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The ripple effect of the business interruption and its effects on the supply chain of the SMEs: An insurance perspective.

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CHAPTER 4.

A MODEL FOR THE ESTIMATION OF INDIRECT DAMAGES AND RECOVERY TIME DUE TO BUSINESS INTERRUPTION

CHAPTER 5.

CASE STUDY: FI.TIM S.R.L.

INTRODUCTION

The rapid globalization of the last 20 years has seen the development of new business strategies and it has increased also some risk conditions that previously could not be considerate.

Concepts such as lean production or JIT (just-in-time strategy) have become dominant economic model, but if from one side they have increased the flexibility of the various supply chains, from the other side they have increase their vulnerability.

This means that the effects of a catastrophic event affecting a particular industry located in a specific area, are now rapidly transmitted to all the related business around the world.

Globalization has introduced a sort of systemic risk into global supply chains. The increasing trend to look globally for resources in order to reduce costs, has significantly raised the risk of disruption of the various supply chains.

The use of a cost-effectiveness and maximum flexibility approach for the modern supply chains, has created a lot of side effects that in case of catastrophic events could be translated into a significant business interruption.

This approach, combined with the rise of natural catastrophes, is becoming a huge problem that was not present in the past and that represents a big threat in particular for those companies which cannot afford big losses due to a business disruption.

The earthquake and tsunami in Japan and the devastating floods in Thailand both happened in 2011, are the demonstration of how huge are losses after a catastrophic event, not only for the country itself but also for industries around the world economically linked to those countries .

The massive physical damages in Japan and in Thailand affected the supply chains of many global companies, it disrupted sourcing and manufacturing in a consistent number of industries around the globe.

This can be extremely challenging for the activity of the supply chain management.

A significant example is the unexpected lack of metallic paints for the worldwide automotive industry as a result of the earthquake in Japan of the 11 march 2011.

The automotive metallic paint is made all over the world using the pigment Xirillac. This is exclusively produced by the company Merck Kgaa located in a plant that was closed immediately after the earthquake and only 45 kilometres far from the Fukushima nuclear plant.

The interruption of the productivity of this company has eliminated the only source in the world of the pigment Xirallic for many of the biggest auto makers, including Chrysler Group , Volkswagen, BMW, Toyota and General Motors.

Considering that almost 90% of cars built around the world adopt the metallic paint, it is easy to understand that the supply chains of the automotive industry have suffered extensive damages due to the amount of outstanding orders.

This example of course is one of the worst-case scenarios that could happened to an industry and all the related supply chains.

However the same topic can be related to other less catastrophic events that every year happen around the world, and in particular to the earthquakes and floods that are hitting the Italian area in the last years.

The challenge is on two level, the first is the resilience of the single company after a business interruption, and the second is the overview of a worldwide supply chain identifying which could be the weak links in case of natural disaster.

Today companies are examining how to better mitigate disruptions not only due to catastrophic events but also due to possible breakdown inside the plant, to fire risk and also to the possibility of losing some key-man for the company.

The only way to deal with these threats is certainly to have a supply chain risk management systems even if this might add some extra-cost.

The objective is to find a standard model that evaluate the level of risk of a company using the available data. For this reason in the next chapter will be examined the complexity of the most common supply chains in Italy, to see how natural catastrophes and other disruptive events are increasingly putting them at risk, and what that means for both insurance and industry.

CHAPTER 1.

CHATASTROPHIC EVENTS AND ECONOMIC DAMAGES : THE SITUATION IN ITALY

1.1 Catastrophic disasters and economic losses

According to Munich Re (Munich Reinsurance Company, one of the world's leading reinsurers) the 2011 has generate a record of 380 billion of dollars of economic damages, and only 105 billion of these were insured [Munich RE 2012].

However all the catastrophes happened in 2011 do not represent an anomaly, in fact the number of natural disaster have increased steadily over the past three decades.

Munich Re reports that the total number of disaster events in seven years, during the 80s, was less than 400. Then in every year from 2000 to 2011, there were more than 600 events (800 events in six of those years).

In 2005 happened more than 1,000 catastrophic events.

In term of losses caused by catastrophic events, the average annual economic and the average insured losses during the last 30 years were respectively $75 billion and $19 billion. But if we consider only the last decade the average economic and insured losses are $113 billion and $35 billion.

This can be attributed to the economic growth and to the rapid globalization, which have significantly increased the insured values and insurance density due to the vulnerability of the supply chains spread around the world.

Focusing more on Europe, in accordance with the Global Manufacturing Outlook provided by KPMG, more than a third of manufactures in Europe is giving so much attention on risk, reliability and flexibility of their globally integrated supply chain [KPMG 2013]

The trend of companies is to move their business processes to neighboring countries that offers lower costs and that are possibly closer to the end markets.

The large majority of manufactures around the world thinks that the next wave of innovative supply chain is coming.

Today companies focus their attention not only on cutting costs, but also to invest to guarantee an optimal resilience in case of business interruption.

It is becoming necessary to have a good risk management structure inside every company, especially in those countries, like Italy, where the culture of risk applied to the business field is still not really widespread.

1.2 How Italy faces the risk of business interruption

Historically the Italian industry is characterized by the presence of a large number of SMEs (Small and medium-sized enterprises). In case of business interruption, these companies are subjected to a big effort in order to rapidly restart the production, but usually they do not have enough financial resources to cover the losses, due to the limited size of their business.

One of the last conferences of AIBA (Associazione Italiana dei Broker di Assicurazione e riassicurazione) showed that less than 20% of Italian companies, compared with 80% of German companies , has a policy that protects against any kind of indirect economic loss resulting from a stop of the production.

We can define the indirect economic loss or indirect damages as the impossibility to use the business properties (buildings and machinery) in order to produce goods and assets, which results in a loss of revenues.

This usually happens after natural disasters or accidents, but fortunately there are insurance policies that allow to cover part of these business losses.

This kind of insurance covers also those situations where there are not direct damages to property, but the loss of revenues occurs because of accidents like a power outage or breach of contract from a supplier or a partner.

So the direct damage is usually linked to the indirect damage, but the first considers only the effective breakage of the property, and not the losses due to the impossibility of producing goods.
As a consequence if only the 20% of Italian companies has a specific policy for indirect damages, in case of a natural catastrophes, the scenario could be really dramatic.

The current Italian situation faces a dangerous risk of under-insurance for businesses, and this is a big threat for the whole Italian industrial system.
The insurance program of the great majority of Italian companies, does not provide any kind of coverage for the risk of consequential damages.
A study carried out by the CEA (Comitato Europeo Assicuratori) showed that the indirect damage is on average 2.5 times higher than the direct damage [AIBA 2013].
In particular, one of the most significant data, is that the 40% of companies, that remains inactive after an accident for more than three months, goes bankrupt within two years after the reopening.
They fail because of the impossibility to overcome the financial difficulties, whereas an adequate insurance coverage from indirect damages, could have guaranteed the restoration of the previous conditions of the company.
This collides with the fact that Italy is the most exposed European country to earthquakes, floods and atmospheric events.
The 82% of Italian municipalities is at hydrogeological risk and the 67% is located in a seismic risk zone.
In addition, 6 million people live in areas considered at high risk and 22 million live in areas with intermediate risk. The 6.1% of the country is exposed to landslides.
The importance of insurance coverage for the industrial sector is still not considered a priority for a lot of entrepreneurs.
It's necessary to increase the awareness of the risk of failure due to disruptive events, especially today that the government is not able to ensure support in case of economic emergencies.

1.3 Lack of risk management culture inside Italian SMEs

Italy is the European country with the largest number of Small and Medium Enterprises: there are almost 3.7 million of companies which can be considered attractive for the insurance market [SBA 2014].

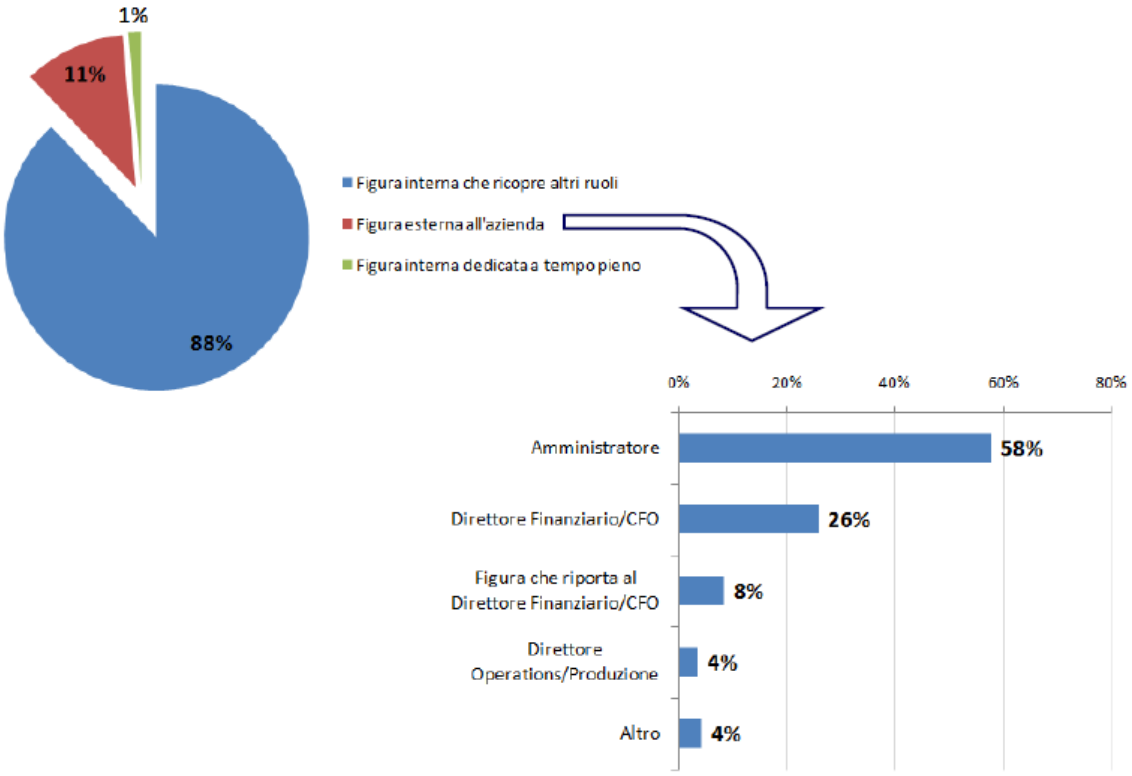
This number is referred to '' business economy " (industry, construction, trade and services) and not to businesses related to agricultural, forestry and fishing, or other non-commercial services such as education and health. SMEs represent the 99% of the number of firms in Italy and they characterize the economic and social structure of the country.

However they have the limitation of not paying proper attention to all the insurance aspects necessary to ensure the continuity of the company in case of natural disaster. Usually this happens because the company lacks figures with the necessary know-how in the field of risk. Data relating to the insurance situation of SMEs confirm the reluctance of the entrepreneurs to protect their business and their employees with the right insurance policies.

The second edition of the “Osservatorio sul Risk Management nelle PMI italiane”, conducted by the Politecnico di Milano and Cineas (University consortium to spread the culture of risk), points out , after a study conducted on a sample of about 700 companies, that there are few SMEs with an employee dedicated to a full time risk management activity. The role of the risk manager is usually covered by a figure inside the company that does not have the appropriate skills to carry out a proper risk assessment [RiskGovernance 2014].

Usually this figure covers mainly other roles: the CEO, the chief financial officer (CFO) or the person in charge of the production.

Figures covering the role of the risk manager within a company



Source : Risk Governance - Il Risk Management nelle piccole e media imprese italiane.

These roles do not have the competences to identify and recognize the crucial risks of the SMEs, so they cannot produce an efficient insurance plan. Mainly they assess the risk situation only based on their past experiences.

Considering the recession's context of the Italian economy and the worrying situation in Europe, SMEs are increasingly obliged to take the challenge to discover new markets.

The aim is to establishing convenient commercial transactions with those countries that offer raw material at a lower cost or that have a growing demand of goods.

This has been the trend of the 2014, aligned with the need of the SMEs to assess the risk situation considering the foreign suppliers and wholesale distributors [RiskGovernance 2014]

It is necessary to have the right tools to highlights the risks to which the company is exposed and to propose the most appropriate insurance plan.

Only through a constant monitoring of the riskiness of the company, it is possible to reduce the unexpected and to limit losses.

The optimization of insurance costs for the SMEs can be obtained by a risk assessment developed in collaboration between the entrepreneur and a specific professional figure (insurance broker, insurance agent or an insurance consultant)

The advice offered by insurance operators is helpful to increase the awareness of risks at all levels of the company.

This also allows entrepreneurs and workers to acquire a risk culture, which provides the tools to recognize and avoid the everyday situations that may threaten the productivity and the company's reputation.

Italy, according to the Federation of European Risk Management Associations (Ferma), occupies the last place for the quality of its Risk Governance activities and it suffers a huge delay in this field.

Most of the SMEs, which represent more than 90% of Italian companies, undervalue or ignore the benefits generated by having a good risk management [FERMA 2014]

Even if the costs for a risk management structure and an insurance coverage are higher than the immediate benefits, in the long term view, a company increase also management's ability to identify, avoid and monitor all the risks related to business processes.

"Enterprise risk management: empirical analysis of the Italian market" is another research conducted by Cineas in collaboration with the Politecnico di Milano (Prof. Marco Giorgino, Professor of Global Risk Management at the University) [Cineas 2011].

The objective of the survey was to measure how Italian SMEs perceive the risks and what are the techniques and tools available for the risk management.

The study was conducted on 1324 companies (belonging to 32 sectors of industry and services) with a turnover of no more than 250 milion.

The main result is that only 46% of the sample responded that there is a specific unit dedicated to risk management headed by the CEO.

The remaining 54% does not have a structure dedicated to risk management and most of these companies do not plan to introduce it in the near future.

The paradox is that the question concerning the existence of a risk management policy, has received a positive answer from 80% of companies surveyed.

Actually this “risk management policy” is only a dissemination of internal documents and meetings among the staff of the company, under the approval of the CEO.

For the future it is needed a change of approach in risk management: from the estimation of the probability of loss to an active tool for a clear vision of the risk situation of a company. Only in this sense, the companies will appreciate the value of the enterprise risk management strategies

Gianmario Vincis, CEO of Olympia Broker SMEs, an Italian company specializes in insurance and risk management, said that “the figure of the risk manager is still very undervalued in our country and it is mostly concentrated in large companies. Actually the criticality of this economic period makes essential, especially for small and medium enterprises, to exploit the experience of professionals who are able to define the guidelines to remain competitive, to work in a secure environment and to create new opportunities for development” [Assinews 2012]

CHAPTER 2.

ANALYSIS AND RISK EVALUATION OF THE SMEs

2.1 Analysis of the SMEs in Europe and in Italy

Italian industry has the higher number of Small and medium-sized enterprises (SMEs) comparing with all the other European countries. The majority of the SMEs operate in the wholesale and retail trade, where it is concentrated 86% of total employees of this kind of companies.

Italian SMEs are really numerous also in the manufacturing, in those traditional sectors which have been the strength of the Italian industry in the last decades. In particular there are three main areas, the first one is food and beverage, linked to the fact that food products made in Italy have an international fame. The second is textile and clothing, a sector affected by a strong competition especially from Asian countries but that still remains a key sector for the Italian economy. The last area is the production of metal products, machinery and equipment [SBA 2014]

Between 2008 and 2013, a lot of Italian companies have been unable to continue to run their business. Before the international crisis started in 2008, the Italian manufacturing industry was the biggest in Europe, but during those years it has suffered the competition and the strong economic depression.

Small and Medium-sized Enterprises constitute the backbone of the Italian's economy, but also in other countries there is a considerable number of this type of companies. In fact across all the European Union there are almost 21.5 million SMEs in the non-financial business sector, and they represent the 99.8% of the total amount of enterprises.

Total Number of enterprises in Europe

	Micro	Small	Medium	SMEs	Large	Total
Number of enterprises						
Number	19,969,338	1,378,374	223,648	21,571,360	43,517	21,614,908
%	92.4%	6.4%	1.0%	99.8%	0.2%	100%
Employment						
Number	38,629,012	27,353,660	22,860,792	88,843,464	44,053,576	132,897,040
%	29.1%	20.6%	17.2%	66.9%	33.1%	100%
Value added at factor costs						
Million Euros	1,362,336	1,147,885	1,156,558	3,666,779	2,643,795	6,310,557
%	21.6%	18.2%	18.3%	58.1%	41.9%	100%

Source: Eurostat, National Statistical Offices and DIW Econ

The Italian scenario is characterized by 4.4 million of Small and Medium-sized Enterprises with very different characteristics, needs and potential. This shows the importance of small business for the Italian economy, but it is also indicative of the presence of bottlenecks and limits to the growth of the Italian industry [SBA 2014]

Small businesses with a turnover of up to 10 million euro, are more 200,000, and even if they represent only 5% of the total enterprises, they account for 21.5% of the total value of the Italian production.

Midsize companies are approximately 20.000 (0.5% of the total) but contributes to 19.8% of the total value of the production.

Total Number of enterprises in Italy

	Numero di imprese			Numero di dipendenti			Valore aggiunto		
	Italia		*UE-28*	Italia		*UE-28*	Italia		*UE-28*
	Numero	Quota	*Quota*	Numero	Quota	*Quota*	Miliardi di euro	Quota	*Quota*
Microimprese	3 527 452	94.8%	*92.4%*	6 629 987	45.8%	*29.1%*	201	30.4%	*21.6%*
Piccole imprese	171 658	4.6%	*6.4%*	3 049 375	21.1%	*20.6%*	141	21.3%	*18.2%*
Medie imprese	19 126	0.5%	*1.0%*	1 837 003	12.7%	*17.2%*	118	17.8%	*18.3%*
PMI	**3 718 236**	**99.9%**	***99.8%***	**11 516 365**	**79.6%**	***66.9%***	**459**	**69.5%**	***58.1%***
Grandi imprese	3 139	0.1%	*0.2%*	2 960 003	20.4%	*33.1%*	201	30.5%	*41.9%*
Totale	**3 721 375**	**100.0%**	***100.0%***	**14 476 368**	**100.0%**	***100.0%***	**661**	**100.0%**	***100.0%***

Source : SBA 2014 Italy

In particular referring only to the “business economy”, that is industry, construction, trade and services (excluding all the business related to agricultural, forestry and fishing and also non-commercial services such as education and health), there are 3.7 million of SMEs only in Italy. Considering that there are a total of 21 million of Small and Medium-sized Enterprises, Italy has almost the 20% of the total of them.

So, in the perspective of fostering the process of restarting the Italian production system that, historically, does not make a proper use of insurance instruments, it is fundamental to guarantee the stability and the continuity of Italian SMEs.

The non-life insurance sector, excluding motor insurance, represents 1% of the Italian GDP, a percentage lower than 50% compared to the European average. Increasing the diffusion of insurance protections in Italy, it is a priority in order to mitigate the risk exposure and to support the development of the Italian economy.

According to SBA 2014, Italian companies are increasingly offering their products to the international markets. In 2013 It has been recorded a positive trade balance of export- import due to the increase of the exports to countries also outside the European Union.

Highly specialized sectors show a growing propensity to export, in particular manufacture of machinery and equipment, production of leather goods and food and beverage industry, sectors that are really important for the Italian economy.

Entrepreneurs operating in these sector, cannot afford long business interruption, also because they do not want to lose the reliability with foreign customers built over the years. Moreover the annual report of the European SMEs 2013/2014 shows that the biggest problems for SMEs are the access to finance, finding new customers and the fact of keeping skilled workers inside the company.

Having a solid insurance plan it is certainly a strength for the SMEs because a good risk coverage allows companies to increase the chances of being funded [ANIA, Cerved 2014].

As a consequence, a stable financial situation provides a positive image of the companies to potentials new customers and it also becomes more attractive for skilled employees.

Today Italian industry is moving towards an international context, in fact small and mid-sized manufacturers are performing well in the export industry, especially for those SMEs located in the northeast of the country that are equipped with effective export strategies. In any case the country needs to constantly improve the results, especially facilitating the access to finance and reforming law relating to insolvency.

Gabriele Ratti, project manager of Willis, emphasizes that "the underinsurance among SMEs is an Italian specificity, with a third of the companies on this band is not ensured against liability, thus exposing themselves to high risks."

A scenario that is produced by Ratti is also because of the traditional difficulty of reaching smaller companies ("70% of SMEs have never received a study on the risks from a broker '), a situation that is changing, however, in recent times [Dell'Olio 2013]

2.2 Evaluation of the major risks of business interruption for SMEs

The risk landscape is evolving at high pace, due to the growing interdependence between different type of industries.

For a lot of international businesses, the supply chains are not just few isolated suppliers and distributors. Today companies include a lot third parties such as product distributors, service providers, manufacturers, contractors, and logistics firms (transportation, warehousing) located all over the world.

At the same time all of them rely on their own infrastructure, including electric and telecommunications providers, transportation services, and the supply networks. A single interruption in any part of the supply chain can cause a domino effect hardly avoidable by companies taking part of the production flow

An interesting survey made by Allianz points out that Business interruption (supply chain), natural catastrophes, and fire risk are the major sources of risk which in the last year have caught the attention of companies from all around the world [Allianz Risk Pulse 2014].

"Identifying the impact of interconnectivity between different risks is a top priority for risk managers. Today's business continuity plans must prepare for an increasing range of risk scenarios which need to reflect the sometimes hidden knock-on effects. For example, a natural catastrophe can result in BI, systems failure, power blackouts and a host of other perils."

Axel Theis, CEO, AGCS

Top 10 global business risks for 2014

2014		2013	Rank	Trend
1	Business interruption, supply chain risk	43%	46%	(1)	—
2	Natural catastrophes (for example, storm, flood, quake)	33%	44%	(2)	—
3	Fire, explosion	24%	31%	(3)	—
4	Changes in legislation and regulation	21%	17%	(4)	—
5	Market stagnation or decline	19%	12%	(8)	↗
6	Loss of reputation or brand value (for example, from social media)	15%	10%	(10)	↗
7	Intensified competition	14%	17%	(5)	↘
8	Cyber crime, IT failures, espionage	12%	(-)	(-)	NEW
9	Theft, fraud, corruption	10%	(-)	(-)	NEW
10	Quality deficiencies, serial defects	10%	13%	(6)	↘

The third annual Allianz Risk Barometer survey was conducted among risk consultants, underwriters, senior managers and claims experts in the corporate insurance segment of both Allianz Global Corporate & Specialty (AGCS) and local Allianz entities. Figures represent the number of responses as a percentage of all survey responses (557)

Allianz

During the last two years of this research done by Allianz , Business Interruption and supply chain risk have occupied the first position of the ranking global business risks, more than the 40% of respondents rating this as one of the three most important risks for all the companies.

Allianz Global Corporate & Specialty estimates that business interruption and all the other losses related, typically account for 50% to 70% of insured property catastrophe losses, as much as € 33 billion a year [Allianz Risk Pulse 2014].

The use of just-in-time and lean manufacturing strategies have become standard practices, the trend to look for suppliers and distributors from all around the world and the increasing of natural catastrophes are a the three main reason to push people to need to evaluate the level of risk of the supply chain.

Usually after a disruptive event such as an earthquake or a flood, it takes years to fully recover the pre-event productivity. Rarely the effects of a catastrophic event are limited in that area, if only one supplier is affected by a business interruption, all the supply chain suffers of production delays.

However the identification of critical suppliers is not always an obvious exercise, and this has both insurers and businesses concerned.

In the graph below, it is possible to see the major risks divided by sector. For example speaking about the manufacturing sector, the most worried risks are in order business interruption, natural catastrophe and finally the fire risk natural catastrophes and BI/supply chain risk.

In fact for manufacturers is hard to manage the global demand of semi-finished product and raw materials in case of disruptive event, considering also the strong competitions in this sector.

Top business risks in 2014 by industry

	Engineering/Construction		Manufacturing		Transportation	
1	Natural catastrophes	40%	Business interruption, supply chain risk	60%	Theft, fraud and corruption	46%
2	Business interruption, supply chain risk	35%	Natural catastrophes	42%	Natural catastrophes	25%
3	Market stagnation or decline	33%	Fire, explosion	36%	Fire, explosion	25%
4	Fire,explosion	27%	Market stagnation or decline	24%	Market stagnation or decline	21%
5	Credit availability	18%	Intensified competition	24%	Intensified competition	21%

	Power & Utilities		Marine & Shipping		Financial services	
1	Changes in legislation and regulation	53%	Natural catastrophes	38%	Changes in legislation and regulation	39%
2	Business interruption, supply chain risk	53%	Theft, fraud and corruption	24%	Natural catastrophes	25%
3	Power blackouts	24%	Business interruption, supply chain risk	24%	Market fluctuations	25%
4	Natural catastrophes	21%	Market stagnation or decline	21%	Business interruption, supply chain risk	18%
5	Fire, explosion	15%	Changes in legislation and regulation	17%	Loss of reputation or brand value	18%

Figures here represent the number of responses as a percentage of all responses (between 28 and 60 responses per industry)

Source : Allianz

Focusing in particular on the situation of the Italian SMEs it would be useful to consider what are the main risks insight the different kind of companies.

Moreover the different insurance guarantees should have different level of importance, in terms of reduction of risk, depending on the type of the business sector considered.

For example sawmill or a paper mill have a much higher fire risk compared to other types of business. The goal is to find what is the importance of indirect damage in those industries in which SMEs mainly operate.

As described in the previous paragraph, the majority of Italian SMEs works in the wholesale and retail trade. Then there are numerous SMEs operating in the manufacturing industry, especially in sectors as food and beverage, textile and clothing and in the production of metal, machinery and specific equipment.

The best approach is to give a quantitative indication of the degree of coverage of a small-medium enterprise, considering its main characteristics, for example in terms of the type of business sector, and insurance guarantees activated.

A study carried out by the Coordination Committee of ANIA (national association of insurance companies) and CERVED (Italian Information provider) worked in this direction.

It consisted in the construction of an indicator called "degree of insurance coverage of SMEs" created with the advice of professionals and with a subsequent control of reasonableness based on the average prices of insurance guarantees considered. Through this tool, companies can evaluate which insurance they can take out according to that particular sector [ANIA 2012].

The indicator in fact identifies the probability more effectively than only considering the number of activated policies, in fact it gives a different weight to the policies based on the type of industries.

The level of insurance coverage of the SMEs is a percentage value between 0% to 100% depending on the number of policies of the company, representing in other words the capacity to reduce the volatility of earnings linked to insurable risks to which the SME is exposed.

Starting from the industry's most widespread in Italy, the whole sale and retail trade, the indirect damages has a weight of 11% on all insurable risks.

Share of insurable risk reduction - Wholesale and retail sector

Garanzie assicurative di interesse		Quota di riduzione	
		Numero addetti	
		1-5	6-250
1	Incendio base	25	25
1.1	Incendio cop. estesa	11	12
2	RCT/ RCO	21	20
3	Furto	13	14
4	Danni indiretti	11	10
5	Elettronica	5	4
6	Cristalli/ vetri	4	4
7	Tutela legale	5	5
9	Guasti macchine	1	2
14	Cop. Fotov./ biomasse	1	2
15	Informatica	1	2
	TOTALE	100	100

Source : ANIA

It is interesting to consider that the different kind of businesses never reach a degree of insurance equal to 100%, because in that case there would be no more business risk connected to the skill of the entrepreneur or the quality of the company. In particular for the wholesale and retail trade, the degree of insurance coverage is 56%, so the policy for indirect damages strictly related to the business interruption represent a big part of this percentage. This is linked to the importance of this kind of insurance in this industry sector, and the fact that most Italian SMEs are avoiding to take out this type of insurance is not a good signal for the stability of the Italian economy.

GCA medio per settore di attività

Settore di attività	GCA medio
Commercio, turismo e trasporti	56%
Edilizia	27%
Manifattura e agricoltura	43%
Altri servizi	34%

Source : ANIA

Moving towards the manufacturing industry, the degree of insurance is even lower but the percentage referred to the indirect damage is higher in some cases. This mean that having a policy that covers the business interruption, has a bigger impact in the manufacturing industries, due to the presence of machineries and complex production cycles. Especially in those sectors such as food and beverage, textile and clothing and production of metal, machinery and specific equipment.

Share of insurable risk reduction - Textile industry

Garanzie assicurative di interesse		Quota di riduzione	
		Numero addetti	
		1-5	6-250
1	Incendio	22	22
1.1	Incendio cop. estesa	11	12
2	RCT/ RCO	19	20
3	Furto	9	9
4	Danni indiretti	12	12
5	Elettronica	5	5
7	Tutela legale	4	4
9	Guasti macchine	5	5
14	Cop. Fotov./ biomasse	2	1
15	Informatica	0	0
16	Rischi merci trasportate	4	3
18	RC Prodotti	7	7
	TOTALE (rischio assic. rid.)	100	100

Source : ANIA

2.3 Definition of Indirect Damage and methods to estimate losses

When a damage occurs inside a firm there are 2 types of losses arising from it: the first one is easily identifiable and is related to the replacement cost of the good that is damaged.

If for example a fire burns down a machinery you have to purchase a new one or to pay someone to restore it to its full functionality. This type of loss is called direct loss.

The damage can be caused by a fire, as in the example, but also by a breakdown, a theft or a natural catastrophe, such as a flood or an earthquake. Anyway there is also a more hidden kind of loss which stems from the fact that maybe that machinery is essential for the production process.

If it stops working the whole firm stops, with a consequent loss due to the fact that the firm is no longer able to produce and sell its products for a certain amount of time, while it still has to pay for running costs such as leasing, personnel, utilities etc. This type of loss is called indirect loss.

Since the first kind of loss is tangible and easy to be defined, insurance policies covering it are far more popular than those covering the second kind of loss, which is intangible and much harder to define in economic terms.

As a matter of fact there exist different types of insurance policies covering from indirect losses, and they are commonly referred to as “business interruption policies”. The first type of policy reimburses the indirect loss as a percentage of the direct loss.

If for example the direct loss amount to 10.000€ and the policy implies that the indirect loss is the 10% of the direct one, then the reimbursement for the indirect loss will be 1.000€. The main advantage is that they are straightforward to calculate but absolutely not accurate in defining the correct amount of loss that the company incurs: in fact it might well be that the direct loss is small while the indirect one is material and in this case the coverage is not effective.

The second type of policy is denominated LOP (loss of profit) and quantifies the indirect loss as the amount of gross profit that the company has lost following the accident.

This in turn is calculated multiplying the loss of revenues times the gross profit ratio, that is a ratio representing which percentage of the revenues is gross profit. This policy is for sure more refined than the percentage one and requires at least the availability of the certified balance sheet of the company to retrieve the mathematical quantities in order to carry out the calculation.

It exist an even more refined type of business interruption policy which grounds on the contribution margin. In the case of Italy it came in 1994, thanks to the work of ANIA, the national association of insurance companies.

The contribution margin is calculated as the difference between revenues and variable costs. In this way what is reimbursed by the insurance company is the amount of profit lost plus the amount of fixed cost that the firm is obliged to bear even though the production is stuck. The whole cost for personnel, 30% of costs for services and 70% of other costs are included among fixed costs.

CHAPTER 3.

BUSINESS INTERRUPTION AND INSURANCE COMPANIES

3.1 History of BI and insurance exposure of Italian industry

Historically the concept of business interruption could be used since the appearance of agriculture, in fact the adverse conditions or the low and high seasons could have caused shortages and disorders between suppliers and customers.

Over the years different kind of businesses have grown in size and nature. The industrial revolution in the 19th century, has completely changed the way of doing business, with a huge impact on society.

History of the Business Bnterruption insurance

1797	First attempts by Minerva Universal (UK) to insure consequential costs and loss of income.
1817	The *Hamburger Generalfeuerkasse* covers loss of rent as a supplement to fire insurance.
1821	Time loss policy introduced in England, also known as the *per diem* method, involving daily/weekly compensation.
1857	*Chômage* insurance introduced in France, known as *système forfaitaire*. The consequential cost from a fire loss is covered by a fixed percentage of the fire sum insured.
1880	Dalton, an insurance agent in Boston (US), introduces the expression "use and occupancy", already a familiar concept in fire insurance, for the insurance of the loss of production following a fire.
1899	The British loss of profits system, where turnover is a key figure, is developed by Ludovig McLlellan from Glasgow, Scotland.
1906	Business interruption insurance based on the UK model introduced in Sweden.
1910	Machinery business interruption policy approved in Germany by the supervisory authorities.
1938	The gross earnings form – also known as the US system (see also 1986) – introduced in the United States.
1939	Standard business interruption wordings known as the "standard policy" are drawn up in England and Ireland, forming the basis of what is known as the UK system.
1956	Independent fire business interruption policy introduced in Germany.
From 2000	Greater focus on business interruption exposure in response to society's increasing dependence on electronic media, globalisation and the terrorist attack on the World Trade Center.

Source: Swiss Re - Business Interruption Insurance - Technical publishing Property

In the 1980's have been introduced various notions such as just in time production (JIT), optimization of internal processes, outsourcing of non-core activities and globalization.

Actually they have generated multiple health benefits for industry, but there are also many side effects.

Raw materials, semi-finished products and finished products are no longer stored inside the plant, so in case of unexpected events affecting suppliers or distributors, it is difficult for a company to ensure normal production activities

A cost efficiency view, based only on outsourcing activities that do not give added value or on opening new plants in some developing countries, would be a perfect mechanism just in an ideal world.

The reality is that if even something small goes wrong in the several interactions between customers, manufacturers, suppliers, retailers, distributors, the result is a supply chain interruption with a process shut down.

In a fragile business, the impact of a minor inconvenience can spread widely and quickly all over the workflow.

Concerning Italy, to have a general estimate of the current exposure of natural catastrophic events, the 2012 was a year full of natural disasters, with really high costs in terms of property and lives lost.

In May 2012 the earthquakes in Emilia Romagna has been one of most destructive in the history of that area, and it has generated around € 12.6 billion of damages for more than 10,000 industrial plants. Insurance industry estimates that insured damages from the earthquakes amount to € 1.2 billion.

The most harmful flood event hit Tuscany on 13 November 2012, leaving 700 homeless and causing damages for € 110 million.

According to the annual insurance report by ANIA, the Italian exposure to earthquake and flooding risk for 2013 (the total exposure of the sector to these risks, with regard to firms in industry, crafts and wholesalers), amounts to more than Euro 350 billion [ANIA 2013] [ANIA 2014]

3.2 Explanation of the concepts of BI (Business Interruption) and CBI (Contingent business Interruption)

In order to start to explain the concept of business interruption, it is useful to propose a clear definition proposed by an American court case happened in 1975.

This law case is referred to an oil refinery company that has suffered a 96 days' business interruption as a result of an accident occurring during the construction of an additional implant.

The case points out some interesting aspects about the function of a business interruption insurance policy.

The meaning of business interruption (BI) is "a breaking or suspension of production earnings of an operating business. The general purpose of business-interruption coverage is to do for the business what the business would have done for itself had no loss occurred. Typically, this involves computing the earnings lost during the period necessary to restore the business to its pre-accident condition. This period is referred to as the "suspension period" [Great Northern Oil Co. 1975].

This explain also why having an insurance policy is one of the best way to protect a business, in fact it can refund all the losses and damages derived from the impossibility to use essential assets to run a business. This becomes particularly necessary when a company or its suppliers are hit by natural hazards.

The term supply chain covers suppliers, customers, after sales assistance an all the other services that enables an organization to sell the final products.

Thus supply chain is defined as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer" [Mentzer, DeWitt, Keebler, Min, Nix, Smith, And Zacharia 2001].

From an insurance standpoint, it has been developed the concept of CBI (Contingent Business Interruption), that links the business interruption with the whole supply chain of a company. This type of insurance refunds lost profits and other possible costs, such as necessary continuing expenses, due to an insurable loss but suffered by one or more of its suppliers or customers.

For example a contingent business interruption provides coverage for the additional costs to obtain goods from alternative sources after the stop of the traditional supplier because of an unexpected interruption.

The difference between a standard business interruption insurance (BI) is that the CBI covers the policyholder also from a loss resulting from damage of a third party. Usually CBI insurance is purchased as an extension to the indirect losses coverage.

Generally larger organizations, with a great exposure to risks, have a Taylor-Made policy since they are broader and they have more complex structure, whereas a standardized policy, possibly divided by sectors, could be sufficient for small and mid-sized organizations.

CBI policy provides the losses had during the period of time called "period of restoration", the reasonable amount of time that should be taken to repair the damages and to resume the normal business operations. Basically the contingent business interruption mirrors the supply chain.

In order to not confuse the concept of business interruption with the contingent business interruption, the BI results only from an interruption of the supply chain

within the organization (for example a stoppage between two plants of the same company).

Instead CBI is an interruption of the supply chain due to an event that occurs outside the considered company, and which could affects suppliers, customers or other operators.

Usually CBI and BI are determined through the insurance coverage triggered for for the properties of the company.

These types of policy are strictly linked between them, in fact it is not possible to consider CBI and BI as different entities. Moreover BI is an extension of the policy for property damages and in turn CBI is an extension of the standard business interruption.

To make it clear, for example if a company is located in Italy and its main supplier is situated in Japan in an area subject to tsunamis, the Italian company needs a tsunami coverage in order to activate the benefits from the CBI insurance, even if the Italian assets do not need a tsunami coverage.

Following talks with insurance operators, emerged that a big issue for SMEs is that the concepts of business interruption and contingent business interruption are often misunderstood or not emphasize by insurance agents.

Usually this problem is due to different factors:

- It is hard to identify all the components and the variables of the supply chain,

- Entrepreneurs fear of revealing too much information about their company;

- The inherent complexity of the policy becomes an obstacle for insurance agents when they have to offer this kind of coverage to entrepreneurs;

- Lack of risk culture from entrepreneurs (especially for the Italian market).

So also cultural issues are involved, and all around the world the concept of risk can be perceived in many different ways. Moreover it does not exist a “one size policy” for BI and CBI insurance coverage, because no organization is the same.

Basically the task of the risk management is to explain the importance of this coverage and to propose the best solution to mitigate risks , but in order to make a clear and valid assessment, it is needed an instrument that enables to evaluate the main factors affecting the BI and CBI policies.

Moreover the contingent business insurance coverage is subject to several limitations, that must be considered by the buyers.

First of all there is usually a time element or a deductible limitation, for example the coverage for lost income due to an interruption, is activated only after a waiting period or when a deductible is exceeded.

Usually the policy provides the indemnity only for the period beginning 72 hours after the time of the direct physical loss, or in excess of a stated amount of money.

There is also a limited period in which the BI and CBI policies are active, it will be refunded only the losses incurred during a reasonable period of time until the supply chain operations have been fully restored.

Another limitation is the territorial restriction, losses could not be covered if they happened outside a coverage territory of the policy or in some areas with an high exposure to catastrophic risks.

For example after the earthquake and tsunami in Japan happened in March 2011, these hazards became two common policy exclusions for this area. The same is for business disruptions due to a nuclear reaction or radiation contamination.

There are also some important issues to consider while preparing a CBI reclaim after a business interruption. In fact It is often more complex than preparing a BI reclaim, largely because the entrepreneur must assemble all the documentation in order to show the damages to the third parties.

Because of the complex business models developed by many international companies, contingent business interruption losses may occur at a variety of locations, instead the BI reclaim is referred only to the company itself.

For this reason the entrepreneurs have to fully understand the links in their supply chain in order to know what is covered by the CBI policy, this calculation is often a complex analysis that almost always requires the help of risk managers.

Business interruption and contingent business interruption are very sophisticated products, and for this reason are more suited to mature markets and big companies.

But the continuous evolution of the market and the international context in which the SMEs operate have created the need to assess accurately the exposure to risks for all the companies with a complex supply chain, regardless of company size.

In an ideal world, in order to control all the different risk exposures, it would be necessary to have specified in the policy the names of all the operators within the supply chain with also the location of their production plants.

However at the moment this is almost impossible, but insurance companies are moving towards this direction trying to create an effective database with all these data.

The development of global supply chains without any barrier between different states, has created multiple challenges for entrepreneurs and insurance companies [Allianz Risk Pulse 2012].

Certainly it is needed a joint effort. Industries and risk managers have to identify and understand which are the external suppliers with the main impact on the considered organization, and only after this evaluation they can transfer the risk to the insurer.

Insurance companies need to develop new tools in order to provide the right products for the different kind of business, and not only for corporate.

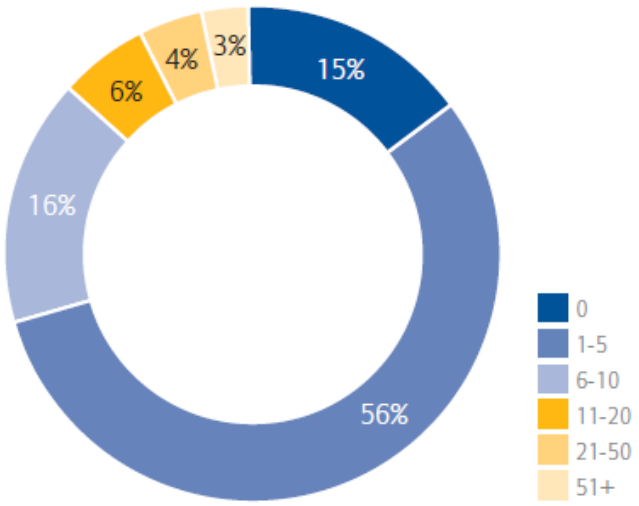
Only with an accurate knowledge of the real risk exposure, they could justify the price of a policy.

3.3 Diffusion and main reasons of business interruption

The UK Business Continuity Institute's 2011 supply chain resilience report has revealed that 85%, of a sample of 559 companies in 62 countries, had experienced at least one disruption during the past year, and the main reason was the adverse weather, cited by 51% [BCI 2011].

Percentage of firms with supply chain interruptions happened in the past 12 months

(0 to 51+ is the number of incidents)



Source: Allianz

They also reported that the disruptions were not easily resolved and they suffered long term problems, creating also a tense atmosphere with the shareholders.

Because of the supply chain disruptions, half of the sample of the survey reported productivity losses, almost 30% of the companies had a drop in revenues, the 38% reported an increase of the costs.

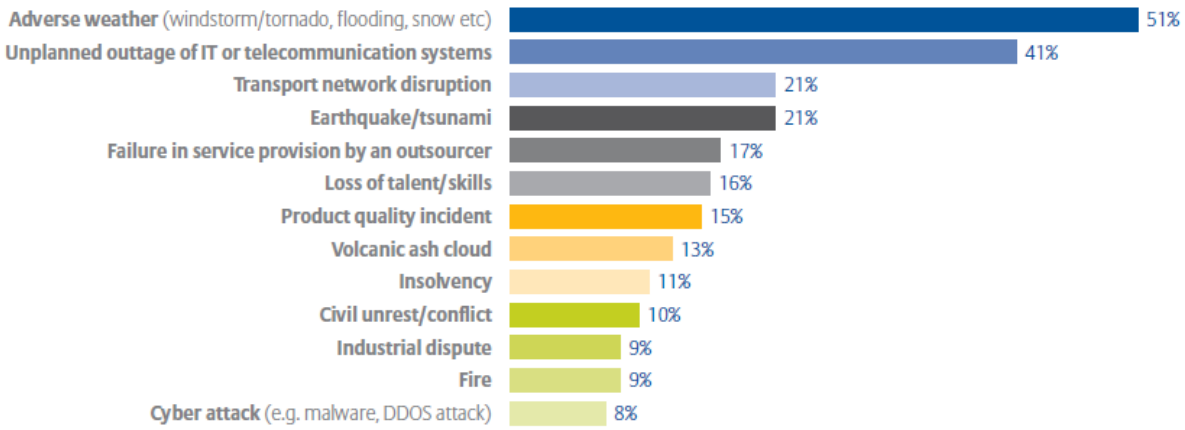
Another research, “The Effect of Supply Chain Disruptions on Long-term Shareholder Value, Profitability, and Share Price Volatility”, made by the Kevin B. Hendricks, points out that supply chain disruptions can be the principal cause of high performance-related costs for many years after the event [Hendricks, Singhal 2005]

In particular, companies, which have sustained a great supply chain disruption, operate at a lower performance level for at least 2 years after the disruptive event.

The studied companies experienced a falling between 33% to 40% of the share values during the period of interruption, and they suffered an average downturns of 30% in returns on sales, a drop of 7% on the sale growth and the costs rise of 11%.

Even if the main reason of business interruption is the adverse weather, it is interesting to know what the other major source of supply chain disruption.

Main reasons of business Interruption



Source : Business Continuity Institute

Essentially BI and CBI insurances cover the net profits that a property, insured by an entrepreneur, loses after that an insured risk damages or destroys a covered property and interrupts the production. Both insurances cover also the business ongoing costs such as wages, building lease or mortgage costs and some other fixed costs.

So BI insurance responds only when the entrepreneur owns the property that is damaged.

Instead CBI insurance responds also when the damaged property is controlled by a supplier or customer that has a strategic position within the supply chain of the company.

The main difference is that in the second loss scenario, the plant of the insured entrepreneur do not have any physical damages.

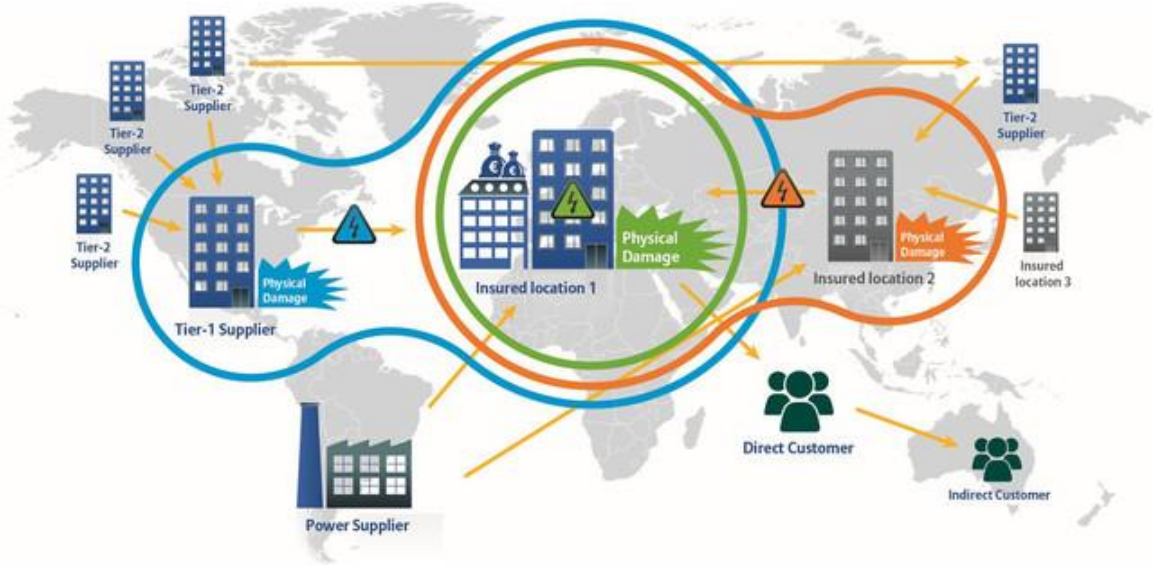
CBI insurance would be triggered because the insured entrepreneur is still forced to slow down the production of his plant because the damaged supplier cannot deliver any raw materials or semi-finished products.

Both insurances provide cover for natural catastrophes such as hurricanes, earthquakes, flooding, so the risk manager have to carefully choose which natural disaster has to insert in the policy.

The insurance policy will be triggered only if the main risk factors, which could affect especially the supplier situated in a country far from the entrepreneur, must be considered also in the policy of the entrepreneur.

In fact natural hazards could be really different according to the different world locations, but in this case the entrepreneur has to consider the main risks of a foreign supplier such as risks of his own company even if they are extremely rare in his territory.

BI and CBI Coverage



Source : AGCS Allianz

In the graph the green and the orange lines represent the BI coverage. The green line covers the loss of income that a business suffers after a physical damage at the same plant.

The orange line stands for the coverage of the loss of income when a direct physical damage loss at one of the insured's facilities disrupts operations at another property of the same owner.

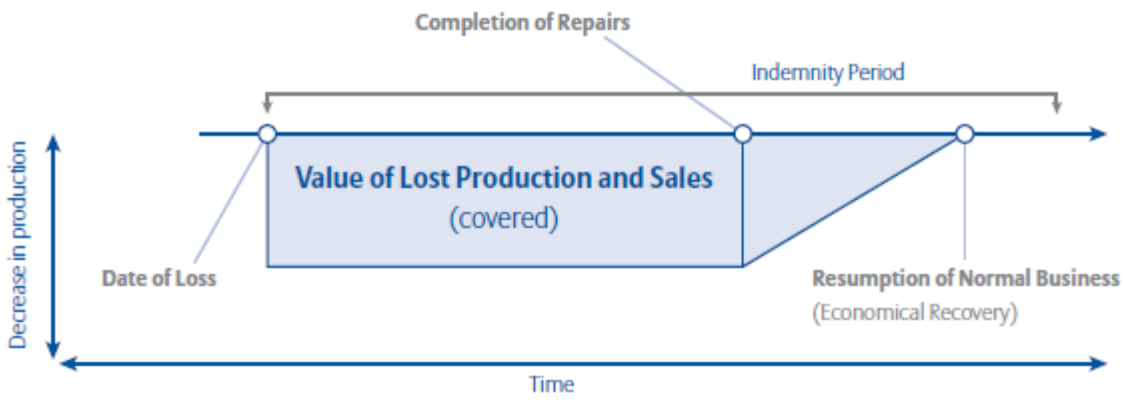
The contingent business insurance instead covers the loss of income of an insured entrepreneur when a supplier or a customer suffers a physical loss creating a disruption to the insured's own business.

3.4 Different kind of BI e CBI policy between Europe and USA

For industrial risks, insurance companies offer risks policies that cover losses caused by hurricane, earthquake, tsunami, flood, fire, plus other additional minor perils, something similar to an all-risk coverage.

In Europe the coverage forms is the gross profits form. So the insurer policy covers the lost profits until the entrepreneur is able to restore its earnings levels near those he had before the catastrophic event.

Gross Profit Form



The period of indemnity is usually agreed between 12 to 36 months, a period in which the production is suspended causing a loss of profits.

If the company recovers its profit levels before the end of the agreed period, the refund is stopped. For the same reason at the end of the agreed indemnity period the refund ends even if the capacity of the company is not restored.

The policyholder have to demonstrate the profit that he would be earning during the indemnity period, considering also the economic changes and the market conditions.

In the USA it is used the gross earnings form, so the insurance company covers lost profits until the damaged facility is completely repaired and operative.

In this case lost profits are covered for an undefined period of time but only until production is fully resumed regardless of the net profits.

Nevertheless it is possible to pay for an extended period of insurance indemnity so the company would be insured until it restored the net profits to the pre-interruption level.

The gross Profit form and the Gross Earning form can be applied to both business interruption and contingent business interruption insurance. Usually CBI insurance has lower limits than the BI policy, so it is restricted by the time that the plant is operational again.

Indeed insurance is a fundamental risk management tool for companies to reduce these negative effects, but taking out an insurance is not the final solution.

The best approach for fighting the supply chain risk is a combination between an adequate coverage and risk prevention techniques.

3.5 Detecting and monitoring the critical risk exposure

A recent research done by of The Supply Chain Risk Leadership Council (SCRLC), composed by risk managers from large manufacturing companies, has pointed out 13 different risks which would threat the future supply chains.

In particular the greatest threats are represented by climate change, globalization , JIT, lean supply chains, increasing social inequity, and the Global capital/economic/banking system disruptions.

All these risks would potentially defeat the supply chains in terms of availability of critical resources, transportation routes and the stability of economies [SCRLC 2013].

Also public authorities could play an important role, spreading risk awareness initiatives and avoiding giving building permits for sites clearly exposed to natural catastrophes.

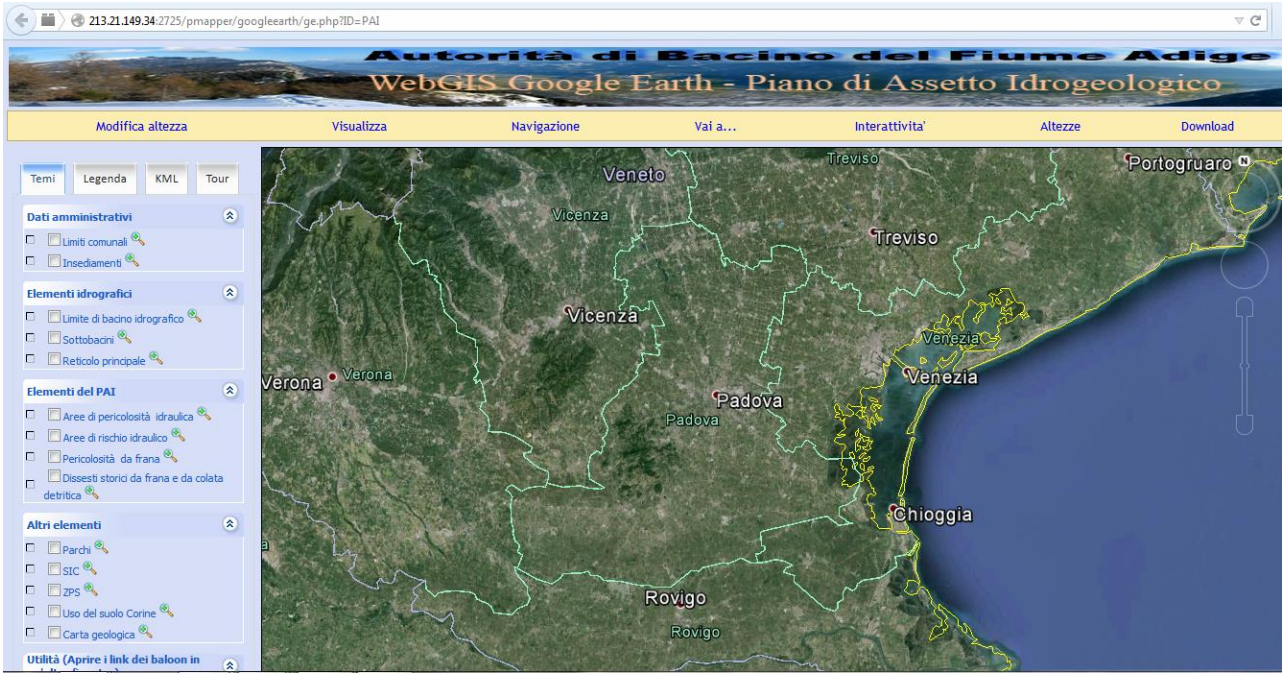
From another side risk managers, insurers and brokers have to carefully map all links and interactions inside the supply chains in order to carefully assess the risks involved, for example trying to diversify the different suppliers.

In particular this can be done through a detailed analysis of the hazard maps available also online.

Public authorities have the duty to improve the maps of the potential hazards in order to give high quality information.

A clear example is given by the data available on the website of the Italian authorities of the river basin district of the Eastern Alps.

Flood Risk Map (Autorità di Bacino del Fiume Adige)



Source : bacino-adige.it

Certainly one of the issues that industry has to faces today is that a lot of countries still do not have high quality information about their exposure to natural hazards.

So it is absolutely necessary to spend more resources, money and time on collecting information about the areas most subjected to catastrophic risks.

An initiative in this direction is the one promoted In January 2012 by the US Department of Homeland Security called "National strategy for global supply chain security", thus recognizing that supply chain disruptions pose a risk not only to the economy but also potentially to national security [United States Federal Government 2012]

After the detection of all the main risks facing a company, the following step is to understand which are the processes to mitigate them, justifying the investments.

First of all is fundamental to establish some alternative suppliers. Having a single source of raw material of semi-finished products could be lethal in case of a long business interruption of that particular supplier.

In some cases it is recommended to invest capital in critical plant or spares, in order to bring core and non-core activities back in house and to maintain a minimum level of strategic stock.

Another crucial step is to monitor the locations of the production sites. Referring to the KPMG report on "Global Manufacturing Outlook Competitive advantage: enhancing supply chain networks for efficiency and innovation report", only 9% of the interviewed companies said that they could have been able to assess the impact of a global business disruptions within some hours [KPMG 2013]

So only 9% of this sample has the competitive advantage to quickly respond to failures within their supply chain.

As shown before, in a world rich of data, there are many information and feeds available online which can help supply chain managers to mitigate the risk of critical suppliers and to make the company more resilient.

This process should be considered a good practice for organizations, but after the first assessment, the cycle has to start again, in fact it is important to reassess all the risks every time that the supply chain landscape is changed.

There are also other events, different from the natural hazard, that can undermine the performance of a company, affecting the business for a long-term period of time.

Now insurance companies are investing on how evaluate the losses due to disruptive events, but there are damages, such as the decline of an investor's confidence in the ability of the company or the resign of key human resources, that are really complicate to assess.

For example the risk associated with the presence of a key-man, who often is critical for the performance of the enterprise, should be calculated and taken into account, trying to quantify the incidence within the performances of the company.

From analysis conducted by insurance experts for SMEs, it emerged that one of the main possible causes of the economic difficulties of a small-medium enterprise are events that prevent the key-man to carry out his activities [ANIA 2012].

In this case in fact, the SMEs must rely on economic resources to satisfy the immediate needs, that are the costs to research and replace the previous key-man and to remain operative the company during the time of transition.

So key-man insurance coverage assumes a big importance for the company, that would become the beneficiary in case of in case of total or partial inability to work of the key figure.

3.6 Ripple effect of the business interruption on the insurance companies

From the insurer's perspective, if there is a strong and qualified Supply Chain Risk Management inside an organization, it is easier to offer optimal insurance policy.

If there is a risk manager inside the organization, the insurance companies have a clearer situation on the company's supply chain, so only the right residual risks would be transferred to the insurer.

There is also the additional advantage of enabling the purchase of all these non-traditional policies. Today these policies are mainly available only for the corporate industry, but the increasing attention that policyholders pay to supply chain risk management is encouraging the insurers to offer BI e CBI coverage also to SMEs.

But insurance companies need more robust data, more transparency between enterprises and insurers, and an active risk management.

The data needed to evaluate the riskiness of the supply chain are the same data that are extremely useful for insurers to ensure a solid capitalization and to better manage the accumulated exposure of the supply chain-related losses.

In fact a natural hazard could hit a lot of policyholders of the same insurance company so they have to be sure to not offer coverages to an excessive number of organizations in the same geographical cluster in order to avoid possible huge losses.

However the transparency of the companies about their supply chain data have positive effects both for insurers and organization. Firstly it gives a clear view to insurers of how a client understands who are the critical suppliers and what risks these suppliers usually face.

In this way it becomes easier to develop an accurate business continuity plan that allows to increase the stability of the company even if a key supplier unexpectedly closes down.

The other reason has a direct impact on the number of insurance that a client should take out.

Insurance company can better answer to the request of the clients that usually receives higher coverage limits, paying an adequate risk premium.

Moreover using a professional quantification method, as the one presented on the following chapter, the indirect damages can become much more straightforward to evaluate and to insure also for SMEs

In a global industrial context, it has become a big challenge to assess the accumulation of risk between different supply chains avoiding huge losses.

3.7 Evolution of the Supply Chain risks

Building resiliency within supply chains. SMEs should consider to re-add some redundancy into the lean and just in time approach that have dominated over the last years.

This could be consider a reversal movement in the world of business, in fact outsourcing has been one of the best and easy way for companies to reduce the costs of production.

Moreover redundancy must be used for constantly testing the business continuity plan, trying to evaluate also the supplier's business continuity plan.

An idea of the model proposed in the next chapter, is to perform a benchmark between the different companies of the same sector with similar supply chain, in order to evaluate the resiliency of your company compared with the other.

Today are emerging new types of risks for the business interruption, but they are not related with damages to properties such as the BI and CBI.

These new forms of coverage are being developed for many perils that usually are not covered but that can shut down a company own operation or a supplier plant, causing a costly supply chain interruptions.

According to a study of the UK BCI's Supply Chain Resilience, these coverages are called non-damage perils and are going to be a huge threat for enterprises, even bigger than natural catastrophes damages.

The manufacturing companies interviewed, declared that information technology, communications systems, transportation network problems and energy scarcity were the threats that must be taken into serious consideration by an insurance standpoint.

These policies, traditionally uninsurable, during the last years have disrupted supply chains, pushing insurance companies to create insurance for these non-damages perils.

The non-damages perils would extend the BI and CBI coverage, developing a new non-damage scenarios, such as utility service interruptions, political risks, labour strikes, insolvency of suppliers and also civil actions.

This has been possible only thanks to multinational corporates that are able to collect these complex data, making something that some years ago was not even considerable.

This evolution is going to be available also for SMEs, and it will give to the risk management the possibility to cover a series of risks previously uninsurable, whereas insurance companies will offer new risk solutions to their clients increasing the value of the insurance market.

CHAPTER 4.

A MODEL FOR THE ESTIMATION OF INDIRECT DAMAGES AND RECOVERY TIME DUE TO BUSINESS INTERRUPTION

4.1 Main reasons for the development of a model for the assessment of the business interruption

In 2014 the number of natural events increased worldwide.

Floods hit United Kingdom from December 2013 to February 2014; then the Balkan area of Bosnia and Herzegovina, Serbia, Croatia, and Romania has been flooded on 13-30 May 2014 and the India - Pakistan area was inundated from 3rd to 15th of September 2014 followed by Philadelphia that experienced the same event on 12 August 2014. Severe storms, i.e., Hurricane Odile hit Mexico on 11-17 September 2014; then France, Germany, Belgium were struck in June 2014; simultaneously Florida experience the same weather induced catastrophe. A major earthquake in China, on August the 3rd, caused millions of economic losses (insured and not). 2014 showed an increased frequency of droughts, one can recall the example of Brazil, of California and Japan.

The cited events of the 2014 caused overall losses of more than 1,500 million $.

Natural catastrophes and more frequent accidents of a smaller magnitude (for example combustion, ruin, etc.), are always threatening businesses.

Risk Management and loss prevention techniques are available to understand and to mitigate the risk coming from these events. Anyway, there are no models to represent the effects of business interruption on productive systems that will enable a holistic multi-perils assessment.

The proposed research will enlighten the downtime of productive systems caused by natural and endogenous hazards, as fire hazard or machine internal damages.

Based on the results of background researches, a model will be used to take into account the effects of flooding, earthquake, tornadoes, and more frequent losses caused by fire, machineries damages and etc.

The proposed framework will allow engineers, building owners, and other stakeholders to manage risk and define performance objectives for individual buildings accordingly. In addition this model won't focus only on individual buildings and structures, but also on the entire building inventory of a community or network systems such as the supply chain of a business.

Certainly post-disaster damages evaluation is really important for a SME but at the same time it is really difficult to perform an assessment truly significant. It is complex because it requires resources and quality information.

Concerning the business restoration, Lindell describes three different time phases in disaster recovery [Lindell 2013].

The first phase is disaster assessment, involving emergency operations and a preliminary damages assessment. Then the short-term recovery starts, consisting in securing impact zone and in establishing conditions to begin recovery process of structures and business. Finally the long-term reconstruction defines the time of entire recovery process considering the whole impact area and all possible aspects (psychological, demographic, economic and political aspects).

Focusing the attention on business recovery, there are two different approaches to the economic impacts of catastrophic disasters affecting businesses:

- An economic approach, based on the analysis of the SME flow process chart and financial and the supply chains subjected to disruptions. It has the purpose of defining and assessing business strategies in order to mitigate management aspects of the company related to disaster risks.

- An Engineering approach, based on the analysis of correlations between disaster characteristics and their impact on business process. The aim is to estimating economic losses, recovery cost and indirect damages of business system.

Following an engineering approach, the proposed model evaluates a recovery time in which are included losses and costs that must be supported by the company to fully recover the productivity of the business.

Moreover, even if the objective does not consist in formulating a business strategy analysis, the identification of the flow process chart of a company provides additional information for the entrepreneur in order to mitigate the risks of his business.

The benefits of the model will give positive consequences not only to local SMEs, but in future it can also be applied at a corporate level.

4.2 The objectives of the model

The present research shows a method to evaluate and analyse the possible restoration scenarios after catastrophic events. The restoration scenario is defined by the time in which businesses can return to their full pre-disaster functionality level.

The recovery time is necessarily correlated to the amount of damages caused by a specific event

The aims of the study are:

- Considering how buildings and facilities influence the restoration process;
- Assessing an average restoration scenario for the production system.

The most common software for damage loss estimation, calculate a restoration assessment for the single components and then they consider the final damage of a business only as the sum of the damages of the components.

However in this model, the damages of a plant take into account the propagation of the damages between the components within the production process and the supply chain.

This is possible only through a disaggregation of the system single units and the development of a flow chart that simulates the real process of the business.

Moreover, through a probabilistic sampling with definition of an average recovery scenario, the model reduces the uncertainties and improves the reliability of the simulated recovery processes.

An important assumption is the consideration of only direct damages, without considering for example the social indirect damages. This model has been tested on a SME producing lifts and benches, for the reason that the manufacturing of machineries is one of the most developed industries in Italy.

The production has a well-defined process and in general presents some necessary production steps which are common to different machineries.

Moreover starting from a basic manufacturing model it is possible to implement the method on other cases.

Machineries are highly vulnerable to catastrophic events, In fact the damages to productive components could mean a critical loss for the SME.

The big advantage of this model is the modular framework that can be applied for different industry typology, the input are the parameters related to the catastrophic event and the definition of the flow process chart of the company. Moreover it can be applied also to different supply chains using the single units like a single operator of a supply chain.

4.3 Indirect losses and business damages

Proposed Risk Matrix : it has been developed a matrix to represent the most critical risks for business continuity.

Element	Event	Earthquake	Flooding	Tornado	Fire
Building		Is lightweight or heavy building? - Masonry type (bricks before 1960) - Concrete (precast concrete with tilt-up walls or with columns and beams) - Steel (steel frame structures including those with infills walls or concreate shear walls) - Wood (new trend)	What is the level of the buildings? The main variables are the water height, speed, and for how long a building remains flooded. - Building location (flood zone designation) - Building age (pre-FIRM or post-FIRM) - Lowest floor location (above adjacent grade) - Foundation system - Building materials found below flood level	Has the roofing uplift strength? - Roofing is lightweight and not well bounded with the sub-structure. - The effects of a tornado are negligible for masonry and concrete, while the wooden structure is more likely to be damaged.	Is the structure flammable? What's the resistance? What's the fire insulation? - thermal shock - corrosion - degradation - combustions
Machinery (short - long)		- Misalignment of the productive line (especially for long machinery ex. ceramics industry). - problems of accuracy and tolerance - breakages mechanical systems	- level of the water. - hard to replace/repair - infiltration - broken hydraulic - fresh or salt water - mud - humidity - sediments - corrosion - degradation	Uncovered roof means that rain could ruin the machineries causing corrosion and degradation	High impact damages (time of replacement)
Warehouse		Materials/Goods damaged after falling from shelves. Automated warehouse can be damaged.	Damages depend on the level of the water. Automated warehouse.	Materials and goods can be ruined by rain in case of an uncovered roof	Highly flammable goods/material
IT		Various kind of damages	Risk of short circuit	Electric components ruined by atmospheric events	High impact damages

Referring to buildings, they come in different materials from the most common concrete to the emerging trend of wood.

The typical productive building in Italy is made of concrete, usually is precast concrete with tilt-up walls or with columns and beams. The precast building changes its behaviour according to the design code and earthquake prescription provided by the code. The second most common building material used to erect productive buildings is steel. Steel is a lightweight material, the most common causes of failure is rain over snow. The water is trapped inside snow increasing its specific weight and causing the collapse, usually for buckling of unrestrained columns or bracings.

Light buildings, like the steel ones, are frequently damaged by tornadoes. The roofing is lightweight itself made of corrugated metal steel, with a layer of thermal insulation and a finishing on the inside of the building.

Buildings can be made of bricks and mortar, the masonry type, this type of building is a typical construction system before 1960s. Bricks buildings are heavy structures, this implies that earthquake is a severe action, while floods are affecting this type only is the speed of water stream is above a specific threshold. Tornados are not directly affecting this type of building, unless the roofing is lightweight and not well bounded with the sub-structure. Roofing structure can be made of masonry, concrete, or wood. The effects of a tornado are negligible for masonry and concrete, while the wooden structure is more likely to be damaged.

Table 5.1 Model Building Types

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1	Wood	Wood (light frame and commercial and industrial)		All	1 to 2	14 to 24
2	Steel	Steel frame structures including those with infill walls or concrete shear walls	Low-rise Mid-rise High-rise	1-3 4-7 8+	2 5 13	24 60 156
3	Concrete	Concrete frame or shear wall structures including tilt-up, precast, and infill walls	Low-rise Mid-rise High-rise	1-3 4-7 8+	2 5 12	20 50 120
4	Masonry	All structures with masonry bearing walls	Low-rise Mid-rise High-rise	1-3 4-7 8+	2 5 12	20 50 120
5	MH	Mobile Homes		All	1	10

The problem of business damage is complex due to the very inter-related nature of economic processes.

Business damage contributes to the definition of risk because it's the main component of indirect losses. The main theory behind economic loss modelling is the equilibrium between supply and demand.

Direct damage to properties and pre-event economic conditions (unemployment rate, import-export balance, the shape of the economic system) are the main feature of the problem.

The possible funding by state after a catastrophic event can condition the process.

It is well known a catastrophic event can cause effects also on unaffected economic sectors due to business relations increasing the effect known as "ripple effect".

All businesses are known to be both forward linked and backward linked. The forward link represents the businesses need to sell their product, the demand can come from the affected region or outside.

4.4 Evaluation of the risk

The two main aspects for the estimation of the disaster recovery are the definition of damages extent and consequent restoration process behaviour. They could be obtained considering the disaster risk for a system. Jelinek and Kraussman proposed a general definition of risk corresponding to the product between hazard, vulnerability and exposure [Jelinek, Krausmann2008].

$$R = H \times V \times E$$

where:

R is the Risk,

H represents Hazard (different type of catastrophic events),

V is Vulnerability due to the level of the hazard, in general terms V(H),

E is the economic value of exposed goods, namely Exposure, in general terms E(V,H).

The only independent variable is the hazard, it describes the probability that a disaster of a specific intensity happens in a given area for a given return time.

So considering a system with some default characteristics, it is possible to evaluate its vulnerability and consequently the exposed value. Damage assessment and recovery process are based on vulnerability of system components.

Considering a damaged component, from a certain starting intensity measure of a disruptive event, according to hazard probability, it is possible to assess the level of damage through the definition of different damage states. Each damage state defines a correspondent loss of functionality. Each loss of functionality of a plant and its facilities involve in:

- A correspondent repair cost. It depends from extent damage and characteristics of the plant and allows to calculate the disaster economic impact for the system regarding only direct damages.

- A correspondent restoration time. It is considered as a hiding cost and is characterized by multiple factors. It is the variable of this model, an many factors influence it.

The steps previouly described can be implemented following a similar framework method to the one suggested by PEER's approach, a performance based approach to the problem of earthquake analysis, developed by Porter [Porter 2003]. The framework of this method can be developed also for a loss analysis caused by a flood disaster, changing variables and using those for flood provided by Hazus. Porter considered four different steps, starting from the hazard analysis, damage extent is obtained through structural response. Then, knowing structure damage states, is possible to assess the decision variable. Analytically the model can be exposed as:

$$g[DV|D] = \int\int\int p[DV|DM, D]p[DM|EDP, D]p[EDP|IM, D]dIMdEDPdDM$$

Where:

g[X|Y] refers to the occurrence frequency of X given Y;

p[X|Y] refers to the probability density of X conditioned on knowledge of Y;

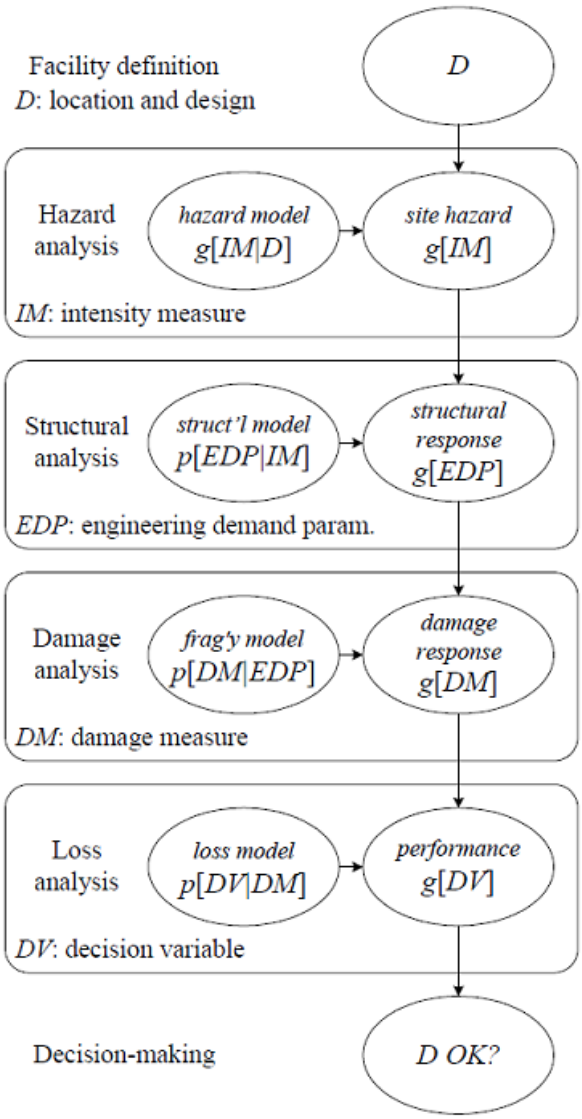
DV is Decision Variable;

DM is Damage Measure;

EDP is an Engineering Demand Parameter;

IM is the Intensity Measure of the catastrophic event.

Porter's maker decision framework



Source : Porter 2003

To implement a similar conceptual approach, it is possible to personalise each step using several assessment methods and existing tools in engineering literature. Concerning a business system risk, among the most valuable methodologies to assess damages and recovery time, for this model have been used some methods derived from ATC13 and HAZUS approaches.

4.5 ATC-13, ATC-45 and Hazus

The ATC-13 (earthquake) and the ATC-45 (wind storms and floods) methodologies, edited by the Applied Technology Council (ATC), were commissioned by FEMA (the Federal Emergency Management Agency) [ATC-13 1985] [ATC-45 2004]. Due to the lack of loss and inventory data in the literature, ATC established an advisory project composed of specialists to define the necessary input to use for loss assessment .

Besides the methodology for earthquake damage and loss estimates and inventory information, the final report made by the specialists contained also estimates of the recovery time for many facilities and structures classes. This estimate method is a simulation model known as FEMA Earthquake Damage and Loss Estimation System (FEDLOSS).

The model employs a modular structure to ensure a major flexibility using different kinds of data. Model inputs are facility earthquake damage and loss estimates and it is characterized by the cross matching between the economic sector facility data (facility types) and structure inventory data (structure types). FEDLOSS allows the calculation of:

- Expected physical damage caused by the natural disaster;
- Expected losses from collateral hazard.
- Expected percentage of loss of function or usability and time required to restore the facility to its pre-damage usability;
- Expected percentage of population killed and injured.

Considering damage assessment for earthquake, the estimates of percent physical damage caused by ground shaking are expressed through correspondent damage states defined as showed in table.

With this damages classification is possible defines damage probability and calculate expected economic losses for the considered facilities.

ATC damage states for earthquake

Damage state		Damage Factor Range (%)	Central Damage Factor (%)
1	None	0	0
2	Slight	0 - 1	0,5
3	Light	1 - 10	5
4	Moderate	10 - 30	20
5	Heavy	30 - 60	45
6	Major	60 - 100	80
7	Destroyed	100	100

Source : ATC

Instead for flood damages, the ATC-45 establishes Post-Flood Evaluation Criteria for three building posting categories: Inspected, Restricted Use, and Unsafe.

Additionally, the Council has established six categories of building evaluation criteria: Overall Damage, Vertical Load Carrying System, Lateral Load Carrying System, Column movement-magnification due to eccentricity, Degradation of the Structural System, and finally Erosion, Sedimentation, Slope, or Foundation Distress.

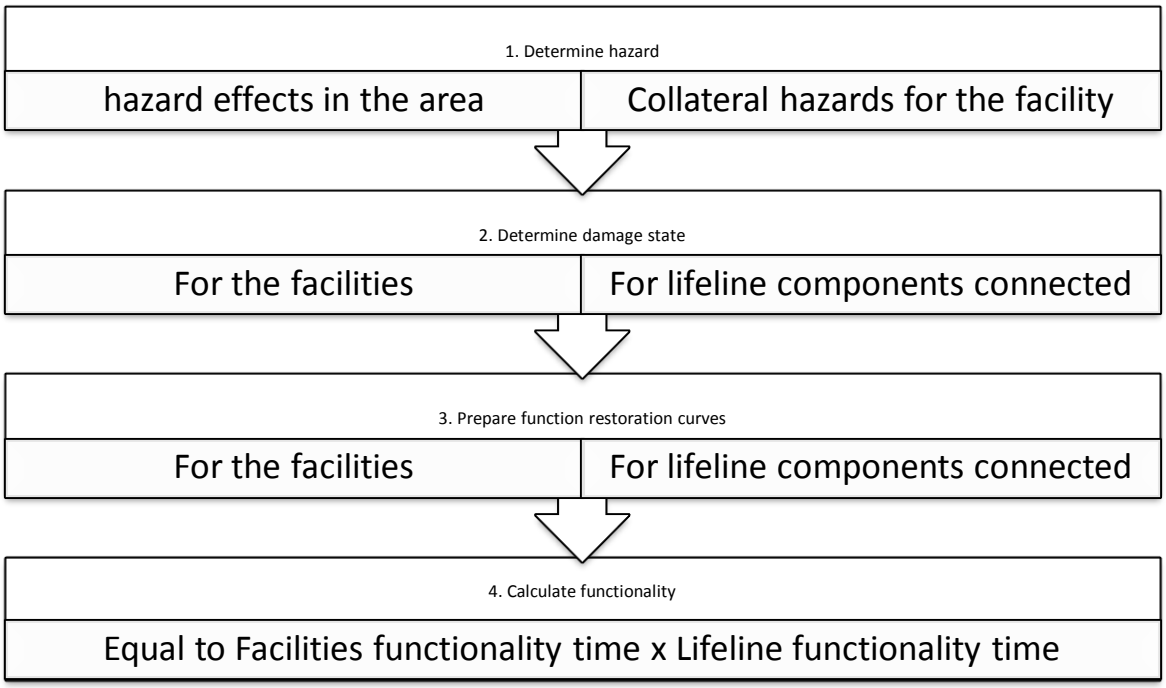
The other interesting point developed by this engineer application is the loss of function and restoration time estimates. These variables are directly related to direct damage to the individual facility and direct damage to lifelines on which the facility depends.

Impact of lifeline failures on loss of function on particular facilities largely depends on damage extent of lifelines components.

An important assumption is the consideration of only on-site effects, such as damage to the structure, damage to the equipment necessary for the operation of the facility and loss of on-site utilities.

Resulting weighted-mean restoration times for each facility class are computed for each damage-factor level and each restoration level considered. The ATC process used to obtain and calculate functionality of facility during restoration time can be schematized as in the figure below:

ATC methodology framework.



Source : ATC

HAZUS software can be thought as the ATC method evolution [HAZUS 2003].

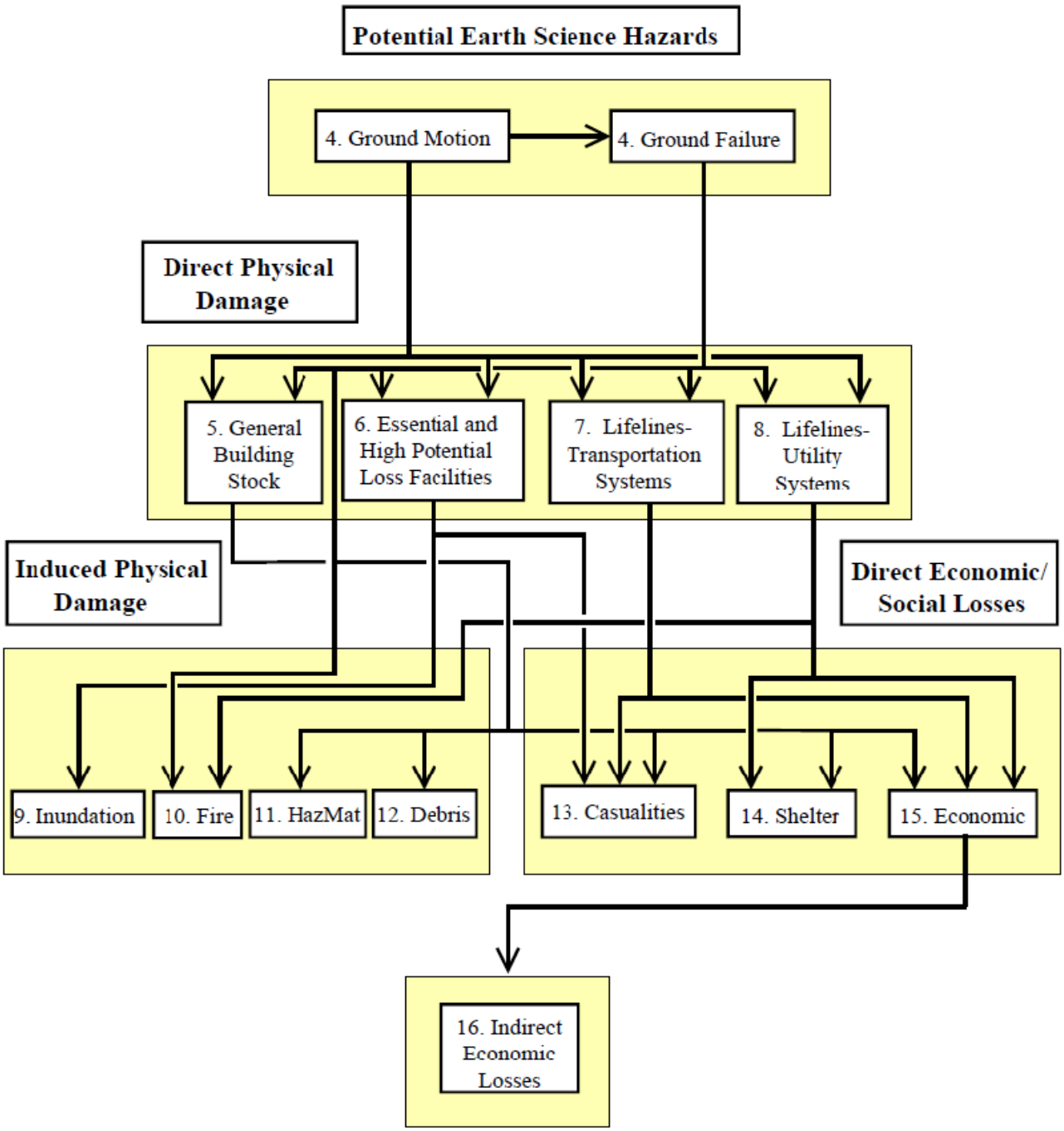
It has been developed from FEMA and built with a Geographical Implementation System (GIS) technology, this commercial off-the-shelf loss and risk assessment software package, was released for the first time in 1997.

Effected by an updating process, later versions of the software were released. Actually, HAZUS is define as a multi hazard (MH) modelling software, since it can model different types of hazard (flooding, hurricane, coastal surge and earthquake).

Considering the performing earthquake loss estimation, it's conceived for regional estimates to plan and simulate efforts to mitigate risk and to prepare emergency response and recovery. Earthquake loss estimation methodology presents a modular framework to facilitate model improvement adding or modifying individual modules.

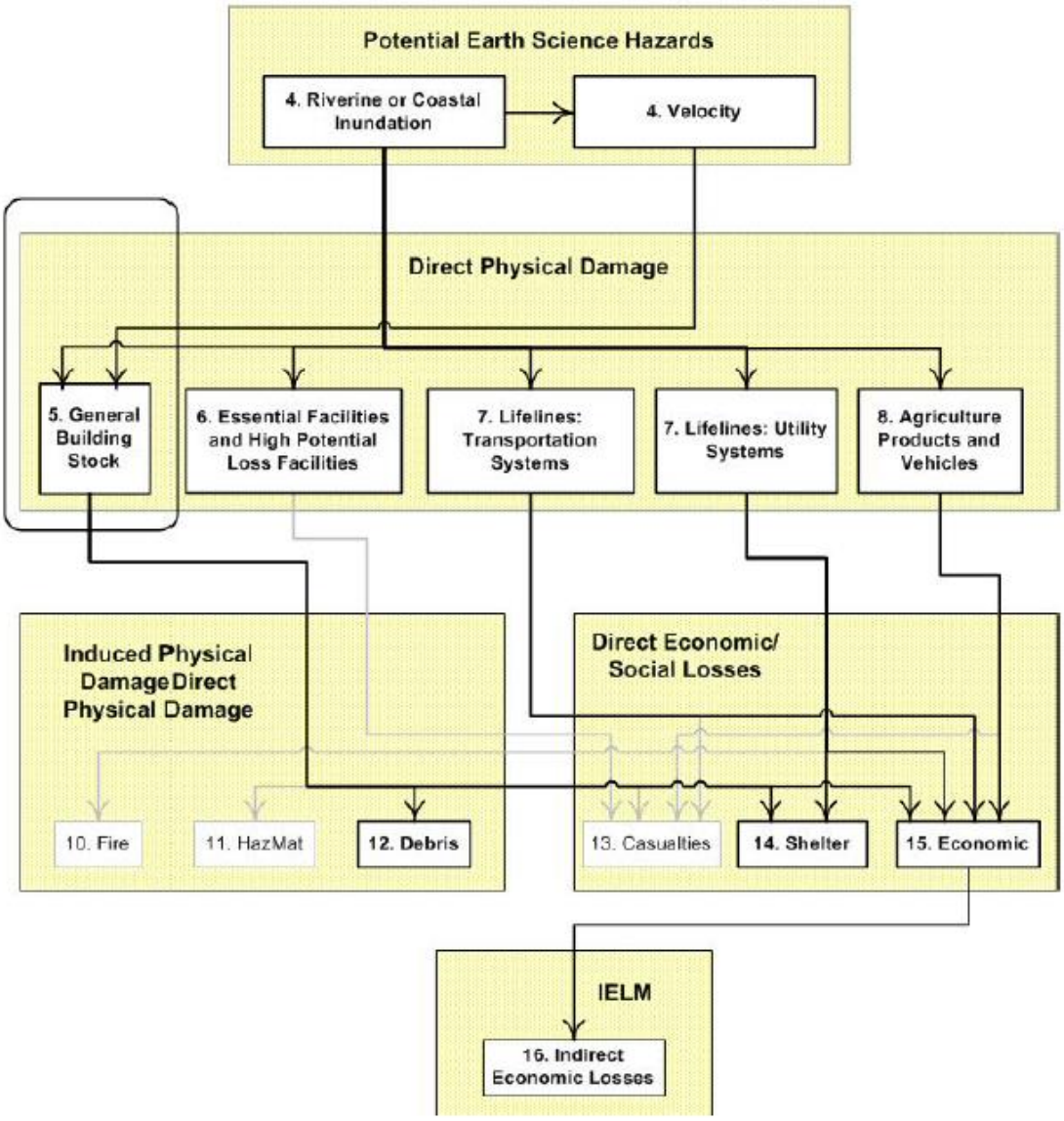
This approach consents a logical evolution of the methodology as research progresses and the possibility for software users to limit their studies to selected losses. For example, although this methodology was implemented for North America territory, HAZUS toolset has been adopted by emergency management organization worldwide such as Singapore, Canada, Australia and Pakistan, thanks to its reliability and the possibility to modified input data and modules aspects depending on region study characteristics. HAZUS methodology framework is represented in the figure below:

HAZUS methodology framework for earthquake



Source : ATC-13

HAZUS methodology framework for flood



Source : ATC 45

This methodology permits many kind of analysis, among which:

- Describing damage states;
- Developing building damage functions;
- Grouping, ranking and analysing lifeline systems.

Damage functions, defined according to a probabilistic approach, allow to assess structure damages extent, correlating the hazard intensity to a correspondent structural damage state.

HAZUS implement two types of damage functions, namely fragility curves and capacity curves. Those are characterized by the typology of structure or system and the intensity measure of the ground motion considered as input. The model, differently from ATC, considers different damage states.

HAZUS provides damage functions for a great number buildings and lifeline systems, accurately classified.

Finally, the model analyses also non-structural components for each building typology. Once the damage state has been obtained, is possible to evaluate direct and indirect losses using several analytical methods provided by the model.

The definition of restoration time isn't a primary object for HAZUS software.

To assess the recovery process, the model develop probabilistic functions, namely restoration curves, using ATC methodology previous described. These functions are provided only for lifelines components and transportation systems in order to optimize building monetary losses estimate. In fact, this is calculated as the sum between:

- Monetary losses due to building damage: it considers cost of repairing or replacing damaged buildings and their contents;
- Monetary losses resulting from building damage and closure: it considers losses due to business interruption.

4.6 Methodology and framework of the model

The calculation of restoration scenarios for a system, starting from hazard earthquake variable, requests the definition of several steps and correspondent variables.

In the model development, different methods and methodologies have been used, according to model purpose and analysed system typology. However, there is the possibility to implement the model in several industry sectors exists, in fact the model is illustrated with a general approach, remarking that the research is more focused on the model explanation and analysis than on the results interpretation.

Essentially, the method is based on the correlation between an intensity value of the catastrophic event impacting on the system and the correspondent restoration time for the system.

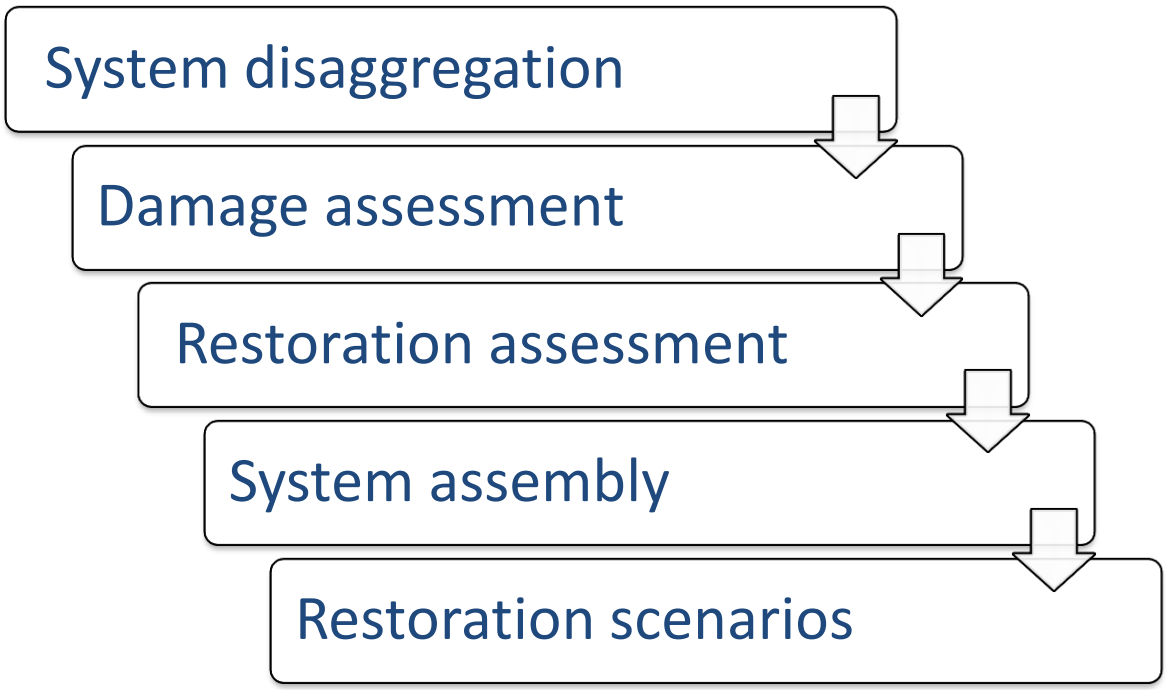
It is useful to remember that the probability that a hazard occurs in a specific area is given by risk maps available at the international level.

So the correlation is obtained through some intermediate phases which can be handled as separated modules. The analysis of the module is repeated several times, depending on the number of components of the system.

In fact the most interesting characteristic of this method is the disaggregation of the system analysed in individual and separated components in order to better define the recovery process relatively to the type of SMEs.

Initially damages and restoration analysis are implemented for each system component. At a later stage components are assembled into the flow process chart, matching the several restoration analysis and considering the mutual influence between components to determinate the final system restoration scenario. The steps of the model are:

- Disaggregation of the system in components vulnerable to the event: this first step involves the definition of some “elementary” components which compose the process system;
- Assessment of components damages: for each component, the damages extent is calculated through the use of fragility functions;
- Assessment of components restoration process: for each component restoration process is calculated through the use of restoration functions;
- Assembly of the components into the system analysed: components restoration functions are aggregated using a process diagram flow into the system;
- Definition of system restoration scenario: it is the output of the diagram flow and the final result providing a possible recovery time.



Fragility and restoration functions are probabilistic functions specific for each component. Fragility curves, which relate to the event intensity measure in input with a correspondent damage state in output considering the structural fragility, are implemented as fragility functions.

Restoration curves, which define restoration time, given as input the damage states (obtained from fragility curves) and additional recovery characteristics, are used as restoration functions.

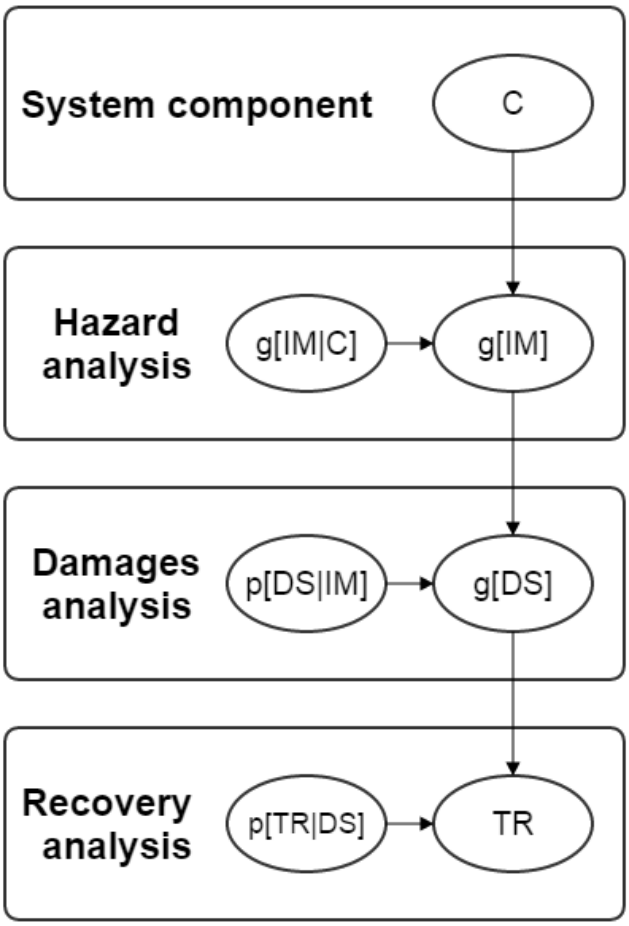
Moreover the parameters of components restoration curves are used in a diagram system flow to simulate the productive process of a company, obtaining the restoration scenario system.

Finally, using a probabilistic sampling method, it is possible to define an average restoration scenario for the whole system.

For a single component (C), each framework step involves a different variable analysis. The starting hazard variable, correspondent to the intensity measure (IM), is transformed progressively in equivalent damage state (DS), loss of functionality and restoration time (TR).

The figure below shows a model conceptual scheme similar to the one developed from Porter's maker decision framework. The reference suggest the possibility to use the present model also as a decision maker, since it is possible identify the most problematic components of the system restoration and to make the appropriate decisions.

Porter's maker decision framework



Source : Porter 2003

It is important to remind that, even if scientific literature presents several methods similar to the present model, they are usually oriented to evaluate specific study cases, without a general connotation and economic process losses, without a deeply restoration process assessment.

In the sections below are described the methods used for model steps.

4.7 Disaggregation in vulnerable components

The first step of the analysis system model requests the definition of the system process steps and the identification of the vulnerable seismic components. While the characterizations of system processes strictly depend on business typology, the identification of vulnerable components for seismic analysis presents some general characteristics:

- **Component size**. Since it is unfeasible considered as vulnerable component each single machinery or specific elements into a system process, a vulnerable component can be intended as a single process elements or as a combination of several process elements, depending on available damage dataset.
- **Involvement level into the process.** In a simplified analysis, it makes sense considering only the main elements of the process which are not immediately replaceable.
- **Level of vulnerability.** A component is vulnerable to a catastrophic event if it is subjected to damages which can compromise its functionality.

It is important to remark that a process system corresponds to an industry manufacturing process which describes the transformation of basic components in a final product. In fact, potentially the model could be applicable also to whole supply chains, even if, in this case, the model analysis would require the definition of two different levels of vulnerable components, one referring to each process system and one referring to all supply chains business and connection structures between them.

4.8 Damage assessment : fragility curves for the structure

Components damage assessment gives an idea of the power of the event and its direct impact on the process. Literature provides innumerable methods to evaluate damages, in the present research has been used a probabilistic approach to assess the damages, through the implementation of fragility functions.

These functions describe the structure (or component) response to the earthquake or a flood directly correlating the intensity measure with the correspondent possible damage state of the structure. As fragility functions, fragility curves have been used.

In order to describe fragility curves, firstly it is necessary to define some damage states connected to them. Damage states are described using a performance scale of damage level in ascending order of size, which defines the extent and severity of functionality losses. There are different approaches, for example following the HAZUS approach for the earthquake, it is possible to define 5 damage states:

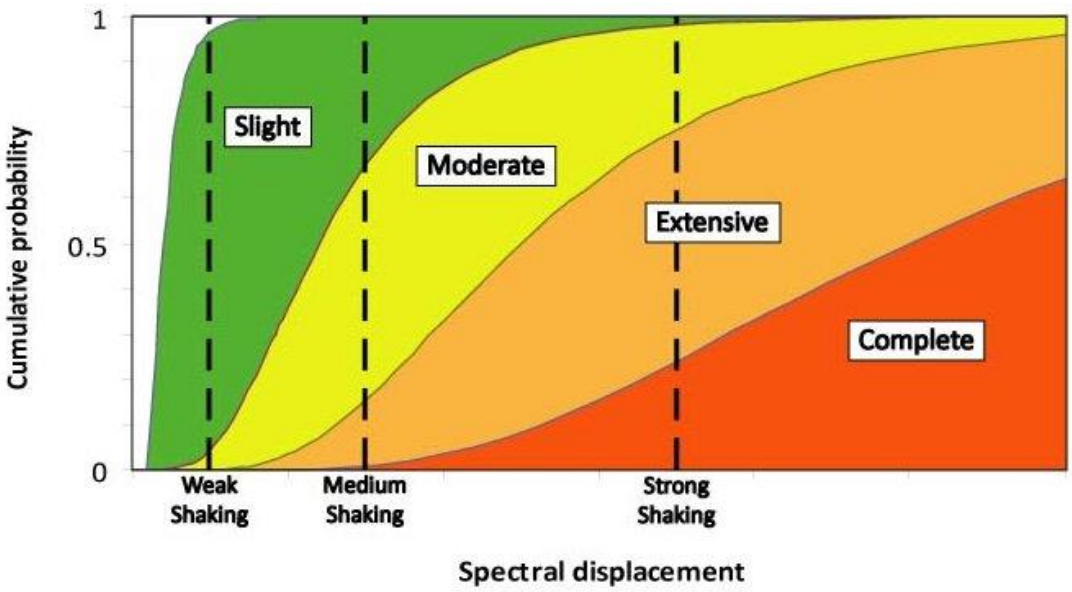
- None
- Slight
- Moderate
- Extensive
- Complete

Each of these levels describes the entity of physic earthquake damages on the structure, from the absence of injuries (None) to the collapse (Complete). Obviously, damage states descriptions changes depending on analysed component characteristics.

Regarding the flood state of damages, there is an approached based on the level of vulnerability of the facility. In this case there are 4 states : none, low, medium and high.

To estimate the damage state reached by the components, fragility curves have been developed. Fragility curves describe the probability of reaching or exceeding different state of damage, given an earthquake intensity measure. In other words, these fragility functions define boundaries between damage states. Their implementation can be obtained in an empirical or in analytical way.

Example of a Fragility curves regarding and earthquake



Source : ATC

Analytical fragility curves are developed by modelling vulnerable elements of structure in order to find the intensity measure of each damage state, simulating numerically the seismic response. On the other hand, there are empirical fragility curves, which are directly calculated using damages dataset of real catastrophic event.

An analytical approach permits to obtain best results but at the same time it requests a high calculation resources and a perfect knowledge of the specific characteristics of structures and mechanical behaviour of materials.

Moreover, their computation does not request great amounts of information and resources. Empirical curves can be evaluated in different ways, depending on size and characteristics of available database.

Porter, describe the most common procedures for creating fragility functions using various kinds of data, ascertaining the possibility to obtain them also from small or incomplete database.

Certainly, the greatest weakness of the empirical approach is the characterization of fragility curves using particular database of specific events, invalidating their application to other environment, with really different conditions.

Acknowledging the features of both approaches, for the purpose of this research empirical fragility curves have been obtained, because of the lack of real studio cases and the necessity of easy and quick calculation.

Probabilistic fragility curves can be fitted by log-normal cumulative distribution. In this case, they are represented by the formula [FEMA 1999] :

$$P\left[ds \middle| IM\right] = \Phi\left[\frac{1}{\beta_{ds}} \ln\left(\frac{IM}{\overline{IM}_{d,ds}}\right)\right]$$

Where:

Ds	damage state;
IM	intensity measure;
β_{ds}	is the standard deviation of lognormal distribution;
Φ	is the standard cumulative log-normal distribution function;
$\overline{IM}_{d,ds}$	is the IM that defines the mean value of each damage state;

Each fragility curve corresponds to a probability density function related to its correspondent damage state threshold. Intensity Measure is identify by peak building response, usually Peak Ground Acceleration (PGA) for earthquake or the level of the water in case of floods.

4.9 Damage assessment : fragility curves for the components

Considering the business processes analysis, fragility functions have been calculated using the available database for the components considered.

To develop machinery and exposed building fragility functions, curves parameters (means and lognormal standard deviations) provided by HAZUS have been used.

Regarding non-structural components, HAZUS distinguish different categories of elements. Each of these categories contains different non-structural elements. Moreover, non-structural damages are considered to be independent of the structural model building types. Hence, non-structural statistical medians are the same for each building type, while β values are slightly different for each building type, since the log-normal standard deviation is the sum of different standard deviations among which some related to building types response.

List of typical non-structural components and contents of buildings

Type	Item	Drift-Sensitive*	Acceleration-Sensitive*
Architectural	Nonbearing Walls/Partitions	•	◦
	Cantilever Elements and Parapets		•
	Exterior Wall Panels	•	◦
	Veneer and Finishes	•	◦
	Penthouses	•	
	Racks and Cabinets		•
	Access Floors		•
	Appendages and Ornaments		•
Mechanical and Electrical	General Mechanical (boilers, etc.)		•
	Manufacturing and Process Machinery		•
	Piping Systems	◦	•
	Storage Tanks and Spheres		•
	HVAC Systems (chillers, ductwork, etc.)	◦	•
	Elevators	◦	•
	Trussed Towers		•
	General Electrical (switchgear, ducts, etc.)	◦	•
	Lighting Fixtures		•
Contents	File Cabinets, Bookcases, etc.		•
	Office Equipment and Furnishings		•
	Computer/Communication Equipment		•
	Nonpermanent Manufacturing Equipment		•
	Manufacturing/Storage Inventory		•
	Art and other Valuable Objects		•

Source : Hazus

According to machinery component described in the table, two non-structural categories have been considered, both acceleration-sensitive:

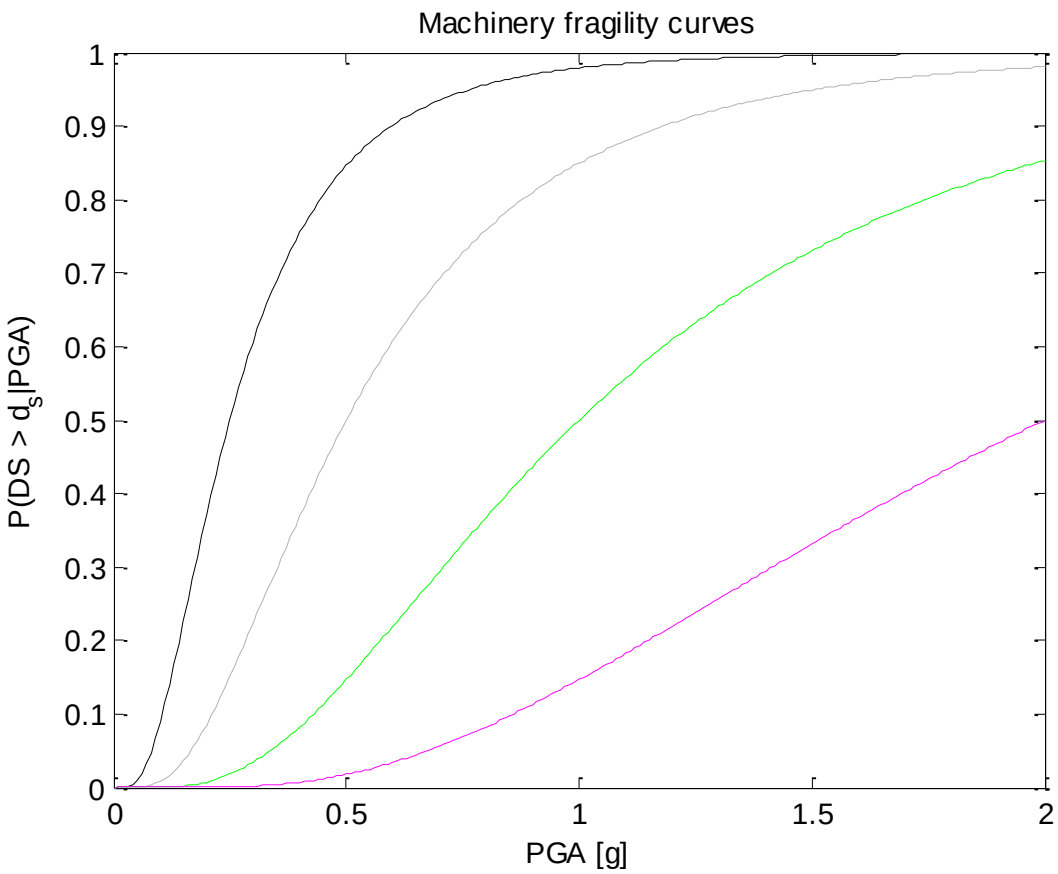
- **Manufacturing and process machinery**, represent the whole of internal machineries;
- **Manufacturing/storage inventory,** represent the whole of storage structures;

Below are showed fragility curves and correspondent parameters .

Fragility curves parameters for machinery.

Internal Machinery and Storage		
Type	*IM*	*Seismic Design*
Non Structural Acceleration-Sensitive - PC1	PGA	Moderate
Damage State	*μ*	*β*
Slight	0,25	0,68
Moderate	0,50	0,67
Extensive	1,00	0,66
Complete	2,00	0,66

Source : Hazus



Source : Hazus

4.10 Components restoration assessment through restoration curves

Once components damage states are defined, it is possible to assess the corresponding recovery time. Unlike damage assessment, it is hard to find some methodologies for restoration estimating, since generally this is considered as a secondary factor when evaluating the economic impact of a catastrophic event.

The best approach consists on using a probabilistic approach for the restoration functions.

In particular for a single component, restoration function is dependent on:

- Degree of damage;
- Importance of the component in post-event recovery;
- The availability of manpower and resources for restoration or reconstruction;
- The availability of supplies, replacement parts, and services.

Because of the general lack and high peculiarity of these information, restoration functions evaluation is difficult and full of approximations. Similarly to fragility functions development, recovery functions can be evaluated in an analytical or an empirical way.

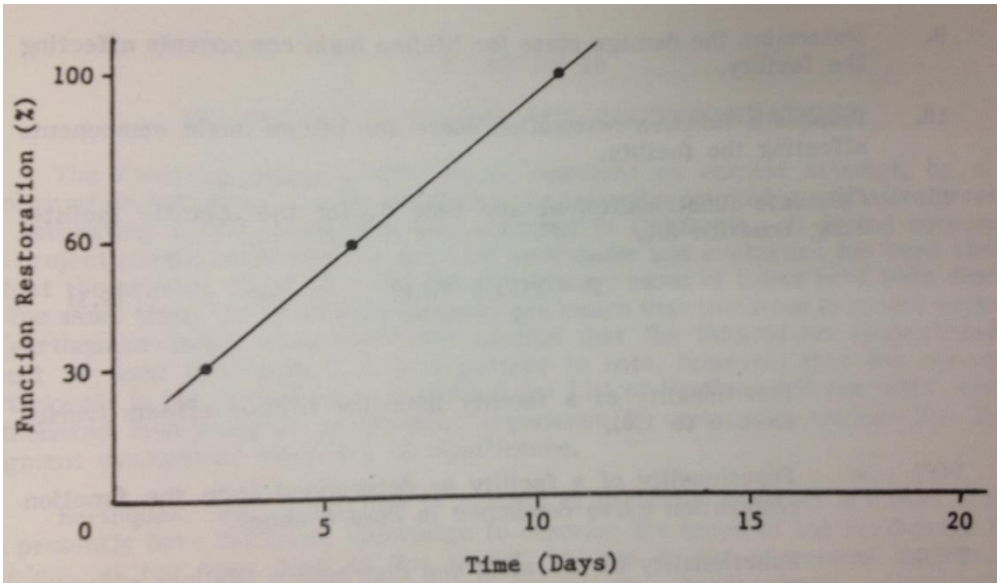
In this model , as restoration functions of a company components, some recovery curves have been implemented. They relate the component residual functionality to a correspondent recovery time function.

The component residual functionality depends on the component damage state, obtained with fragility curves.

Basically, a restoration curve expresses the time required for restoring function at a given component to the pre-event level.

It is defined by the restoration day number and the percentage of component functionality. Restoration curves follow the ATC 13 approach.

Example of a linear restoration curve



The ATC methodology presents a method to create empirical restoration functions and it provides probabilistic parameters to develop restoration curves for different social classes of facility functions.

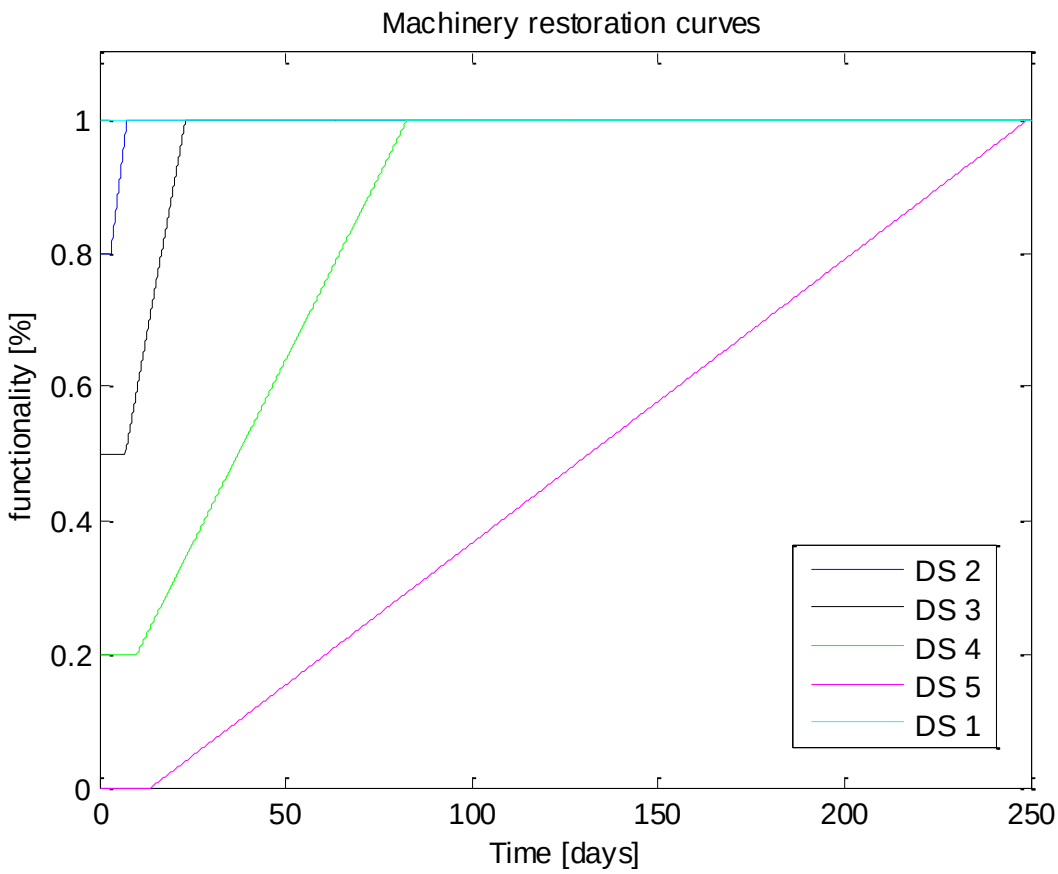
This methodology provides means and standard deviations expressed as restoration day number, obtained through weighted opinions of a board of seismic engineering experts. ATC restoration curves used in this framework are based on some assumptions:

- Component damage state describes the state of direct damage and service lifeline damage to the facility;
- Unlimited resources are available for reconstruction;
- The time to restore function at a component includes restoration of all factors critical to that component;
- Restoration curves are developed with linear functions.

Restoration curves parameters for machinery

Internal Machinery and Storage		
Social class	Processing	
Damage State	*μ (days)*	*β*
Slight - DS2	4,40	5,30
Moderate - DS3	16,10	14,40
Extensive - DS4	72,70	63,90
Complete - DS5	235,60	115,20

Source : Hazus



Source : Hazus

4.11 System assembly and flow process chart

System assembly is the most important step of the model. In fact, it allows to sum the restoration time of each component, obtaining the final system restoration scenario.

This part of the process deeply depends on the system structure and its own characteristics. In fact, this step simulates the productive process, which can be developed through a flow process chart that helps the entrepreneur.

Flow diagram allows to consider, within the restoration process, the effects given by the components position inside the process and the connection typology between components.

Generally a flow process chart diagram is commonly used to indicate the general flow of plant processes and equipment. But it displays only the relationship between major equipment of a plant facility and does not show minor system details.

In this model, the use of the flow process chart allows to simulate the business process and to quantify the loss of functionality along the system. The resulting restoration scenario depends on the whole components behaviour. In particular, concerning possible connection typology between components, is possible define two categories:

- **In series components**. In this case the loss of functionality of the former components affects directly the functionality of the other components. If only one component collapse, the whole process stops. Therefore the restoration process is strictly affected by the most vulnerable component;
- **Parallel components**. Loss of functionality of components in parallel does not affect the other components which results uncorrelated. This involves a faster restoration scenario since it is possible to reallocate flow of damaged components in other.

Mutual influence between components affects also the shape of output restoration scenario, which could assume also a curve or a mixed behaviour.

4.12 Model implementation: damage state and restoration time

Moving to a computational point of view, a model implementation is defined as a structure relating to the main three steps: components damage assessment, components recovery assessment and system assembly.

Each of these three modules contains substructures for data input and processing which return valuable output.

For each vulnerable component, considering as input the intensity of the catastrophic event, the model assesses a probabilistic damage state. Each damage state in order involves a fixed loss of functionality, a probabilistic starting delay in the recovery process and a probabilistic restoration time.

At this point, to obtain the resulting average restoration scenario, a sampling method has been used.

It is important to illustrate some aspects related to model input. As already said, the level of the damage, is used as the model input such as intensity measure and it is also used to assess fragility curves parameters.

The method used to evaluate fragility curves is composed of the following steps:

- Assessment of response to the catastrophic event for the component through the generation of capacity curves (structural displacement for each damage state considered);
- Definition of fragility functions, matching component capacity curves with damages states spectrum shape.

Considering the fragility curves of the components, the curves have been obtained using parameters provided by HAZUS (such as machinery and other non-structural elements).

4.13 Monte Carlo method to simulate all the possible scenarios

In order to develop a damage analysis on a system, it is necessary to adopt a probabilistic sampling approach in order to assess the validity of the model. This means defining a set of probabilities which characterizes the results, given certain surrounding conditions.

Probabilistic sampling could be made using an analytical approach, but on a practical basis this is impossible. A possible solution can be the use of Monte Carlo method.

Monte Carlo methods are a broad class of computational algorithms that rely on random sampling to obtain numerical results. It was invented by two physicists in 1946, John von Neumann and Stanislaw Ulam, while they were investigating in radiation shielding at Los Alamos scientific laboratory to solve a problem of lack of data.

The name was given by Nicholas Metropolis in honour of the Monte Carlo Casino. The concept of this simulation is to provide for a chosen variable, a large number of random values, in order to estimate accurately its mean and dispersion in a complex system.

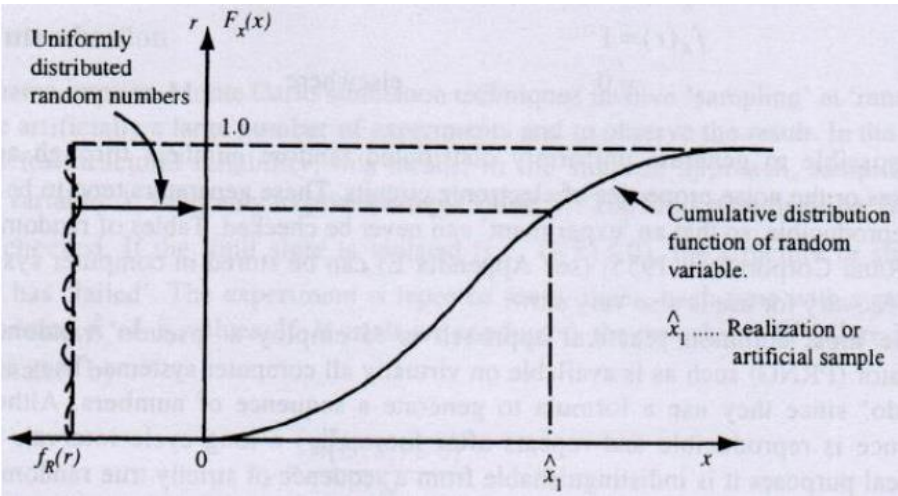
The most common Monte Carlo procedure is the “inverse transform” method. Melchers, talking about structures analysis, illustrates theoretical basis of the method. Considering a basic variable Xi, its cumulative distribution function $FX(xi)$ assumes a value between 0 and 1. The inverse transform method consists in generating a

uniformly distributed random number ri included in the interval (0,1) and equating this to $FX(xi)$ [Melchers 1999].

$FX(xi) = ri$

In this way, if the inverse function $FX^{-1}(xi)$ exists, the sample value xi can be found.

Graphic representation of inverse transform method



Monte Carlo method is used in the presented model to sampling probabilistic variables, in order to assess the impact of statistical uncertainties in the restoration scenarios.

In fact depending on the event probabilities for variable and standard deviation of density function fitting the variable, the output samples present different values which take in account random statistical uncertainties.

In recovery analysis, Monte Carlo method is applied to probabilistic variables given by fragility and restoration curves.

It allows the definition of damage states samples from fragility functions and restoration times samples from restoration functions.

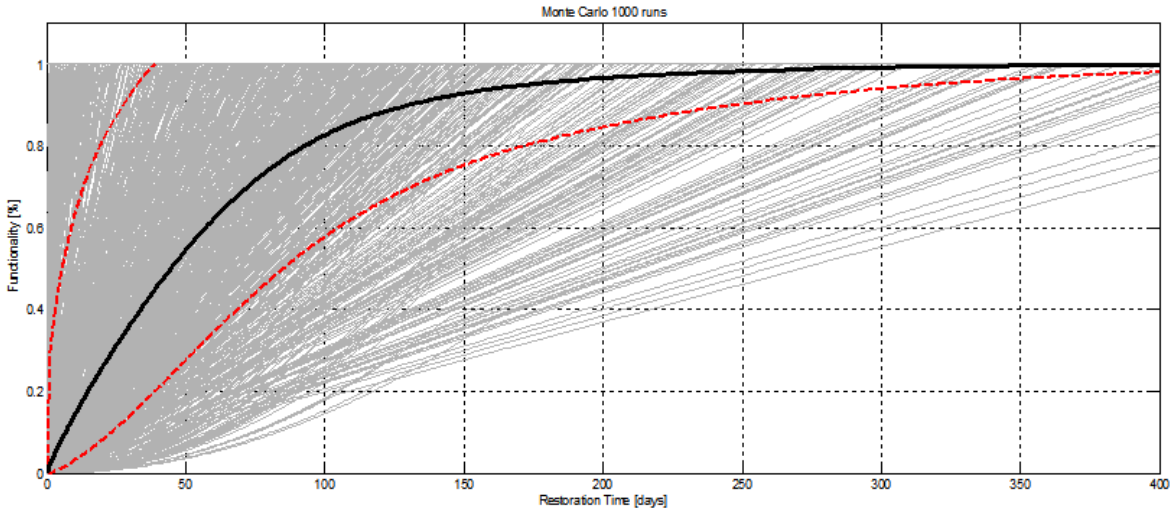
Moreover, Monte Carlo method is also applied to sample starting recovery delay into restoration curves.

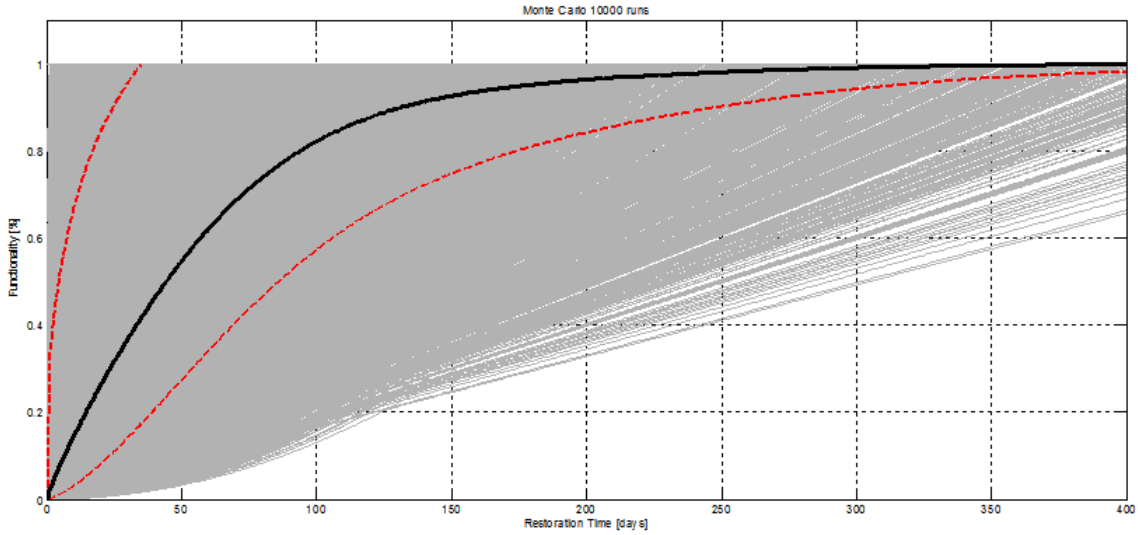
At the end of the model implementations, given a Monte Carlo simulation, restoration scenarios are obtained. However it is necessary to use the same number of Monte Carlo for each sampled variable.

To obtain a valid statistical sampling, 1000 Monte Carlo simulations should be run for each of the three probabilistic variables and simulations must be repeated for each component, allowing the independence between components samples.

As an exemplification, one elementary system of two equal components in series, has been implemented considering two different Monte Carlo simulations number: 1000 runs for the first case and 10000 runs for the second case.

Resulting restoration scenarios are showed in the two figures below. It is clear that even adopting a ten times greater number of Monte Carlo (10000 runs), the resulting average restoration scenarios and variance boundaries times, do not present meaningful differences cause all the possible combinations between components restoration curves are already hit using 1000 Monte Carlo simulations.





System restoration scenarios considering 1000 (top figure) and 10000 (bottom figure) Monte Carlo runs.

Two different software have been used to implement this model:

- **Matlab**: software for generic numerical computation. It has been used to implement the main framework of the model and the substructures of damage and restoration assessment;
- **Simulink**: data flow graphical programming language tool for modelling, simulating and analysing multi domain dynamic system. It has been used to implement the process flow diagram of the system. It works as a substructures of Matlab model framework.

CHAPTER 5.

CASE STUDY: FI.TIM S.r.l.

5.1 Company overview

FI.TIM is located in Casalserugo (10 km from Padua), the company was damaged by a flood the 31st October 2010.

It is a company with 12 employees and it produces lifts and straightening benches for vehicles. Their products are used mainly by body shops. This equipment enables easy and fast repairs after car accidents.

FI.TIM offers a wide range of products (30 different products). The company's flexibility is one of the strengths compared to other manufacturers competing on the same market.

The presence of a wide catalogue of models requires careful management of the operations and the demand for lifters come from all over the world.

They produce different kind of lifts, benches, accessories for lifters, and computerized measuring systems. Generally lifters have 50% of similar components but the in-house design and specific know-how provide a high level of product customization.

Same kind of raw materials and semi-finished products are provided by various suppliers in order to decrease the reliance on other companies. The company works on demand, hence they have few stock in the company.

FI.TIM works with sole agents in each area or country and they provide services to distributors through a high skilled staff. It takes part in the most important expositions in the sector due to the great international demand for lifts and straightening benches.

In the last years export trend is increasing, connected with the strong Italian economic crisis. Currently FI.TIM sales are: 20 % in Italy and 80 % abroad (in 2007 export was 40%).

5.2 Design of the flow process chart

1. Steel suppliers: semi-finished product and raw materials

Mainly suppliers are located in Italy to guarantee the quality of "made in Italy" products, one of the competitive advantages of this company. Materials come from different regions: Veneto, Emilia Romagna e Lombardia.

For this business it's hard to rely on foreign suppliers because the minimum size is beyond SMEs' financial capabilities.

2. Cutting of raw materials (steel plate) and welding of the various components (all in-house operations)

There are 4 welding station and an average lift needs an amount of 15 hours of welding to be done. The strengths are the knowledge recognized by the presence of patents, several foreign awards and well-designed products.

3. Painting process of the components (external painting company, hot dip galvanized steel, zinc-coated, zinc-plated, galvanizing process)

This process lasts for 4/5 hours and guaranteed the quality of the product all over the years.

4. Assembly and testing

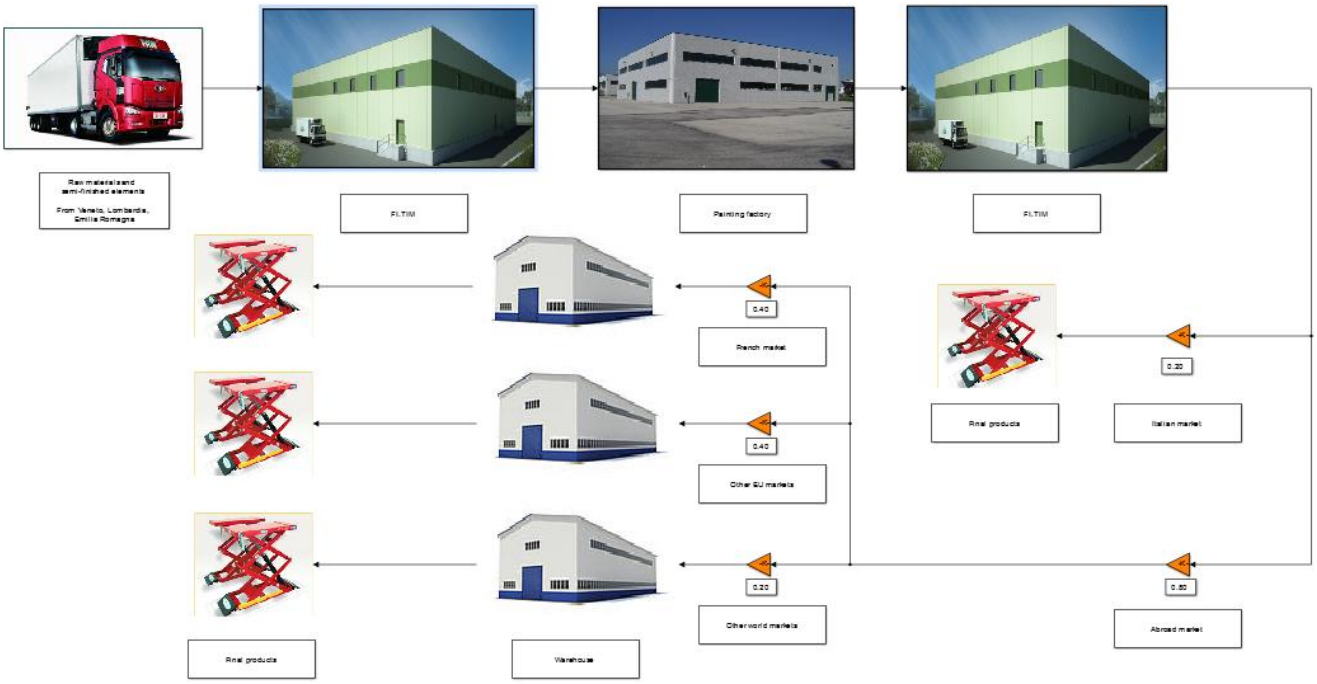
The raw materials and the semi-finished products come back to the plant ready to start the assembly process.

At this point they fit also all the electrical and hydraulics components (sourced from Emilia Romagna region).

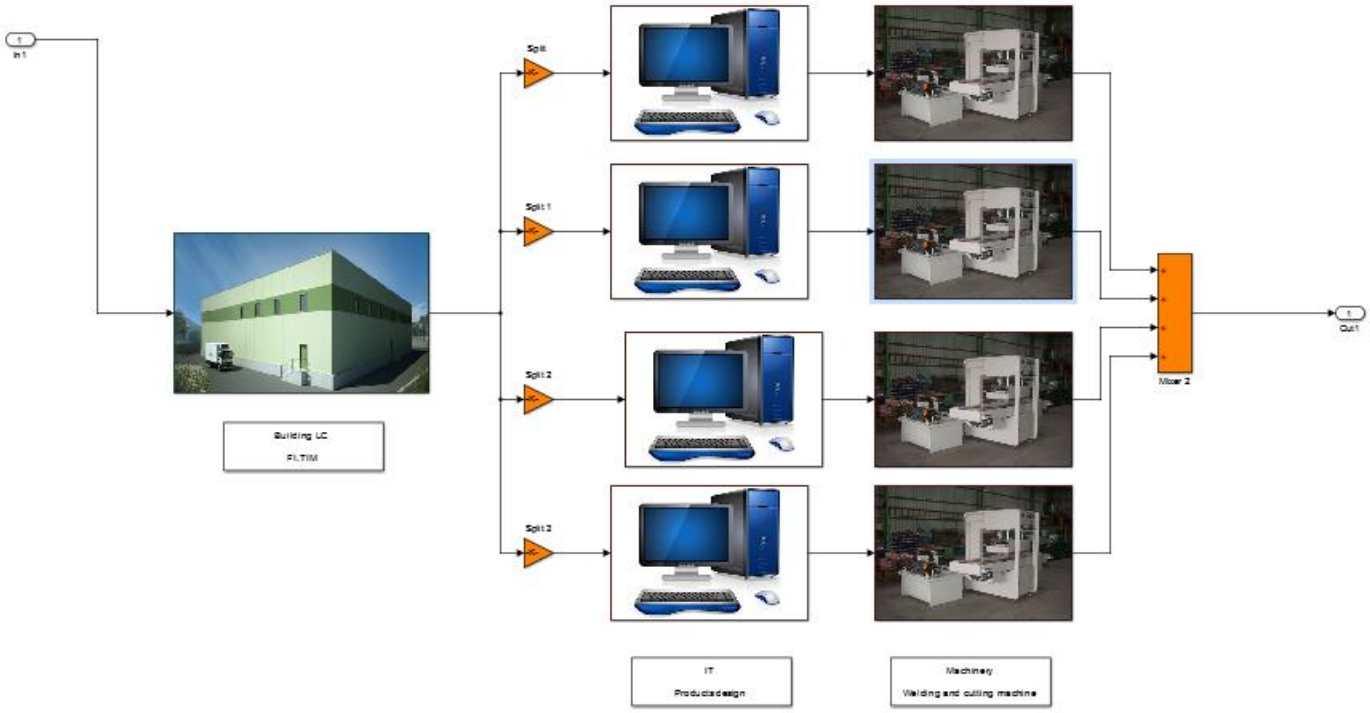
5. Preparing documents and shipping

Every lift and every bench comes with its specific instruction manual, translated in different languages. In fact, the export covers the 80% of the production. FI.TIM has distributors all over the world. In Europe FI.TIM sells especially to France (1 distributor in Paris e 2 in southern France) with the 30% of the export, then in Germany, UK, Spain, Austria, Belgium. Other important markets for the company are USA, Australia, South Korea, South Africa.

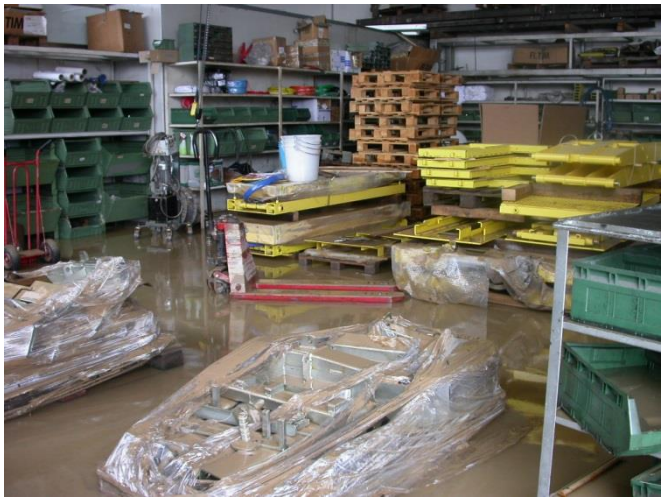
Even if the process is not totally mechanized and depending on the product, work methods and timing can change, it is possible consider three assembly line for the process.



For every unit of the supply chain it is possible to gather more information just selecting the image of the operator. For example selecting the company FI.TIM it is possible to see the production processes within the plant.



5.3 Flood damages in 2010 and evaluation of the recovery time



The mud that submerged the factory caused all the damages, the level of the water was about 80cm. (The owners got warned only 2 hours before). 2/3 days passed from the flood to the end of cleaning operations.

FI.TIM wasn't insured for catastrophes.

Main damages regarded lifts, benches, equipment, plants, electrical system, machineries, control units, raw materials in the warehouse (plan stoppage). The first recovery operation was to clean up and reset the office, to restart the commercial operation.

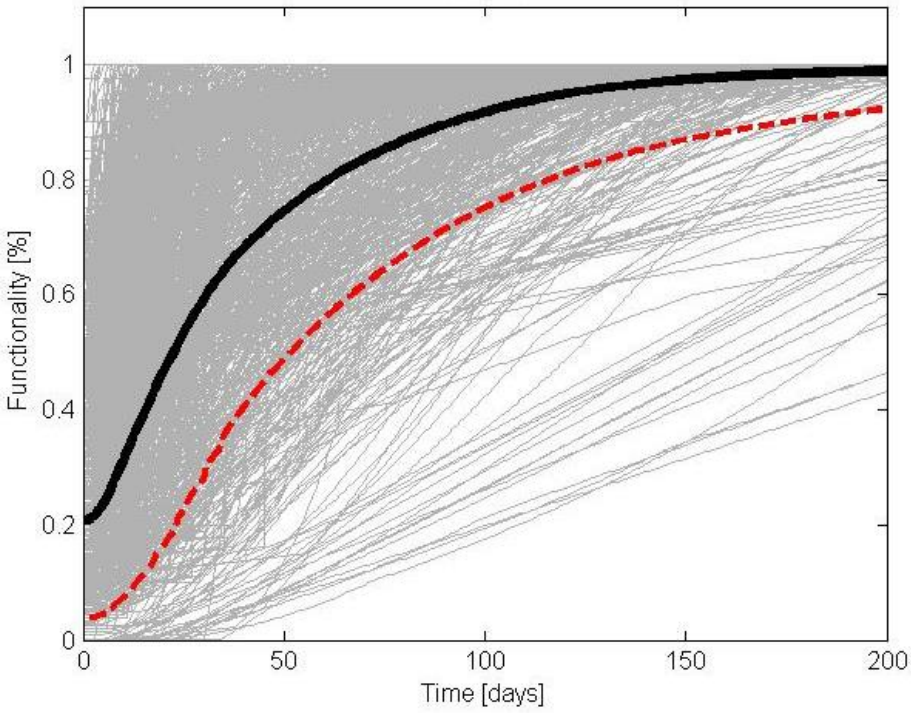
The 15/20% of the functionality was restored after 4/5 days. They needed two months and half to fully restore the functionality of the plant (100%).

The trade-off was the choice between paying an external company to fix the damages or use the employees (12) to fix as much as possible the factory.

Even if FI.TIM has an insurance broker, their policy didn't cover floods. Italian Government gave back the 65% of the economic damages request.

The payment came 2 years after the flood. FI.TIM didn't lose orders but managed to delay products delivery and surge demand from external supplier. In the end, annual production didn't decrease.

When a part of the process is outsourced a new layer of risks is added. Using the proposed method we can assess the risk coming from external sources, as well taking into account the increment productivity that one can source from external suppliers.



The output of the model relates the functionality of the plant with the time for the fully recovery. According to the data gathered from the interview of the entrepreneur, the estimates recovery time is 100 days for the 95% of the productivity. So basically in almost 3 months the company should have been able to fully recover the pre-flood productivity. This could be related to the work done by the employees that contributed to a faster recovery

In the case FI.TIM, the annual production wasn't affected. This fact can be explained looking at the internal production process. While the internal workforce was cleaning inside the productive plan, due to the small size of the business (12 total units of workforce), a part of the productive process has been outsourced. An extra effort has been requested to the suppliers, which promptly responded and increased the production helping the business to recover in less than couple of months.

CONCLUSIONS

In the present research, a model to calculate restoration scenarios after catastrophic event for an industrial system has been presented. The model framework can be resumed by any mains steps:

- Disaggregation of the system process in seismic vulnerable components;
- Definition for each component of damage and restoration assessment;
- Aggregation of components into the system;
- Definition of system restoration scenarios.

The damage and restoration assessment has been obtained through the use of probabilistic fragility and restoration functions. Fragility curves have been used as fragility functions and restoration curves have been used as restoration functions.

In order to improve restoration curves reliability, some additional assumptions have been considered. Firstly, a starting residual functionality, depending on component damage state, then a correspondent restoration curve slope correction and finally a starting probabilistic delay, depending on component damage state.

The system assembly has been implemented using a flow process chart. The model output is a restoration scenario, describing the recovery during a time interval.

Considering a certain disaster intensity measure, an average restoration scenario has been obtained using Monte Carlo simulation, a probabilistic sampling method.

Monte Carlo simulation assesses model probabilistic variables, which are fragility curves and restoration curves, generating multiple variables values and consequently multiple restoration scenarios.

The model has been implemented using Matlab and Simulink software and 1000 Monte Carlo runs for the average restoration scenario generated.

Generally speaking, the model seems to provide reliable restoration scenarios for this manufacturing industry. Concretely, the proposed procedure can have many applications, all related to a decision maker function. It can be used by other companies to check the vulnerability level of production system and to fix possible weak points.

In a greater prospective, it can sustain industrial supply chains and associations in business strategy planning and disaster recovery management.

Finally, it can be used in natural disaster insurance markets in order to price insurance policies of business seismic risk. Obviously, these applications request an opportune model improvement and customization starting from:

- Model implementation using a real recorded case for evaluating the model respect to the reality.
- Definition of a more specific second level of the model structure to consider the interaction with lifelines, logistics, suppliers, costumers.
- Definition of a method to calculate financial business flow and its impact in business recovery.

BIBLIOGRAPHY

AIBA (Associazione Italiana Brokers di Assicurazioni e Riassicurazioni), *2013: le nuove frontiere dell'Assicurazione. Il Broker a tutela di persone ed aziende*, in Broker (periodico bimestrale), Numero 146 (edizione speciale), Aprile 2013, Roma

Great Northern Oil Co. v. St Paul Fire & Marine Ins. (1975) 303 Minn. 267, 227 N.W.2d 789, 793 (USA court case)

Porter, A. K., (2003), *An overview of peer's performance-based earthquake engineering methodology,* Ninth International Conference on Applications of Statistics and Probability in Civil Engineering, ICASP9, 2, 973-980

Jelinek, R. and Krausmann, E, (2008), *Approaches to tsunami risk assessment*, Technical report, Joint Research Center

Allianz Risk Pulse (2014) *Allianz Risk Barometer on Business Risks 2014*, Alianz SE and Allianz Global Corporate & Specialty SE

ANIA, Cerved (2014) *Coperture assicurative e probabilità di default delle PMI*

Mentzer, DeWitt, Keebler, Min, Nix, Smith, And Zacharia (2001), *Defining Supply Chain Management*, Journal Of Business Logistics, Vol. 22, No. 2

Cineas ,Politecnico di Milano, professor Marco Giorgino (2011), *Enterprise risk management: analisi empirica del mercato italiano* (informazioni reperibili al sito http://www.cineas.it/index.php?pag=231)

SCRLC The Supply Chain Risk Leadership Council (2013) *Emerging Risks in the Supply Chain 2013*, White paper

ATC-13, (1985), *Earthquake damage evaluation data for California*, Technical report, Applied Technology Council Report

FERMA, the Federation of European Risk Management Associations (2014) *European Risk and Insurance Report - Executive Summary of the FERMA Risk Management - Benchmarking survey 2014 - 7th edition*

Allianz Risk Pulse (2012), *Focus: Business risks - "Big three" risks trouble companies* , Allianz SE, Munich, Germany

KPMG, (2013), *Global Manufacturing Outlook: Competitive advantage*, Publication number 130103

FEMA (1999), *HAZUS Earthquake Loss Estimation Methodology*, Technical Manual, Washington, D.C.

Risk Governance, Politecnico di Milano Dip. Ingegneria gestionale (2014) *Il Risk Management nelle piccole e media imprese italiane. Sintesi dei risultati della seconda edizione dell'Osservatorio* , Milano

European Commission, (2014), Imprese e industria: Scheda informativa SBA 2014 Italia

ANIA (2013) *Italian insurance 2012 2013*

ANIA (2014) *Italian Insurance 2013 2014*

ANIA (2012) *L'indicatore "grado copertura assicurativa delle PMI"*

United States Federal Government (2012), *National Strategy for Global Supply Chain Security*

Munich RE (2012), *Natural Catastrophes 2011, NatCatSERVICE*

Lindell, M. K., (2013), *Recovery and Reconstruction after a disaster*, Encyclopedia of Natural Hazards, Heidelburg: Springer, 812-824

Luigi Dell'Olio - *Rischio d'impresa sottovalutato nuove cure per un male antico*, in La Repubblica, 29 ottobre 2012, (articolo reperibile al sito http://www.repubblica.it/economia/affari-e

finanza/2012/10/29/news/rischio_dimpresa_sottovalutato_nuove_cure_per_un_male_antico-45478047/)

Editoria Assinews, *Risk management: in Italia, 1 impresa su 2 non ha gli strumenti necessari per affrontare la crisi*, Assinews.it (Il portale del sapere assicurativo), 31 Luglio 2012 (articolo reperibile al sito http://www.assinews.it/articolo.aspx?art_id=11002)

ATC-45, (2004), *Safety evaluation of buildings after windstorms and floods*, Field Manual , Applied Technology Council, Redwood City, California

Melchers, R.E. (1999), *Structural reliability analysis and Prediction*, 2nd ed., Wiley

BCI The Business Continuity Institute (2011), *Supply Chain Resilience 2011* , 3rd Annual Survey

Hazus MH MR4, (2003), *Technical* Manual, FEMA mitigation division, Washington, D.C.

Hendricks, K., Singhal, V. (2005), *The Effect of Supply Chain Disruptions on Long-term Shareholder Value, Profitability, and Share Price Volatility*

WEBOGRAPHY

Associazione Nazionale fra le Imprese Assicuratrici, http://www.ania.it/, last access 27 January, 2015

Autorità di Bacino del Fiume Adige, http://www.bacino-adige.it/, last access 20 December, 2014

EM-DAT the International Disaster Database, http://www.emdat.be/, last access 23 November, 2014

Federal Emergency Management Agency, http://www.fema.gov/, last access 15 December, 2014

Federation of European Risk Management Associations, http://www.ferma.eu/, last access 12 January, 2015

Financial Time, http://www.ft.com, last access 5 February, 2015

Istituto Nazionale di Geofisica e Vulcanologia, http://www.ingv.it/it/, last access 10 december, 2014

The International Organization for Standardization, http://www.iso.org/, last access

Guide to approaches and secondary resources for researching supply chains, http://libguides.rutgers.edu/supply_chain, Last Updated Nov 24, 2014

Munich Re: Leading experts on risk solutions worldwide, http://www.munichre.com/, last access 2 February, 2015

SCOR Global reinsurance company with worldwide operations, http://www.scor.com/en/, last access 8 January, 2015

The Business Continuity Institute (BCI), http://www.thebci.org/, last access 19 January, 2015