered as a threat that may affect the business’ objectives and the normal everyday operations in the shop. ERM is a process to be followed by everyone in the business as there is only one proprietor and 3 full time employees, and 2 part time employees. Therefore, in this case we don’t have a risk management team or a board of directors who are responsible to take care of the whole ERM procedure. The proprietor who is considered as the management of the repair shop is responsible to eliminate the risks and to give guidance to his team to do so as well.

3.1.3. What are the Enterprise Risks prone to Critical Infrastructures?

On the previous Chapter we studied the critical infrastructures, the functionality and importance of each one for the business. The risks emerge from the importance of each critical infrastructure and therefore a reference to some risks is done on the previous chapter. In this chapter we will study in deep some of those risks as well as others that may emerge from others. So, based on the critical infrastructure of that business mentioned in the previous chapter, that are the electricity, internet, water, road network, imports: transportation & ports & airports, fuels, workforce, work environment, location & construction, let’s study the possible enterprise risks prone to them.

First of all, lack of any of the above critical infrastructures may lead to risks such as *delays*, as waste of time will not be avoided. Wasting the working time is always painful for the business, the employees and the customers. When there is lack of any critical infrastructure to assist the engineers’ work they are spending much more time having a task done or they are just wasting their working time waiting for the critical infrastructure to be back available in use so they can start a job.

Each engineer works 8 specific hours a day. For instance, at that specific work shop the engineers work from 8:00am in the morning till 17:00pm in the afternoon with 1 hour break during these times. The critical infrastructures need to be available at the workshop during these times to assist them to work effectively and serve the business’s customers the fastest possible. Nowadays, everyone has limited time, so time is money for the business. If the business is not able to serve will *lose customers* and therefore will have by the end of the day *less profit*.

In addition, any difficulty or lack of, in terms of the critical infrastructures affects the *employees’ motivation & psychology*. Sometimes when the employees do not have the means to work feel a relief that they can just sit down with their colleagues, discuss and relax till they will be able to start working again or leave work to go home. This feeling will be a relief only if the lack of the critical infrastructures will be for a short time of period. In case an issue we face at work with the critical infrastructures lasts for long time then that relief turns to stress as we begin to understand that by

the moment, for instance the electricity or the internet will be back in use, the workload will be much more, as we wasted some time waiting for the resources, and the job we could have done is still waiting for us together with many other tasks that came after, too.

People's motivation makes me think of the concept of Theory X and Theory Y that was developed by social psychologist Douglas McGregor in his book, '[The Human Side of Enterprise](#),' (MindTolls). The theory describes two contrasting sets of assumptions that managers make about their people. Theory X assumes that people dislike work, have little ambition, and are unwilling to take responsibility. Managers with this assumption motivate their people using a rigid "carrot and stick" approach, which rewards good performance and punishes poor performance. Theory Y assumes that people are self-motivated and enjoy the challenge of work. Managers with this assumption have a more collaborative relationship with their people, and motivate them by allowing them to work on their own initiative, giving them responsibility, and empowering them to make decisions.

In case of lack of critical infrastructures workers who belong to Theory X will find nothing to do not to wasting their time at work but those who belong to Theory Y will find anything to do but not to waste their working time. Therefore, managers need to be ready to motivate every employee in case a risk arises and to give them guidelines for what tasks can be done even for instance there is no water available at the business, and to show them how to do the job even without that infrastructure. Having non-motivated employees affects the whole business.

At the specific automobile workshop I visited I have been told by the engineers that motivation and psychology are important for them to work effectively. They are doing a job that each case of automobile they need to repair is a different one. They usually challenge their selves and learn new things till they achieve to repair an automobile. Of course there are simple tasks, part of their routine, but for most of the tasks they need to do they fail many times in the beginning and of course no one wants to fail. For them it doesn't matter if they fail two or three times they need to have the courage to try again and is important to have the availability not to leave a job on the side to do something else but to do two or three trials after a failure. If you fail again then you need to stop and think of possible solutions you can give to the problem. They usually drive out of their minds with their work's pressure, thus every infrastructure is critical for them. Lack of any affects their psychology and motivation to work.

Moreover, mechanics are prone to *injuries* due to lack or malfunction of critical infrastructures. For example, as mentioned on the previous chapter you may also use a manual automobile elevator but the possibilities to get hurt during your trial to repair an automobile using that one are much more than when you are using an electric one. Also, location and construction have a high importance for the business for *security* reasons not only for the employees at the work shop but for the customers that will visit the work shop, too. And water is a must for its importance as described in the previous chapter, as well as for *hygiene* reasons above all. As in every aspect of life, in the business sector, humans' health and security is above all.

For mechanics the security is really important due to the fact that just a simple accident in the workplace or even not, may cost for them their whole career in the business and the market. If for

example, a mechanic gets hurt from an accident, risks leaving the rest of his life with a permanent injury that may not allow him to operate in this market sector on the way he could do it before the injury or even not being able to continue working in the sector at all, and so the business may *lose a key employee*. For the business, it is important to make sure that all of their employees are insured at the workplace and to implement ways to minimize workplace injuries. The employer needs to keep up to date with legislation and remember that part of his job is to stay within the law (ICAEW, 2010).

In the European Union, the European Commission is responsible for the health and security at work, in collaboration with European Agency for Health and Safety at Work and the European Foundation for the Improvement of Living and Working Conditions. In general, the Commission needs to make sure that in legal basis they encourage improvements in occupational health and safety in all sectors of activity, both public and private, promote workers' rights to make proposals relating to health and safety, to appeal to the competent authority and to stop work in the event of serious dangers and seek to adequately protect workers and ensure that they return home in good health at the end of the working day (Europa). In the Union we have 3 committees of national experts, who contribute to developing, implementing and monitoring the EU legislation on health and safety at work. These are the Advisory Committee on Safety and Health at Work (ACSH), the Scientific Committee on Occupational Exposure Limits (SCOEL) and the Senior Labour Inspectors Committee (SLIC).

In addition, with no electricity you have the risk of a *robbery* or of a *fire*, as in case there is no electricity the alarm in each of the cases will not work. The *cost* in both cases may be really high and may be catastrophic for the whole business. As stated in the previous chapter you need to invest a big amount of capital for the construction of an automobile repair shop, therefore in case of a robbery or of a fire you lose your investment and you may not be able to work without what you will lose the next day. Therefore you need to make sure that you protect your investment and the business as a whole every single day. Moreover, generally the market relies on imports, although the employer of a small business as the one in study cannot affect the imports he needs to be aligned with regulations on imports and ensure to the maximum that the needed parts and raw materials, in general, are provided to the business.

Generally, with the lack of any of the critical infrastructures you risk the *business's functionality* and therefore you risk being unable to serve your customers, thus you risk the *company's profit and competitiveness* that will lead to lose customers and in the worst scenario you risk the *closure* of the whole business.

Chapter 4

4.1. Risk analysis and management tool

Risk management tools support the implementation and execution of program risk management in systems engineering programs (MITRE, 1997-2018). In the business sector, the risk analysis and management tools support risk management efforts. To develop a risk analysis tool for one business you need to understand the purpose of using it, the outputs, strengths, and limitations of the risk tool.

Risk analysis and management tools serve multiple purposes and come in many shapes and sizes. Some risk analysis and management tools include those used for: Strategic and Capability Risk Analysis that focuses on identifying, analyzing, and prioritizing risks to achieve strategic goals, objectives, and capabilities. Threat Analysis tools that focus on identifying, analyzing, and prioritizing threats to minimize their impact on national security. Investment and Portfolio Risk Analysis that focuses on identifying, analyzing, and prioritizing investments and possible alternatives based on risk. Program Risk Management that focuses on identifying, analyzing, prioritizing, and managing risks to eliminate or minimize their impact on a program's objectives and probability of success. And finally, Cost Risk Analysis that focuses on quantifying how technological and economic risks may affect a system's cost. Applies probability methods to model, measure, and manage risk in the cost of engineering advanced systems. (MITRE, 1997-2018).

The purpose of this thesis is to create a critical infrastructures risk analysis and management tool to support the risk analysis and management of a small business of an automobile repair shop. In order to select the right tool we need to define the risk analysis and management process to follow. Ultimately, the tool must support the process. According to the article from the MITRE site (MITRE, 1997-2018), when selecting a risk analysis and management tool, we need to consider these criteria: to be aligned to risk analysis objectives, to support decision making, the accessibility of the tool, the availability of data, the level of detail and the integration with other program management/systems engineering processes.

4.1.1. The Risk Analysis and Management Process: The Criteria

Firstly, the process needs to be aligned to risk analysis objectives. We shall ask; does the tool support the analysis that the organization is trying to accomplish? Is the organization attempting to implement an ongoing risk management process or conduct a one-time risk analysis? We study the case of a small business but of a business that does rely on the critical infrastructures. Therefore, that business needs to follow a risk analysis process with the main objective to avoid or to minimize the probability to face a risk as a result of the lack or malfunction of any of the critical infrastructures as described in the previous chapters. This process needs to be implemented to an ongoing risk analysis and management tool and not at a one-time risk analysis as for the business, infrastructures are required for the workshop's operations on a daily basis and the lack or malfunction of one of them may affect others, too. For instance, electricity affects internet connection as well.

Secondly, the process needs to support decision making. We shall ask; does the tool provide the necessary information to support decision making? For many managers decision making is the most difficult tasks they may have within a business. Decision making is part of the risk management as no one can be sure that a decision is the correct one before the results of it emerge, even this will be a quick decision for just simple tasks or a biggest one that will affect more aspects of the business. For the case of the automobile repair workshops, the proprietor, that is the manager of the business, and the employees, take many decisions within a day, as their job is based on case by case reparations of automobiles. Therefore, I need to choose a tool that will support their decision making when they are at risk due to critical infrastructures.

Thirdly, we need to test the accessibility of the toll. Is the tool accessible to all users and key stakeholders? Can the tool be hosted where all necessary personnel can access it? The risk analysis tools are usually software. In the case of the automobile repair shop we can design a tool that will be accessible for use as other software tools that the engineers are using with the purpose to have their work done.

Fourthly, we test the level of detail. Is the tool detailed enough to support decision making? We need to implement to the tool to use all the necessary details required for that specific market sector and specific reparations.

Lastly, we test the integration with other program management/systems engineering processes. Does the tool support integration with other program management/ systems engineering processes? The tool to be used within the business needs to be part of the current management process already in place so we don't risk the normal management of the business as a whole.

4.1.2. The Bowtie Method

The Bowtie is a risk analysis tool that focuses on a specific key event. That key event is what we need to avoid. An event has a 'before' and an 'after'. The before links threats to the event backwards and causes through which the event could happen, while the after links the event forwards to the consequences if the event occurs (Munier, 2014).

In the case of the automobile repair workshops, the bowtie method can be really useful as the events that may put the business to a risk can be foreseen and prevented or minimized. This process works as a preventive and proactive tool that can give a warning to avoid the main event, and eliminate the main consequences. The advantages of this method are; its low cost, that after the event happens this process will work as reactive for the business, that it can minimize the impact of the event and be informative for future reference. The Bowtie method is schematized in Figure 1 below.



Figure 1: Bowtie Risk Analysis (Enablon, 2017)

Before the creation of the Bowtie analysis tool, first of all the possible risk events need to be identified. For the case of the automobile repair workshops some risk events prone to the critical infrastructures, as described in the previous chapters, will be identified and developed with a bowtie analysis. All these cases will be then provided and accessible to all the stakeholders of the workshop.

4.1.3. Risk Events and Application of the Bowtie Method

4.1.3.1. Delays

I took as first risk event the delays. The threats of that risk are stated on the bellow figure in the first column. These are some critical infrastructures; the importance of them for the business is already described in the previous chapters. On the second column I have listed some measures that can be taken to avoid the risk event, then the risk appears and on the third column I have listed some mitigation measures that can be taken after the risk event happens. On the last column I have listed some consequences that may be the result of this risk event. The steps that an event may follow are not predictable. One event or one consequence may lead to more. The purpose of the bowtie tool is to have in mind what may happen and what you can do before and after an enterprise risk event to eliminate the probability of a possible crisis within the business.

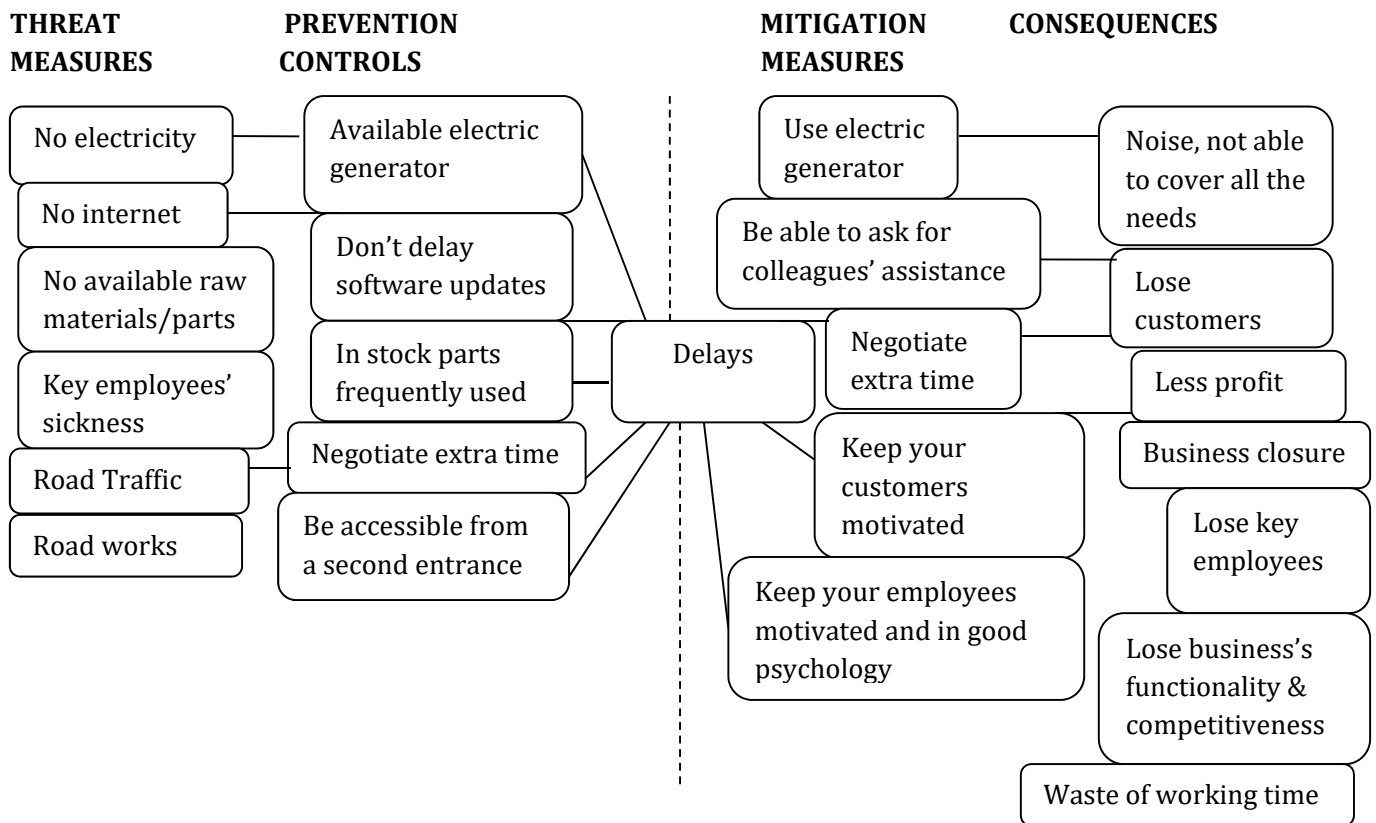


Figure 2: Application of the Bowtie method – Risk event: Delays

4.1.3.2. Damages

Damages are a risk event for the automobile repair shops. As per the engineers at the specific one I visited damages may happen on a daily basis. Usually they are of less importance as they don't cause a permanent damage to the customer's automobile. Damage is considered not being important when you just have a damage of a specific part that can be changed and the problem will be solved but for sure it will cost you time, money and effort. On the below figure I have created a bowtie analysis for that cases.

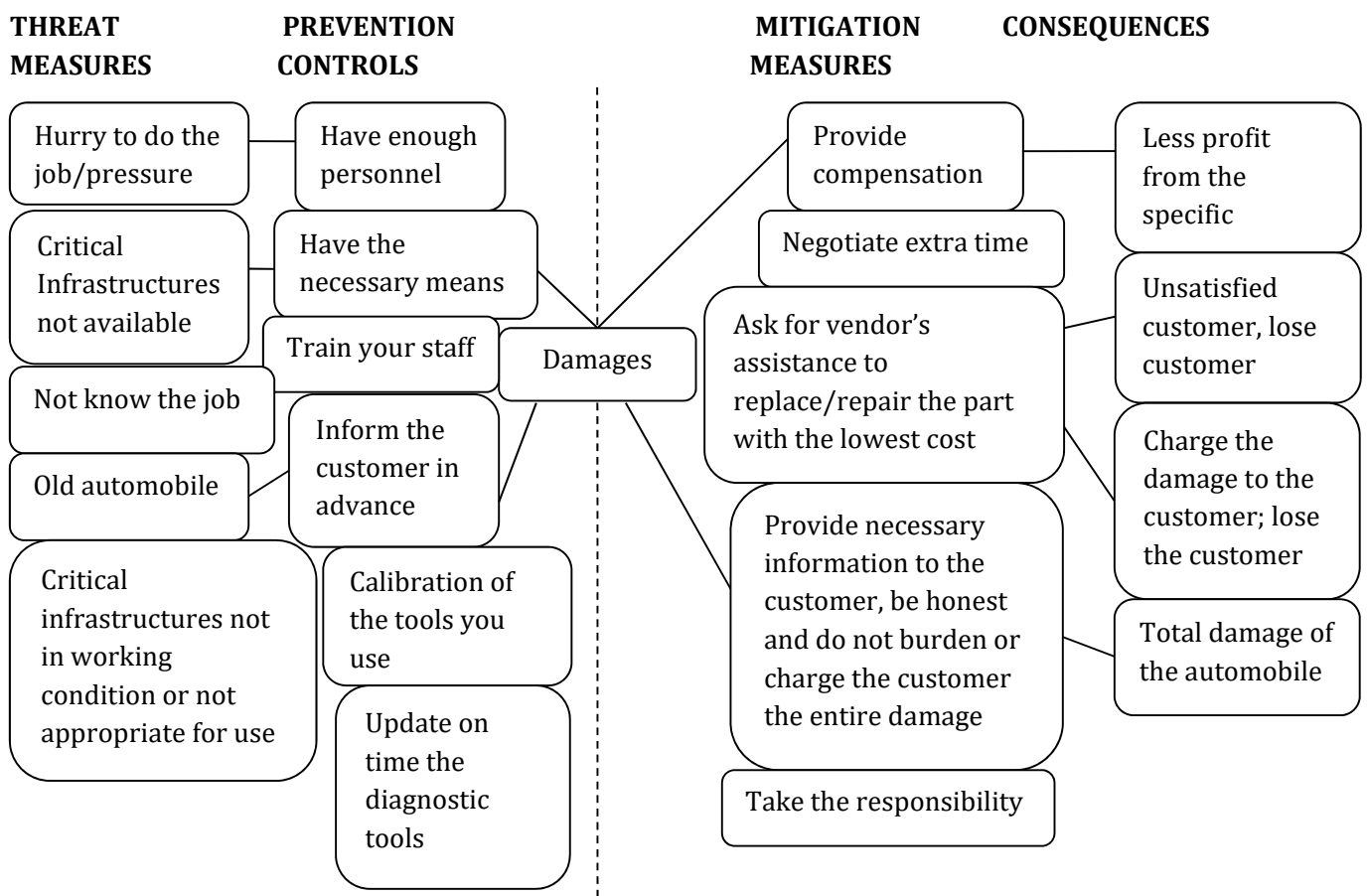


Figure 3: Application of the Bowtie method – Risk event: Damages

4.1.3.3. Accident or Injury

The case of accidents or injuries in the workplace is one of the most serious enterprise risks due to the consequences that may follow the risk event. As manager of a business you need to make sure that you care about your employees' security and that they feel secure at work. If a worker feels that his health or life are in danger will probably look for another job. In the case of accident the threats and the prevention steps a business may take are a lot but when it comes to the mitigation measures and the consequences there are a few steps the managers can take to gain control of the event. Below I have created the bowtie analysis for these cases.

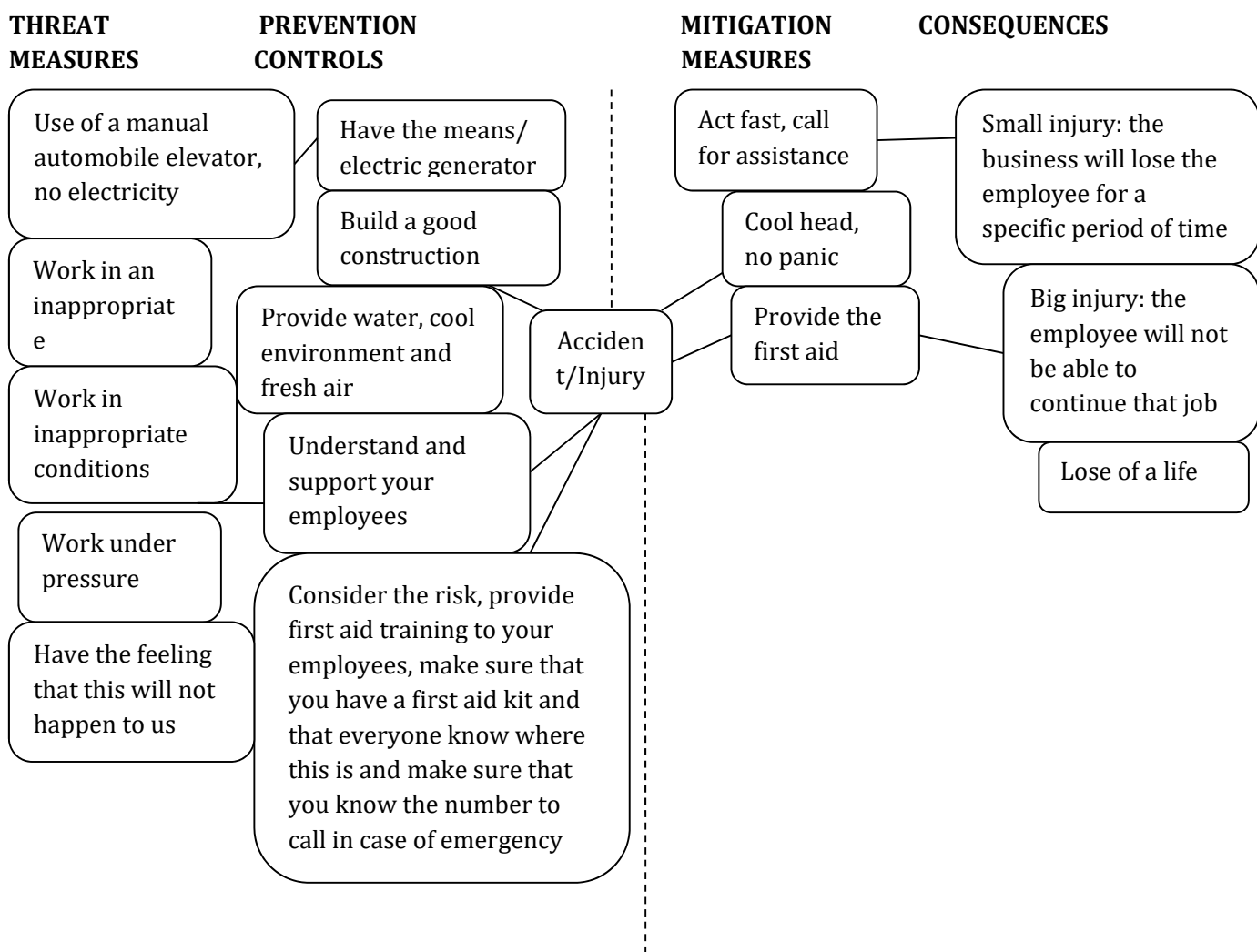


Figure 4: Application of the Bowtie method – Risk event: Accident/Injury

4.1.3.4. Robbery or Fire

The case of robbery or fire is part of the security for the business, the employees and the customers, too. It is important for small businesses to consider the risks of a robbery or a fire because the recovery stage after that event may take long time and cost the business's profit. Small businesses like the automobile repair workshops, which gain money only from a specific service they provide when they lose functionality of that service they cannot take money from another service to cover the needs of the one in difficulty. For example big organization like G.A.P. Vassilopoulos Group (G.A.P. Vassilopoulos Group, 2016) of services which offers many services, in case one service has some difficulties they can get money from another service to cover the needs of the one at risk. However, a small automobile repair workshop has only one business account and every expense needs to be covered from that account. If that account comes up against difficulties, with bad management, this may lead to the closure of the business. On the figure below I have created a bowtie analysis for these risk events.

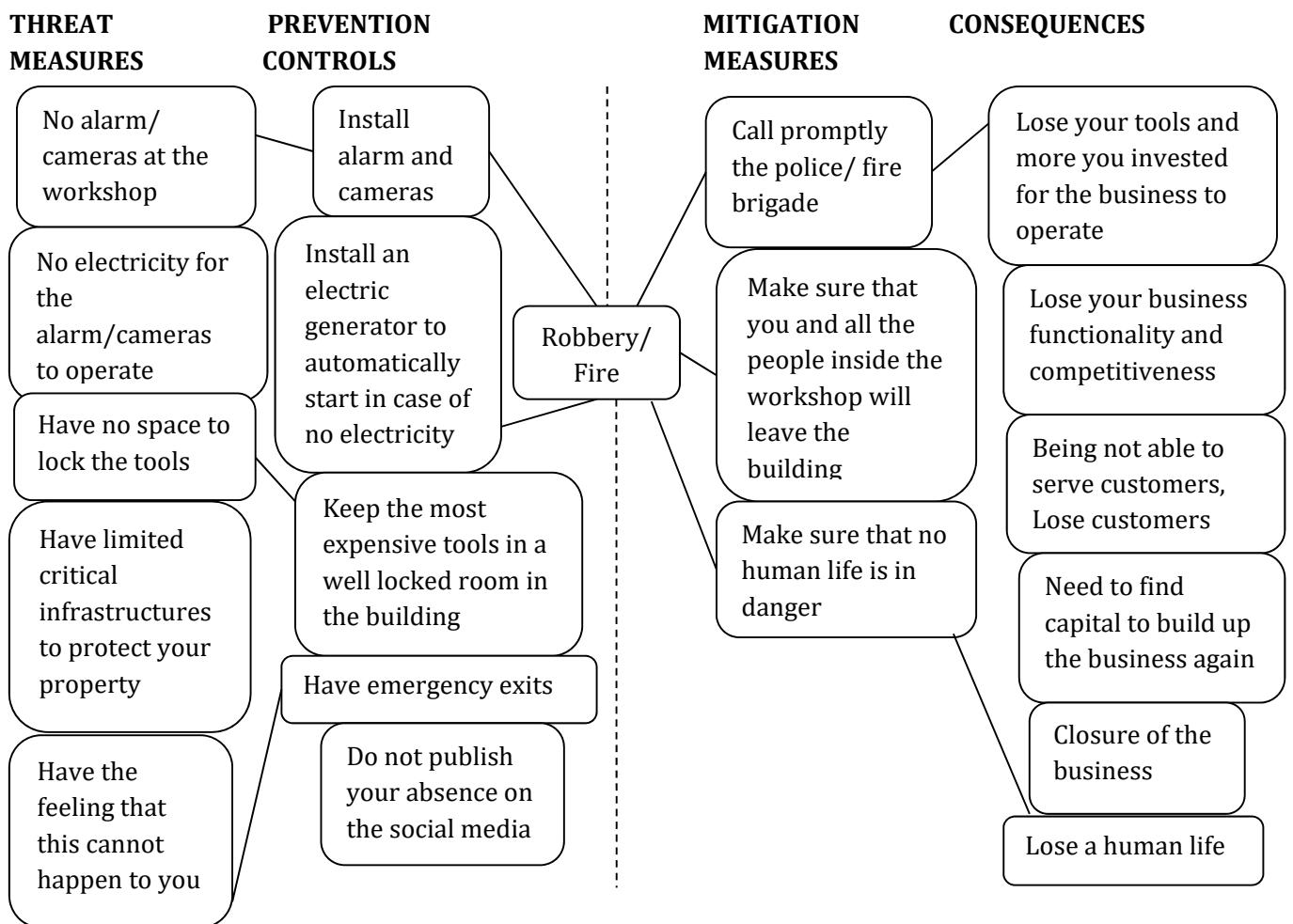


Figure 5: Application of the Bowtie method – Risk event: Robbery/Fire

4.1.3.5. Risk to Lose Key Employees

Big companies can find many replacements in these cases. The amount of work will delay is not as heavy as for small companies which count their services on less employees. In automobile repair workshops customer relations are really important and customer relations are built up among the proprietor and the employees as well. Personally I believe that every employee is a key one for the specific automobile repair workshop I visited. Unfortunately, I saw some threats around the working environment and as I spoke with the mechanics I realized that no prevention controls are taken by the employer. The first step to be taken at this business for me is to build on the esteem and avoid small misunderstandings that rise up from the work's pressure. On the below scheme I tried to figure out the bowtie analysis based on that risk event. The below scheme is not really based on the critical infrastructures but as employees are critical for the business' operations I decided to work on this case, too.

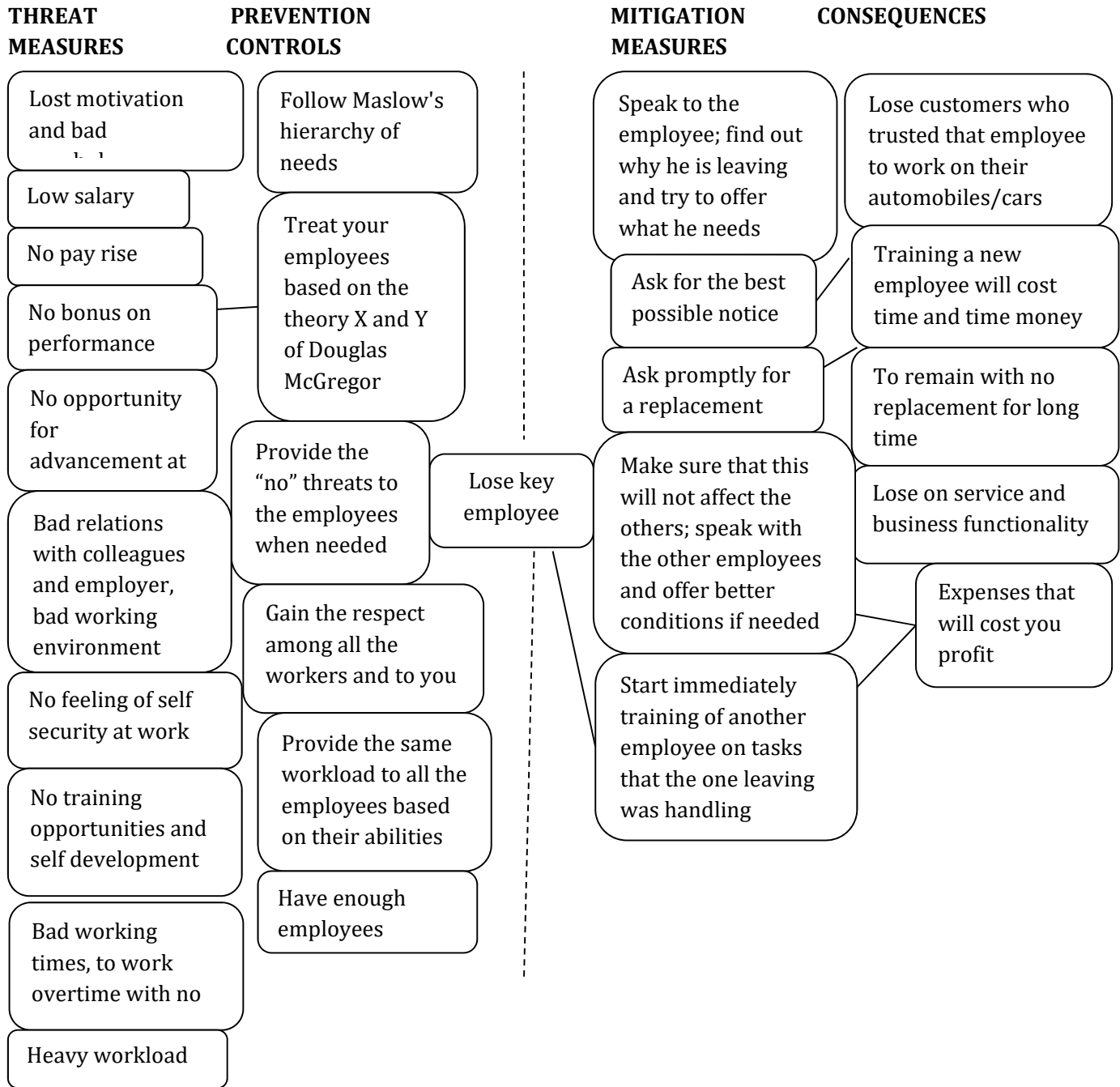


Figure 6 : Application of the Bowtie method – Risk event: Lose key employee

4.1.3.6. Risk to Lose Customers

To lose a customer is a consequence as we saw on previous cases of other risks. But as there is always the probability to gain back a customer that you may lose temporarily after a misunderstanding or a difficult time of the business because of a lack or malfunction of a critical infrastructure, it can be seen as a risk event, too. Below this risk is schematized based only on threats and prevention controls in terms of the business's critical infrastructures.

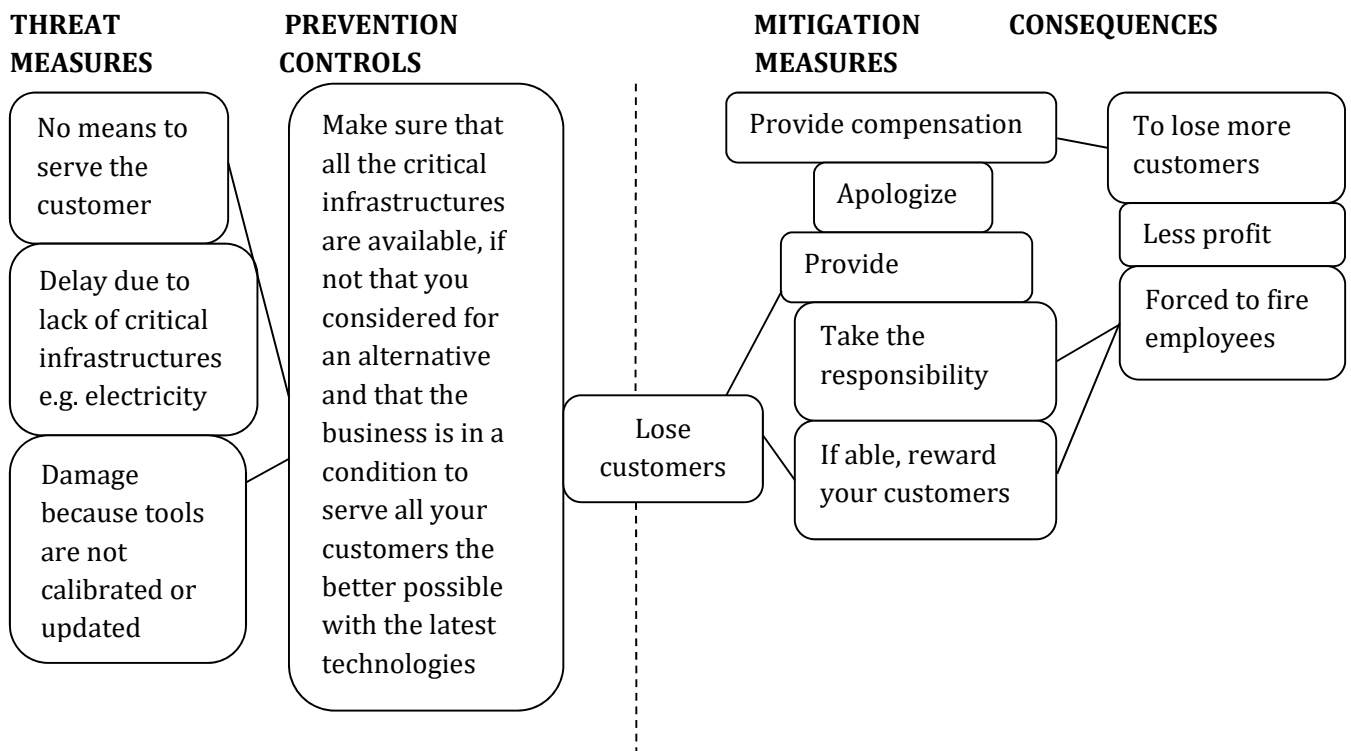


Figure 7: Application of the Bowtie method – Risk event: Lose customers

4.1.3.7.

Risk to Lose Business’s Functionality & Competitiveness

The consequence of one risk event is considered as a risk event of its own. In the business sector one risk lead to more risks. In order to avoid the appearance of a risk or to minimize the consequences from it, one manager needs to be able to identify the risk and prevent them. In the case of the workshops, the critical infrastructures are required for the functionality of the business. Also, as in every market place, workshops have to remain competitive in order to ensure the business continuity. On the below figure I have schematized the bowtie method analysis for the case of the risk event to lose the business’s functionality and competitiveness based on the critical infrastructures.

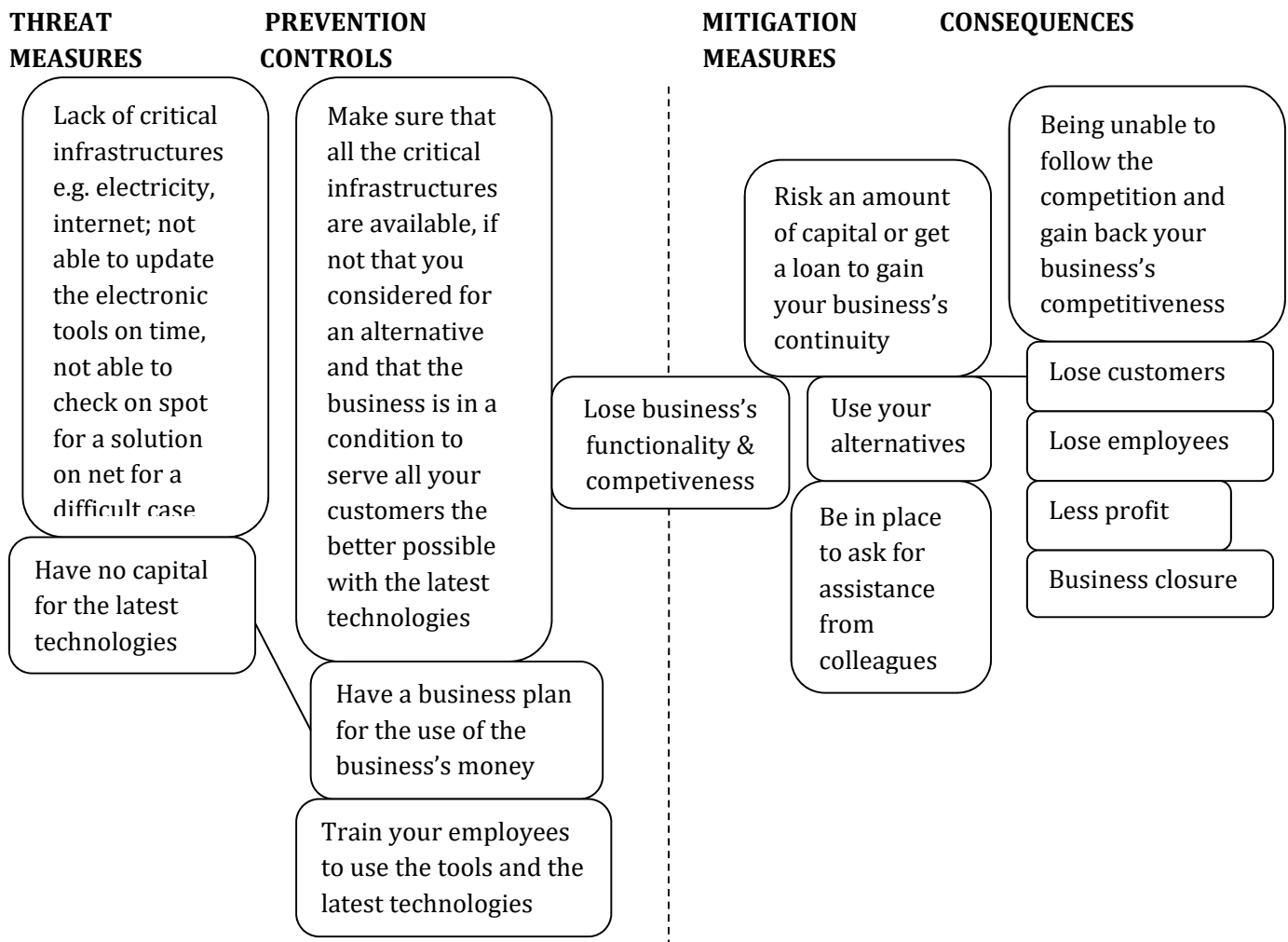


Figure 8: Application of the Bowtie method – Risk event: Lose business’s functionality & competitiveness

4.1.3.8.

Closure of the Business

For this risk event a scheme is not really required. In case the employer of the automobile repair shop will consider and follow all the previous plans as described on the above figures and also the previous chapters of this study, the business closure will be avoided. There are many factors that may lead a business to a permanent closure like the bad management of the business's money and other factors related mostly to the economic part of the business or even a serious health problem of the proprietor. The only way to have an immediate closure of a workshop that will emerge from risks prone to critical infrastructures is after a fire that will totally destroy the entire business. However, even after a fire, if you have a good capital you may build up the business with whatever remained from scratch again. The critical infrastructures may be related to a bad result in the beginning of the appearance of a risk but the consequence of a business closure includes other factors as well.

Chapter 5

5.1. Conclusions

According to A. T. Murray and T. H. Grubestic, in their book *Critical Infrastructure - Reliability and Vulnerability* (A.T. Murray, January 2007), societal functions are highly dependent on networked systems in the developed world. Even the most basic day-to-day functions involve interaction with a variety of critical infrastructure systems. For example, millions of Americans utilize transportation infrastructure to get to work, school, or the local mall. Telecommunication infrastructure is used to maintain contact with family and friends, shop or perform financial transactions. Energy infrastructure is used to heat our homes, power local industries and deliver fuel to our automobiles. While these basic activities are relatively easy to comprehend, the magnitude of infrastructure use is less obvious. They continue by stating that, the concept of reliability is especially important when examining the ability of critical infrastructure to provide continuity in operation. Broadly defined, reliability refers to the probability that a given element in a critical infrastructure system is functional at any given time.

In the business sector in general and as studied the case of the automobile repair workshops, the critical infrastructures may affect many important aspects of the business required for the operations and the development of the business. All the risks related to the critical infrastructures may affect the business profit and the business profit affects the business development and continuity. Therefore, the importance of the critical infrastructures may not be obvious but they can affect the business profit and the whole business in general, no matter the size or the type of the business. In today's modern societies, where technology is in a continuous advancement stage, every business needs to work on its competitiveness, development and business continuity. Every business needs to develop and follow a business plan to manage all the possible enterprise risks and in this plan among other factors is required to include the management of the critical infrastructures and the risks prone to them, as these are the basic requirements for a business existence.

The goal of this research has been achieved. The critical infrastructures are well identified and analyzed inside of the operations of an automobile repair workshop and its needs. In addition, the risks prone to those critical infrastructures are well identified and a risk analysis tool has been created for the main risk events identified, with the use of the Bowtie method. The Bowtie method has been well adapted to the case of the business selected to be studied and the whole research can be a useful tool for the management of the critical infrastructures and the possible risks for that business.

The next goal is for the business to take this tool and apply all these theories in the everyday operations. After all these advises, as decrypted and analyzed in the above chapters and especially

on the figures of the bowtie analysis, will be taken into consideration and applied on the business and followed by the employer and the employees, at that stage we will be able to criticize that risk analysis and make improvements on the analysis.

In every business we should not just create an analysis or a plan and then sit down and say ok we got it. We need to build up a management plan, consider the risks and all the factors that affect the business, e.g. the critical infrastructures, start implementing our “building” into the business and at the same time to continuously assessing and improving our plan.

“The stars will never align, and the traffic lights of life will never all be green at the same time. The universe doesn't conspire against you, but it doesn't go out of its way to line up the pins either. Conditions are never perfect. 'Someday' is a disease that will take your dreams to the grave with you. Pro and con lists are just as bad. If it's important to you and you want to do it 'eventually,' just do it and correct course along the way.” Tim Ferriss, author of *The 4-Hour Work Week*.

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