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MAN-MADE ENVIRONMENTAL DISASTERS AND THEIR IMPACT ON ECONOMY; ECONOMIC MODELING BASED ON BHOPAL GAS DISASTER*

This article examines implications of man-made environmental hazards on ecosystems, the staggering costs of disasters that are borne by governments and the private sector, and the short- and long-term economic collisions that result from anthropogenic perspective when they occur directly or indirectly. Through the article, Bhopal gas tragedy will be evaluated as a case study, along with its various characteristics, to explore the economic, environmental, and social aspects of man-made disasters and to provide an efficient and viable strategy for governing and responding adequately to potential future disasters.

This literature review will discuss current research related to I/O modeling[1] in Disaster Management, with a focus on the use of mathematical models to analyze and predict disaster impacts. At its core, I/O modeling is a way of looking at the inputs and outputs of a system, and using this information to create models that can be used to predict the behavior and outcomes of the system.

I/O modeling has been used in a number of different fields, including economics, engineering, and operations research. The use

* The article is submitted based on the materials discussed during the annual student conference held at Eurasia International University on March 2, 2023. // Հոդվածը ներկայացվում է 2023 մարտի 2-ին Եվրասիա միջազգային համալսարանում տեղի ունեցած ուսանողական ամենամյա գիտաժողովի ընթացքում քննարկված նյութերի հիման վրա:

1 Input-Output (I/O) modeling is a quantitative economic technique used to analyze the relationship and interdependencies among different sectors of a national economy or different regional economies.

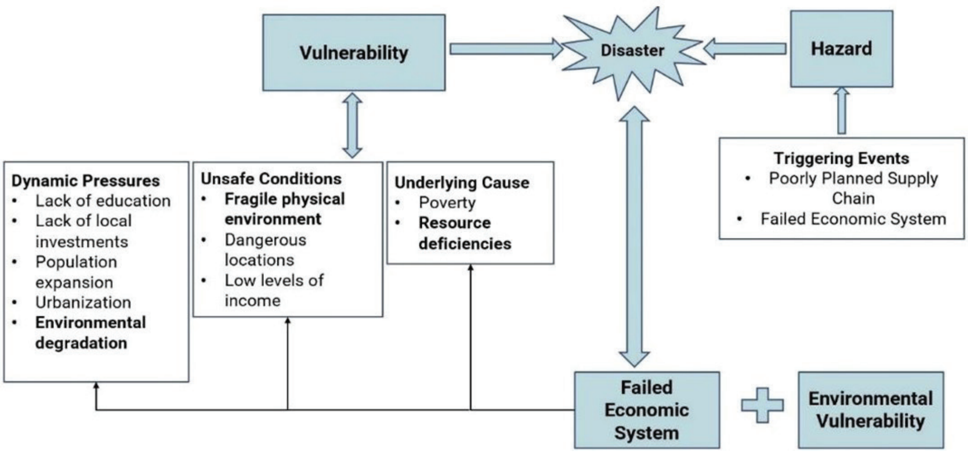
of I/O modeling in disaster management is relatively new, however, with research into the topic only beginning in the early 2000s.

Key words: man-made disasters, Bhopal, disaster, economic impact, I/O modeling, assessment.

Introduction

Globally speaking, any given system is believed to be in a state of equilibrium between society, economy, and environment, and there is a bilateral relationship between underdeveloped economies and environmental vulnerability that increases the possibility for man-made hazards. An enormously disastrous impact on human resources, including society's mental and physical health, is caused by man-made environmental hazards, which typically occur intentionally or unintentionally due to human negligence and carelessness when mishandling dangerous equipment during technological and industrial use caused by failure to detect operational bottlenecks within the supply chain cycles and due to the non-existence of a sustainable supply chain. These factors lead to poverty, unemployment, and long-term social and economic disruption. It must be further emphasized that disasters have a negative impact on both internal and foreign politics. The study proposes a conceptual model (table 1) to explain the terminology in the disaster study with the common causes in an effort to approach a comprehensive overview towards the essence of anthropogenic events.

Table 1: conceptual model for causes and implication of hazards and disasters



According to the model, a hazard is something that should be distinguished from a disaster trigger by having a dysfunctional supply chain and an economy with diminished strength. The hazard intensifies the possibility of vulnerability and triggers disaster when combined with potential economic, environmental, and societal issues as underlying cause and effect factors.

A failed economic system, on the other hand, refers to an undeveloped or emerging system that, when combined with environmental vulnerabilities, leads to environmental disasters. This study speculates that disaster, environmental vulnerability, and a failed economic system are all interconnected.

Resilience in the economic system is a central topic in the disaster impacts' assessment and mitigation. Through numerous literatures economic resilience has been categorized as static economic resilience as well as dynamic economic resilience. While the static resilience defines the ability of a system to maintain function when shocked, dynamic resilience has been introduced as accelerating recovery of a disaster or shock. Subsequent objectives of the article involve suggesting a methodology to achieve a state of economic resilience, facilitating autonomous recovery of the economy while addressing long-lasting impacts on its long-term economic health.

Man-Made Environmental Disasters; Cause and Effects

The common causative elements, and intensifying factors aftermath the disasters have been discussed through this study within two categories based on the suggested conceptual model (table 1): economic, and environmental factors.

Environmental Factors

1. Fragile physical environment fostering disaster's adverse effects.
2. Populating in potentially harmful areas adjacent to hazardous stations (settlement patterns).
3. Environmental degradation reducing the effectiveness of ecosystem to mitigate the risk of disasters (lowering environmental capacity).
4. Over exploitation of environmental resources with ramifications of climate change, habitat destruction, degraded ecosystem services, and intensified impact of desertification and droughts.[2]

Environmental Impacts

1. Capacity reduction of environment to meet social, and ecological objectives inducingvulnerability to pursuant hazards with high level of intensity and frequency.
2. Damage caused to land, water, air pollution, contribution to climate change, loss of biodiversity, deforestation, desertification, wild land fires, and ozone depletion.
3. Loss of natural defense for combating the natural hazards.

Economic Factors

1. Poverty resulting in negligence of hazard factors.
2. Resource deficiencies leading to usage of non-qualified operators/experts/ apparatus.

2 An Overview of Environment and Disaster Risk Reduction in the Arab Region, 2015.

3. Low-income level out-turning society more vulnerable towards loss, and recovery.
4. Lack of efficacious education in severe disaster recovery process, resulting in lack of comprehensible knowledge towards the law, and public policy.
5. Population expansion inducing impoverishment, and promoting economic deprivation.
6. Urbanization as an agent for relocation to hazardous industrial locations.
7. Fragile local economy and lack of robust economic structure reinforcing dependence on foreign investments.

Disaster Economic Effects

1. Considerable downturn in jobs, and community services aftermath the trauma.
2. Asset value depreciation related to the cost of repair or replacement (damage to the households, businesses, governmental properties whose precise data is difficult to pursue, or measure due to the lack of responsible organizations, and central government's avoidance to release the accurate, and liable information).
3. Reduction on the investment front which curbs economic productivity.
4. Interim GDP growth due to the shock aftermath of the trauma provoking the agile reconstruction therefore as growth; however, the long-term GDP growth correlates to the significance of trauma, when there is a mild incident GDP continues to increase over time, whilst after a noticeable disaster GDP decreases due to the inefficient investment usage, nonetheless, the general direction of economic impact seems to be negative over time (Halkos, Managi, and Tzeremes, 2015, p. 9-10).
5. Reduction in consumption due to the asset value loss lowering the overall life quality.
6. Perturbation in dynamic equilibrium due to the relationship between socio-economical units.

Method

This review paper examined the Bhopal gas tragedy as a human-caused catastrophe, exploring various factors leading to the disaster before it occurred and the consequences that followed. The focus was on analyzing the immediate and prolonged economic repercussions of the incident. By utilizing the Bhopal gas disaster as a case study, this research aimed to provide a comprehensive understanding of the broader aspects of anthropogenic disasters.

Consequently, for assessing both short-, and long-run economic effects, the information was gathered over a 31-year period from 137 countries, including high-income, upper-middle-income, lower-middle- income, and lower-income nations. This information by the count of disaster events within each country, is sourced from the Emergency Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disasters (Halkos, Managi, and Tzeremes, 2015, p. 3).

This dataset served as supplementary information for the study to delve more into cause-and-effect relationship of a disaster.

By means of empirical investigations, this research aims to explore the detrimental impact of disasters on economies. It will analyze various variables including payroll, GDP, employment, and the viability of manufacturing enterprises. These studies will scrutinize the alterations observed in industrial sectors and the overall economy due to disruptions in the supply of goods characterized by limited sustainability (ripple effect[3]).

Furthermore, this study will introduce Input-Output (I/O) modeling as an efficient approach to quantifying the economic aftermath of anthropogenic disasters, thereby enhancing the efficiency of disaster management. It is necessary to acknowledge that the data collected from these disasters might have undergone distortion orchestrated by governmental bodies, and political interference, potentially influencing the final outcomes of the calculations.

Additionally, considering that man-made disasters can arise intentionally, the scarcity of comprehensive data and the intricacies of tracing the enduring repercussions of these disasters may leave the data susceptible to misinterpretation, impeding the conduct of comprehensive research. As a result, some of the long-lasting outcomes could inadvertently be disregarded in the research analysis.

Economic Disaster Impact Analysis

This study draws Figure 1 from a comparison between production efficiency level changes and disaster occurrence (natural and man-made) over a long period of time to better understand the economic effects of disasters. The review will discuss the Bhopal gas disaster as an environmental/economic shock according to its pre-disaster causal impacts and post-disaster outcomes. Hence, the input-output technique will be covered in the study as leveraging instruments.

This graph demonstrates that when there is creative reconstruction (providing opportunities for new industries, replacing outdated infrastructure) following the disaster, the high-income countries increased their production efficiency with a higher score in comparison to the low- income countries (target countries for anthropogenic disasters) with a similar trend. It's necessary to take into account that the number of disaster occurrence has been evacuated from the data to achieve the stimulation result for the low frequency and high-density hazards.

There are other studies (empirical studies) suggest evaluation of disaster's impact on payroll[4], GDP, employment, and establishment of survival in manufacturing economies. These studies examine how industry, and total economy level have changed by a disruption in supplies of goods with low sustainability

3 The ripple effect occurs when a disruption in the supply chain cascades downstream to impact supply chain performance, as opposed to remaining localized.

4 Payroll includes all forms of compensation received through government or foreign nations.

(ripple effect) which results in payroll, GDP, and employment decline. Disasters rarely have a significant macroeconomic impact, since the national economy is too big to be significantly disrupted beyond a short period of time (Thomas and Helgeson, 2021, p. 1).

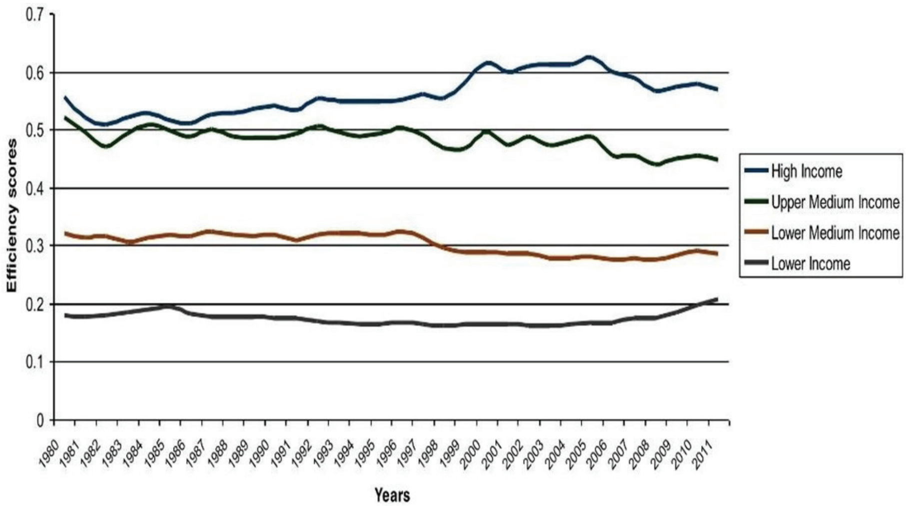


Figure 1: efficiency level of different countries

For examination of this hypothesis, we have considered data gathered over a one-year period in USA, concerning the hazard impact on supply chain disruptions, and business associated losses on payroll, GDP, employment, and survival/creation of establishment. Following the analysis of this study we also consider the supply chain resilience defined as the "capability of supply chain to respond quickly to unexpected events so as to restore operations to the previous performance level or even a new and better one". Many studies using input-output analysis (I/O), social accounting metric (SAM), and computable general equilibrium (CGE[5]) suggest that hazards do not always affect the macroeconomic growth negatively, and in some cases disaster show positive growth effects[6] in some areas.

Following the effect of 6 hypotheseshas been measured and analyzed through a primal (production function) approach using linear regression to indicate the relationship between hazards, and dependent variables (GDP, employment, payroll, and establishments) although, their relationship is not linear.

1. Hazards have a negative impact on payroll, supported by a relatively small impact where a decrease in payroll is intended to represent an overall decrease in labor.
2. Hazards have a negative impact on economic output not supported by the

5 CGE models incorporate price changes using SAM, and IO data.
6 Positive growth results from replacing damaged goods, while the negative impact results from damage to the infrastructure.

measurement, which mayresult in challenges to estimate accurate and precise damage levels.

3. Hazards have a negative impact on employment not supported by the analysis due to the probable imprecision in damage resulting in a lack of significance.
4. The models used in the study with strong significance imply that labor goes down either through a job loss or employee productivity, reducing GDP by 3.9%. Hazards in the upstream supply chain have a negative effect on payroll and output locally.
5. Hazards in the upstream supply chain have a negative effect on employment locally; according to the measurements by the study, there is a high correlation between decreasing the employments by 8.6% in the manufacturing industry and 3% in the total economy (correlation coefficient between the elasticities for total payroll and total employments is 0.963).
6. Risks in the upstream supply chain drive some businesses out, and/or prevent new businesses from opening up locally, but this is not supported by research, which means that even though risk-related supply-chain damages reduce economic activity, they do not cause businesses to close or stop from opening up. (Thomas and Helgeson, 2021, p.12)

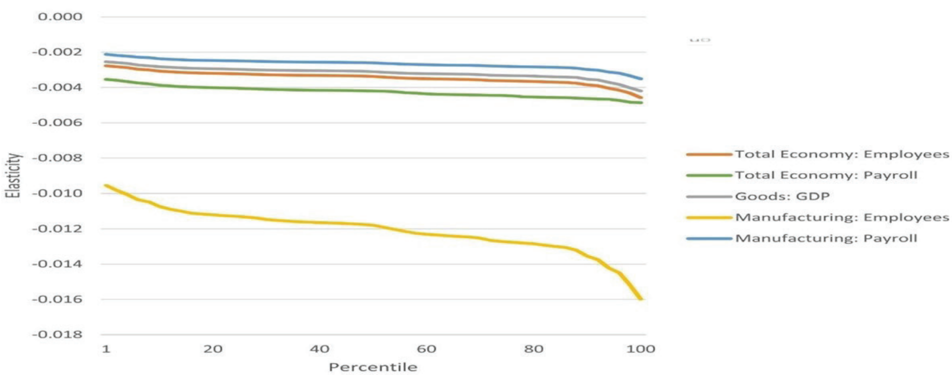


Figure. 2: elasticity in supply chain other variables at mean

Table 2: Stimulation and results summary

Simulation and results summary.

Model	Dependent Variable	Adjusted R^2	Observations	Simulated Impact of Local Damage (2006–2016)			Simulated Impact of Supply Chain Damage		
				Est.	95% Confidence Interval		Est.	95% Confidence Interval	
1	PR_{MAN}	0.9919	22 518	–	–	–	−2.9%	−5.2%	−0.6%
2	GDP_{GOODS}	0.9749	23 878	–	–	–	−3.9%	−6.8%	−0.1%
3	EMP_{MAN}	0.9893	20 981	–	–	–	−8.6%	−10.6%	−6.7%
4	EST_{MAN}	0.9914	8669	–	–	–	–	–	–
5	PR_{ALL}	0.9973	27 183	0.0%	−0.7%	0.6%	−5.3%	−5.4%	−3.2%
6	GDP_{ALL}	0.9966	29 985	–	–	–	–	–	–
7	EMP_{ALL}	0.9980	30 131	–	–	–	−3.0%	−3.9%	−2.2%
8	EST_{ALL}	0.9997	13 487	–	–	–	–	–	–

The elasticity of the supply chain operations, therefore, leads to a significant decrease in GDP growth due to a reduction in productive employment.

Case Study; Bhopal Gas Disaster

The Bhopal gas tragedy cited as the world's worst industrial disaster happened in 1984 in Union Carbide Corporation (UCC) a pesticide plant located in Bhopal city of India manufacturing Sevin, a pesticide commonly used throughout Asia. The catastrophe placed as a result of introduction of water to methyl isocyanate gas (MIC) and setting off chemical reaction released an approximate amount of 42 tons of poisonous gas into atmosphere, exposing more than 500000 people to toxic gases. The official death toll reported 3000 whilst the unofficial rate estimated 8000–10000 (Bogart, 1989), later NY times reported the fatality rate reached to 14000 people as a result of chronic disease. There are, undoubtedly, still people in the community dealing with the long-term physiological and genetic effects of the calamity. The Indian government, the US government, United Carbide, and the employees who oversaw the operations were all charged in this complicated case.

Review on Incident

The accident occurred amidst India's recurring droughts and poverty, particularly in the Northeast. Bhopal was chosen as the site due to its central location and transport access, despite initial relocation suggestions. A decline in profitability led UCIL, a UCL subsidiary, to decide on closing and selling the plant in July 1984, while safety measures were compromised weeks prior. The disaster resulted from poor hazard management, safety practices, and risk perception.

Environmental Aspects of Bhopal Gas Disaster

UCC faced $470 million, however, it didn't compensate for environmental damage. The incident led to widespread toxic chemical contamination in soil and water, causing severe health problems including cancer. Greepeace org's study shows ongoing pollution of soil, water, and breast milk, posing serious health risks for current and future generations (Nair, 2005, p. 6–10).

Toxins spread through the tropics and food chain, burdening bodies. UCC left around 700 tons of corroded waste on the factory premises, worsening victims' suffering. Studies by Greenpeace (1999) and government agencies confirmed hazardous substances like mercury and pesticides in the waste. Further, an investigation found over 20 tons of HCH, a harmful pollutant linked to health disorders. NEERI identified the factory as a high-concentration toxic waste site (Nair, 2005, p. 11–12).

Environmental Actions and Policy Making

As a response to the environmental post-disaster issues, the Indian government required Environmental Impact Assessment statements for any central approval of projects for emission or effluent standards. The statements prepared by committees should contain expert analysis of eco-system and water resource management.

In response to the disaster, the Ministry of Environment and Forest (MoEF) has developed strengthening India's commitment to the environment. Under this new act, the MoEF was given overall responsibility for administrating and enforcing environmental laws, and policies, and integrating environmental strategies into all industrial developments (Broughton, 2005, p. 4).

Further, law actions developed in order to restrict the amount of hazardous material which can be stored within a facility.

Economic Aspect

According to a study published in the Journal of Management Science (Marcus et. Al. 1991), stockresponded positively to defensive activities by the management, rather than accommodative moves by managers toward the victims. By accommodating signals, such as the settlement of $470 million and acceptance of problems within company (UCC), the stock reacted in a negative way (shareholders responding positively to defensive signals) (Nair, 2005, p. 7).

For an economic review of the incident, the study has used two indicators, industrial production[7] index (IP), and stock prices[8] to track the progress of chemical industry before and after the Bhopal incident and hence the potential impact on economy.

1-Industrial production (IP) impact: as shown in figure 4, the index for chemical industry dropped between 1984, and 1985 due to the Bhopal incident probable to the changes in perception toward risk measurements of this industry (sharp drop is evident from the graph); however, passing 1985 the index begins to increase and continues to grow dramatically between 1985, and 1997 (Saraf, 2005, p. 279).

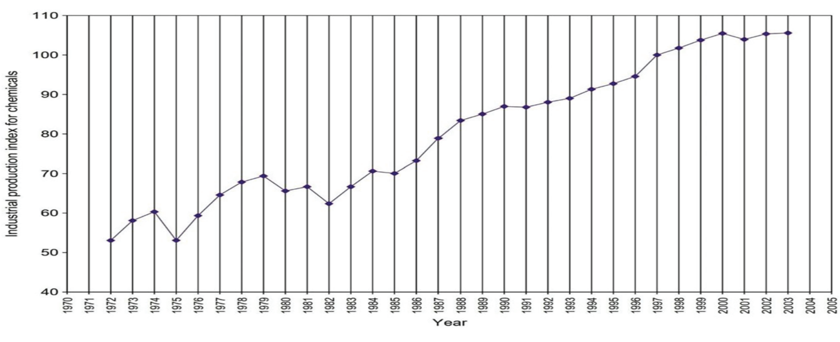


Figure 4: Industrial Index for chemical industry

7 Industrial production index (IP) measures the real output of the manufacturing, mining, electricity, and gas utilities complied by the United States Federal Reserve Board

8 Stock prices of major chemical industries in the United States and India as indicator of their performance

2–To analyze the stock price changes, the study used the stock prices of major chemical industries in the United States, and India as indicator of their performance, it can be seen from these graphs (figure 5, 6) that chemical industry in spite of increased regulation and public opposition grew steadily over the past two decades after the incident, and approached a stable economy.

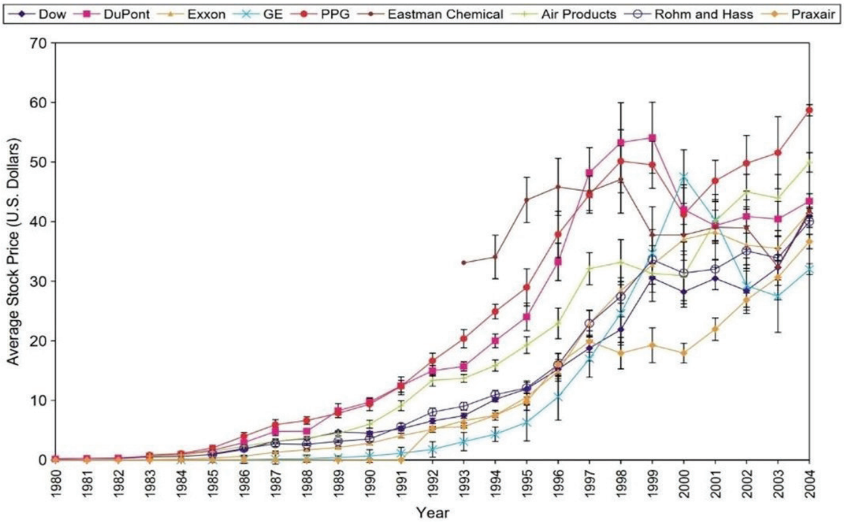


Figure. 5: Stock price for a few US chemical industries

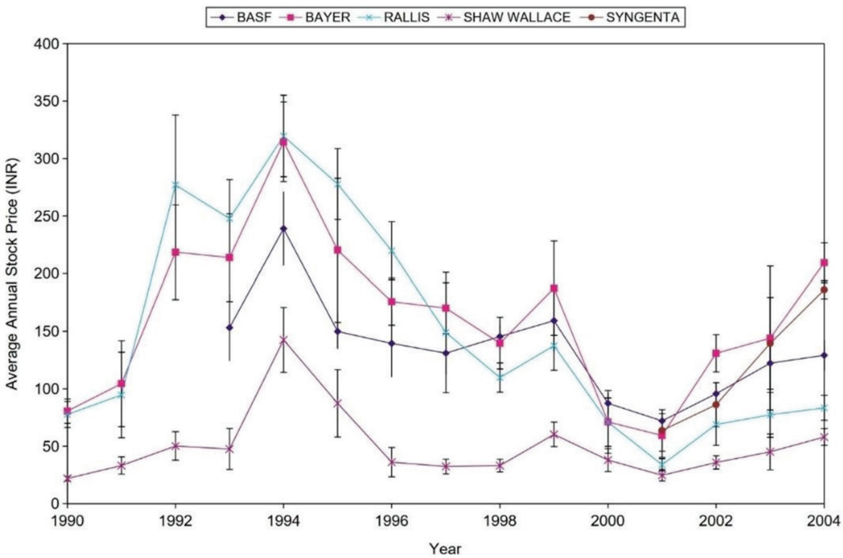


Figure. 6: Stock prices for a few Indian industries

As seen, stock prices probably increased due to more drawn attention towards the chemical industry resulting in more investment (Saraf, 2005, p. 279–280).

I/O MODEL

The basic demand–driven Leontief model gained recognition in the multi–sector economy as a representative static balance between supply and demand at both levels of intermediate and final exchange. Under the assumption of perfect equilibrium between supply and demand, the following equation to express each sector's output across an economy exists:

$$x = Ax + f$$

As the conventional demand–driven Leontief model determines the production level necessary for each industry by the backward propagation of exogenously assigned values of final demand, x gathers the entire output, and A is the total coefficient matrix of the mode (Galbusera, 2018, p. 187–188). This model disregards potential supply chain restrictions and assumes infinite supply elasticity[9] with respect to demand.

The representation formula also includes preset technical (input) coefficients, which ensure that each sector uses inputs in specific amounts to carry out its productive tasks. One unit of output must be produced from each input in a defined quantity according to the Leontief production function. With the aim of evaluating changes in elements that are exogenous to the model of that economy, this model is a multiplier–based analysis. The traditional I/O economy representation enables the incorporation of empirical data relevant to an economic region and its information exchanges with other regions, which has been a key factor in success over the years. However, additional critique asserts that the model's perfect input sustainability assumption is false and the supply–driven formulation is feasible in the event of minor disturbances.

Besides the static representation model, dynamic extensions have been introduced to the formulation of supply–demand as following:

$$x(t) = A(t)x(t) + B(t)x(t) + f(t)$$ [10]

where the technical coefficient has been stated as a function of time in A(t) and as a capital function matrix in B(t) (potentially singular). The non–linear I/O formulation, which takes into account the complexity of many real production processes, and the mixed I/O model, which aims to take into account supply constraints more thoroughly than traditional Leontief techniques by utilizing the concept of purchasing coefficients, as two of the aforementioned aspects (Galbusera, 2018, p. 189).

9 Supply elasticity refers to the responsiveness of the quantity supplied of a good or service to changes in its price.

10 f(t) represents the vector of exogenous inputs or final demand at a specific time "t" in the Leontief in–put–output model.

Disaster Representation in I/O Framework

Impact analysis is certainly one of the many common usages of I/O models, as was previously established. This article focuses on a few of the key issues representing the disaster and its subsequent economic impacts. While initial costs and both short-term and long-term growth effects have been considered as some of the key features, some indirect effects of critical hazards, such as the forward propagation of supply perturbation, different roles for replaceable and irreplaceable components with potential substitution coefficients, and the potential presence of both negative and positive impacts resulting from a hazard, such as immediate triggering, have not always been captured by I/O techniques. Further, while exploiting the I/O supply-demand approaches, the disasters have been interpreted in terms of perturbations to demand and supply on their ensemble.

The major debate relates to the I/O framework assessing the disequilibrium economic setting induced by a major disaster, and an aspect of interest concerns the relationship between post- disaster economic actions and economic growth. Hence, the plausibility that adverse events may have negligible macro-economic impacts or trigger positive economic counter effects is also under theoretical and empirical investigation, and there is the existing possibility that consistent magnitude may lead to minor macroeconomic consequences.

The development of technology might hasten long-term economic growth. Managing the post- disaster decisions, the availability of spare production capacity, and creative destruction, which are long-term losses resulting from a disaster, can lead to poverty traps.

Loss Assessment in I/O Model

The I/O model's loss assessment revolves around the shock impact location and shock wave propagation path, in regard to shock impact localization which is associated with the exogenous variables including **demand-, supply-, or mixed-type.** In the demand-side disruptions which are in continuity of the demand-driven nature of the standard Leontief model, a large portion of the literature concentrates on the demand disruptions with the assumption of persistence in the demand- side perturbation, even though demand-driven models are not free from risks. Hence, estimating the economic consequences of a negative demand shock through I/O models may induce some issues related to the double-counting[11] of impacts on total output and labor income (Galbusera, 2018, p. 190).

A supply shock should be viewed as a disruption to the internal demand in the study of supply- side perturbations in the context of I/O models to adequately analyze the propagation effects of perturbations. Physical damage, inventory loss as an internal constraint, and restricted input

availability for production as an external constraint can all be used to describe

11 Double-counting of losses for instance emphasize the importance of evaluating the indirect costs in terms of value added.

supply-side change. It's important to note that supply perturbations are different from the typical I/O model's allocation logic. Supply restrictions are more accurately taken into account in mixed-sided perturbations, which merge demand and supply-side disturbances. Both the forward and backward effects of the direct decrease in supply of its output have been taken into account.In consideration of backward, and forward linkages and propagation through Leontief the sectoral perturbation is obtained as:

$$\Delta x = L\Delta F$$ [12]

where ΔF acknowledged as demand perturbation (Galbusera, 2018, p. 190).

Conclusion

While occurring less frequently than natural disasters, man-made disasters resulting from human activities pose significant threats to communities. The Bhopal gas incident continues to be a warning sign once ignored, and it still continues to remain the most catastrophic industrial event happened throughout mankind's history. This researchstudy aimed to provide condensed overview for underlying causing factors of man-made disasters, and their consequent effects on the state of the economy, and environment of target nations. The secondary objective was to introduce the importance of modeling the anthropogenic disasters, and to suggest potential approaches for achieving economic models.

Every business setup has the potential for an industrial or technological risk, but this article made the case that risk, a weakening economy, and a deteriorated environment all have an intensifying effect on one another, and a conceptual model was introduced accordingly. Additionally, we looked at how a low-performance supply chain affects the economy as a whole.

Further, the study concentrated on the economic damages to the society by analyzing twoseparate studies for evaluating the overall function of the economy by aftermath of the event, one using data gathered from different countries evaluating GDP changes, and the second one using industrial efficiency and stock prices index in US and India.

While examining the disaster effect using GDP, it's evident that GDP grew over the years of study; however, it's seen that there is a certain threshold level that affects countries negatively in GDP. Meanwhile, IP index, and stock prices study derived a conclusion that affected countries (the US, and India) continue to increase in the indexes after a shocking drop during the year aftermath of the disaster. Putting aside the long-term economic effect drawn from disaster, it's important to consider that countries' reaction to the disaster recovery will depend strongly on the social, economic, and preparedness level for the reduction of the disaster repercussions. Therefore, consensus models and tools for the disaster assessment are required.

Exploiting the increasing volume of data available and fostering estimation

12 L represents the inverse matrix or the coefficient matrix of production coefficients.

capabilities; integrating the I/O analysis framework with other techniques e.g. CGE, stochastic analysis, and other technological models will better tackle the challenges of global supply chains, and the economic state aftermath of the trauma. The study further introduced the link between I/O modeling and assessing economic losses from disasters, highlighting its effectiveness in analyzing impacts based on hazard data to identify risks, response efficacy, and mitigation strategies for potential disaster impacts, emphasizing the need for future research to enhance the accuracy and applicability of I/O models as economic assessment tools for disaster management across various stages and cycles of governance.

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Փարիզա Մոգհադամ
Եվրասիա միջազգային համալսարանի
Շրջանաձև տնտեսություն մագիստրատուրայի երկրորդ կուրսի ուսանողուհի

ՏԵԽՆՈԼՈԳԻԱԿԱՆ ԵՎ ԷԿՈԼՈԳԻԱԿԱՆ ԱՂԵՏՆԵՐԸ ԵՎ ԴՐԱՆՑ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ՏՆՏԵՍՈՒԹՅԱՆ ՎՐԱ. ՏՆՏԵՍԱԿԱՆ ՄՈԴԵԼՈՒՄ՝ՀԻՄՆՎԱԾ ԲՀՈՊԱԼ ԳԱԶԻ ԱՂԵՏԻ ՎՐԱ

Սույն հոդվածը ուսումնասիրում է էկոհամակարգերի վրա մարդու կողմից առաջացած բնապահպանական սպառնալիքների ազդեցությունը, կառաարությունների և մասնավոր հատվածի կողմից կրած բնական աղետների շոկային ծախսերը, ինչպես նաև կարճաժամկետ և երկարաժամկետ տնտեսական ազդեցությունները, որոնք առաջանում են մարդու կողմից ուղղակի կամ անուղղակի ազդեցության հետևանքով: Հոդվածում Բհոպալի գազի ողբերգությունը դիտարկվում է որպես թեմատիկ ուսումնասիրություն իր տարբեր բնութագրերով՝ ուսումնասիրելու տեխնածին աղետների տնտեսական, բնապահպանական և սոցիալական կողմերը, ինչպես նաև առաջադրելու արդյունավետ և կենսունակ կառավարման ռազմավարություն և համարժեք արձագանք ապագա հնարավոր աղետներին:

Վերլուծության մեջ քննարկվել են աղետների կառավարման մեջ I/O (մուտքային/ելքային) մոդելավորման հետ կապված ընթացիկ հետազոտությունները՝ կենտրոնանալով բնական աղետների ազդեցությունը վերլուծելու և կանխատեսելու համար մաթեմատիկական մոդելների օգտագործման վրա: Ըստ էության I/O (մուտքային/ելք) մոդելավորումը համակարգի մուտքերն ու ելքերը դիտարկելու և այդ տեղեկատվությունը օգտագործելու համար մոդելներ ստեղծելու միջոց է, որը կարող են օգտագործվել համակարգի վարքագիծն ու արդյունքները կանխատեսելու համար:

I/O (մուտքային/ելք) մոդելավորումն օգտագործվել է տարբեր ոլորտներում, ներառյալ տնտեսագիտությունը, ճարտարագիտությունը և գործառնական հետազոտությունները: Այնուամենայնիվ, աղետների կառավարման մեջ I/O (մուտքային/ելք) մոդելավորման օգտագործումը համեմատաբար նոր երևույթ է, քանի որ այս թեմայի վերաբերյալ հետազոտությունները սկսվել են միայն 2000-ականների սկզբին:

Հիմնաբառեր. տեխնածին աղետներ, Բհոպալ, աղետ, տնտեսական ազդեցություն, I/O մոդելավորում, գնահատում:

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ТЕХНОГЕННО-ЭКОЛОГИЧЕСКИЕ КАТАСТРОФЫ И ИХ ВЛИЯНИЕ НА ЭКОНОМИКУ; ЭКОНОМИЧЕСКОЕ МОДЕЛИРОВАНИЕ НА ОСНОВЕ ГАЗОВОЙ КАТАСТРОФЫ В БХОПАЛЕ

В данной статье рассматриваются последствия антропогенных экологических катастроф для экосистем, шоковые издержки от стихийных бедствий, которые несут правительства и частный сектор, а также краткосрочные и долгосрочные экономические последствия прямого либо косвенного антропогенного воздействия.

Основным объектом исследования становится газовая трагедия в Бхопале, рассматриваемая как тематическое исследование. Целью является изучение экономических, экологических и социальных аспектов техногенных катастроф для разработки эффективных стратегий управления и адекватного реагирования на будущие потенциальные кризисы.

В этом обзоре литературы будут обсуждаться текущие исследования, связанные с моделированием I/O («входные данные/выходные данные») в управлении стихийными бедствиями, с упором на использование математических моделей для анализа и прогнозирования последствий стихийных бедствий. По своей сути моделирование I/O («входные данные/выходные данные») — это способ рассмотрения входных и выходных данных системы и использования этой информации для создания моделей, которые можно использовать для прогнозирования поведения и результатов системы.

Моделирование I/O («входные данные/выходные данные») использовалось в различных областях, включая экономику, инженерное дело и в операционных исследованиях. Однако использование моделирования I/O («входные данные/выходные данные») в управлении стихийными бедствиями является относительно новым явлением, т.к. исследования по этой теме начались только в начале 2000-х годов.

Ключевые слова: техногенные катастрофы, Бхопал, катастрофа, экономические последствия, моделирование ввода-вывода, оценка.

Հոդվածը խմբագրություն է ներկայացվել՝ 2023թ. մայիսի 23-ին:
Հոդվածը հանձնվել է գրախոսման՝ 2023թ. հունիսի 5-ին:
Հոդվածն ընդունվել է տպագրության՝ 2023թ. սեպտեմբերի 25-ին: