Employment and Income Effects of Weather Related Hazards in the New York Metropolitan Area

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Abstract: The short run effects of natural hazards are simulated through an input-output model of the New York metropolitan area. The results of the analysis suggest that weather related natural hazards and forecasts of weather related natural hazards can have a wide and pronounced short run impact on an urban community.

1. Introduction

Numerous minor and major natural hazards affect the New York metropolitan area annually. While ordinary weather conditions may simply cause some minor inconvenience to economic agents, more severe systems may have an adverse effect on economic activity. Even if many of these weather hazards do not rise to the level of what would normally be termed a disaster situation, they may still result in real property damages and disrupt normal economic activity. The impact of these events may ultimately affect local tax receipts, employment, and income.

The short run response to these natural hazards is fairly limited and depends upon the amount of warning time area residents, firms, and government agencies have with regard to any single potential hazard occurrence. Long run response to the same hazardous situations, on the other hand, is much more flexible. Following the basic economic paradigms of individual and firm behavior, economic agents are assumed to maximize utility subject to some budget constraint, while firms are assumed to maximize profit. The risk associated with known hazard agents enter into this framework by affecting amenities and costs leading individuals and firms to choose locations within the urban area that account for these hazards.

Natural hazards may impact a number of household and firm decisions, from location choice to choices regarding commuting and purchases. These effects are explored in more detail in the next section. Section 3 is a discussion of assessing the effects of natural hazards through simulation with a focus on input-output analysis. Damage estimates from several hazard simulations are then presented.

The conclusions of this analysis are found in Section 5.

2. Economic Impact of Natural Hazards

Natural hazards cause three types of damage or impact, direct, indirect, and induced. Physical damages, injury, and loss of life are all examples of direct impact. Indirect economic impacts are the result of changes in the level of economic activities arising from direct impact. Further changes in economic activity that are the result of post-event alterations in the relationships between economic agents are referred to as induced impact.

A natural hazard event may become what is termed a "disaster", if it impacts a community beyond its in-built response mechanism. The focus of most economic impact studies of natural hazards is on large scale events such as hurricanes and earthquakes. Large scale disaster events may have a generalized impact on the overall regional economy through property losses and damages, affecting sectoral employment levels and regional income, and disrupting normal economic activity. Even if an area is impacted by a large scale event, it may not rise to the level of a disaster.

Under the generalized disaster scenario (and may also apply to lower level situations), the principal short run economic effects are changes in employment levels (positive or negative), income, and potentially prices. Employment changes arise as a result of damage or destruction to residential, commercial, and industrial facilities that lead to temporary disruptions in ordinary economic activity. The cascading effects of the disaster may lead to temporary business closures and consequently rising sectoral unemployment. Other sectors, such as those related to repair and reconstruction may instead experience a temporary expansion, thus leading to rising sectoral employment. Changes in income and prices can just as well be traced through the same framework following a similar line of causality.

In the long run, natural hazards can lead to permanent employment and income changes, accelerate pre-existing social, demographic, and economic trends, as well as changes in regional growth and development. Long run changes in sectoral and total employment and income may occur as a result of incomplete recovery, and disruption to regional linkages. Additionally, the hazard may serve as a catalyst to accelerating pre-existing trends. Hazardous situations may cause firms to reevaluate operations as a result of changing prices, property values, plant profitability and other factors ultimately leading to plant shutdowns or even expansion. All of these changes may further translate into an altered path for regional growth and development.

All weather hazards, large scale or even low level events, have the potential to cause some damage within a community. The economic impact and effects arising from any particular event depends on the hazard intensity, area of impact, level of damage, regional infrastructure, and response mechanisms in place. In essence, the impact of any event is hazard and community specific. For example, in the continental United States, northern cities such as Buffalo, New York and Chicago, Illinois which are regularly hit by winter snow storms are better equipped to handle two to four inches of snowfall than southern cities like Atlanta, Georgia or Charlotte, North Carolina, which receive snow relatively infrequently.

While disasters tend to cause very visible disruptions to economic activities within a community, low level hazards are likely to cause more transient and less noticeable interruptions to these activities. Weather hazards such as minor snow storms, for example, may lead households to delay activities such as shopping or dining out. Physical damages from natural disaster may cause the temporary closure of businesses leading to declines in employment, income, and other economic activities. With less severe events, firms may effectively be shut down as hazardous conditions prevent employees from getting to work, customers from shopping, or as result of event related power failures.

Presumably, households and firms will have accounted for a certain amount of hazard inconvenience in their location decisions. Thus, an ordinary afternoon rain shower is unlikely to cause much disruption to normal behavior. Weather conditions may increase commuter times by shutting down roads and highways, or creating hazardous condition that increase road and traffic congestion, leading to a delay in economic activity.

Inclement weather may potentially shut down a construction site for several days, or even months at a time, thus impacting employment and income, as well as delaying the use of the newly constructed business or residential facility (Solomu and Wu, 1999). Weather conditions may even influence retail shopping activities within the region (Fris, 1997). While shopping trips may only be delayed, some households as a result of the poor weather conditions may investigate other methods to obtain goods and services such as making purchase through the Internet.

Overall, natural hazards are capable of affecting a wide range of economic activities. The transient nature of most low-level weather hazards suggest that their effects would likely cause only temporary impact to most activities. That does not imply that they would have no short run economic or long run impact though, and could potentially cause some perceptible effect on employment and income levels within a community.

3. Hazard Simulations and the New York Metropolitan Area

Simulating the effects of a natural hazard for the New York Metropolitan area present a number of challenges. Focusing on the short run for a moment, a hazard event may create some immediate damage and economic disruption that will impact a limited geographic zone. Firms and individuals outside of the specific impact zone may be unaffected by the actual hazard, but may still experience the indirect or induced effects of the hazard, such as traffic delays, power outages, and similar secondary impacts. Some of these effects can be converted into economic impacts such as lost output, tax revenues, and other similar measures.

Short run losses in revenues and output may be further converted into potential employment effects as well. One difficulty with this approach lies with the fact that some activities, though delayed, may ultimately be carried out, and thus, the overall event impact may be overestimated. There is very likely to be some cost incurred from the delay though, and thus aggregated figures for economic activity will miss some of these costs and losses.

An important corollary to this particular problem arises when analyzing household and firm recovery activities from hazard events. In the event that the hazard caused physical damage, some of the repair expenses may be reimbursed through insurance and other sources. The economic activities associated with these repairs will be reflected in employment and income data as increased production and output. Not all of the damage costs may be recovered by agents, and thus the hazard event may result in some reductions in savings and wealth. These repair and reinvestment activities also represent a diversion of financial resources that could have gone into other investments and improvements to physical capital. A significant portion of replacement and repair costs essentially reflect losses associated with the hazard.

Estimating the long run costs and impacts associated with hazardous events are more difficult to capture within a simulation. The general approach for estimating short and long-run impact on employment, income, and output, is to estimate baseline levels for all three variables from an input-output (I/O) or econometric model which are then used for pre-event and post-event comparative analysis. These models can be further used to simulate the effects of an event on economic activity.

The aforementioned method provides only a partial answer to the question of the costs and impact arising from natural hazards. Costs associated with disruptions may need to be estimated using other more ad hoc techniques, such as imputing time delay costs when commuters are forced to sit in traffic, or as a result of power outages. Many of these disruption costs reflect temporary losses in consumer surplus and welfare that can never be recovered. What, for example, is the cost of sitting for several days in the summer heat without electricity or air conditioning to a household (presuming the household in question would have normally used its air conditioning). These costs are generally uncompensated and difficult to estimate through econometric or I/O methods.

In the following analysis, the New York metropolitan area economy is simulated through a regional I/O table (generated using IMPLAN). The study area is New York City, comprised of the five boroughs or constituent counties of the city, Bronx, Kings, New York, Queens, and Richmond. The I/O table captures the relationships between intra-industry and inter-industry trade flows and industry linkages within the study area. In essence, it simulates how spending, or economic activity in one sector within the study area affects other sectors and industries through a series of direct, indirect, and induced multiplier effects that can be summarized in terms of spending and employment multipliers, changes in final output, and other similar measures.

The input-output table itself is a static simulation that illustrates the regional trade linkages and economic relationships at a point in time. Hypothetical damages or impact associated with a particular natural hazard enter the simulation by affecting consumption, sectoral employment, or sectoral spending, and their effects on final output, income, and employment are estimated from the I/O model. The I/O analysis captures the potential short run effects of a hazard event. Long run effects are not directly observable using this methodology.

Within the framework of the simulation weather forecasts provide households, firms, and government some limited ability to plan for the potential occurrence of a weather related natural hazard. Weather forecasts are used by economic agents in the short run to modify their behavior, i.e., prepare for a particular event, while general knowledge of the potential hazards and experience with the hazards faced in the area are a form of information that individuals use in their long run decision making.

4. Weather Hazard Simulations and Potential Economic Impacts in the New York PMSA

Over the last decade, the New York metropolitan area has been struck by a number of weather hazards such as tropical storms, severe winter storms, and summer heat waves. In general, weather forecasts have given area residents, firms, visitors, and local government and emergency management authorities the opportunity to plan for the event. The simulated hazard impacts presented below are estimated taking the possibility of these hazard forecasts into account. Impact estimates are based upon the I/O generated multiplier effects.

Data for the analysis was obtained from the Bureau of Economic Analysis, Regional Economic Information System, the New York Metropolitan Transportation Agency, the New York Public Service Commission, and the IMPLAN database. Summary data for the New York PMSA, and New York City are presented in Table 1. Selected sectoral multipliers for the New York Metro area are presented in Table 2. Estimates of the weather related impacts are derived by extrapolating the economic changes that would result from a set of hypothetical damages and disruptions that may occur in the event of a hazard event.

Table 1: Economic and Demographic Profile

Population	8,712,60	Per Capita Income	$38,814

Total Personal Income	$338,168,228	Earnings	$288,634,654
Households	3,136,854	Employment	4,678,087

Largest Industries (ranked as percent of total earnings)

Services	32.7%
Finance, Insurance, and Real Estate	29.6%
State and Local Government	9.7%

Table 2: Selected Income and Employment Multipliers

	Income*				Employment Multipliers**			
	Dir.	Idt	Idd	Mult	Dir.	Idt	Idd	Mult***
Maintenance and Repair								
Residential	0.403	0.105	0.133	1.593	10.35	2.71	3.69	1.26
Other Facility	0.541	0.078	0.162	1.444	12.16	1.94	4.49	1.53
Local Interurban Passenger Transport	0.626	0.084	0.186	1.432	23.01	1.84	5.15	1.304
Air Transportation	0.334	0.100	0.114	1.643	6.60	2.41	3.15	1.844
Transportation Serv.	0.445	0.171	0.162	1.747	11.32	3.16	4.47	1.675
Electric Services	0.163	0.055	0.057	1.691	1.96	1.17	1.59	2.410
Building Materials	0.571	0.021	0.155	1.309	21.55	0.45	4.30	1.220
Food Stores	0.543	0.045	0.154	1.367	29.57	0.96	4.27	1.177
Eating & Drinking	0.431	0.090	0.137	1.526	21.78	2.02	3.78	1.266
Misc. Retail	0.480	0.083	0.148	1.482	23.20	1.79	4.10	1.253
Hotels and Lodging	0.406	0.115	0.137	1.621	10.50	2.96	3.78	1.642
Services to Buildings	0.592	0.085	0.178	1.444	19.18	2.02	4.92	1.361
Theatrical	0.348	0.269	0.162	2.238	8.98	6.13	4.48	2.182
Local Government Passenger Transit	2.037	0.162	0.577	1.363	38.93	3.54	15.96	1.501
State & Local Gov. Services	0.907	0.000	0.238	1.262	19.10	0.00	6.58	1.344

Dir: Direct Effect Idt: Indirect Effect Idd: Induced Effect
* Per dollar of spending
** Per million dollars of spending
*** Per unit of employment

The personal income and employment multipliers shown in Table 2 show the direct, indirect, and induced effects of a change in spending and employment within the New York metropolitan area. In the case of the hotel and lodging industry, for example, each dollar of spending would generate $1.62 in personal income. Each $1 million in spending directly generates 10.5 jobs, indirectly generates 2.96 jobs, and induces the creation of an additional 3.78 jobs, yielding a multiplier of 1.642 for each additional job in the industry.

The hazard simulation outlined in Table 3 follows situations that have occurred in the area over the last decade with the predictions and occurrence of severe winter storms and tropical storms. As a result of the weather forecast, the hazard impact can be viewed as occurring in two stages. The forecast of the event drives the first stage of simulated impact as households, firms, and government prepare for the potential hazard by, for example, purchasing emergency supplies, reducing activities, and moving emergency personnel and equipment into place. In the second stage, the event has occurred causing a number of physical damages or impact that will affect economic activity and consumer welfare.

Table 3: Hazard Simulation

Weather Hazard Forecast	**Weather Hazard**
Forecast induced precautionary behavior	Hazard Impact
Households purchase emergency supplies	Physical damages to structures and capital
Government puts equipment and personnel in place	Power outages
Firms take precautionary measures (i.e., airlines cancel flights, etc.)	Disruption to transportation systems
Visitors adjust travel plans (terminate visits early, delay trips, etc.)	Delays to business activity
	Changes in economic activity
	Temporary alterations to commuting patterns

Economic Impacts

Reductions in sectors such as hotel/ lodging, restaurants, miscellaneous retail, etc.
Increases in spending on government services, forecast induced purchases, damage induced repairs, etc.
Impacts on income and employment
Losses to consumer welfare from service disruptions

On a typical weekday, according to the Metropolitan Transit Authority, there are an average of 867 thousand vehicles that use the bridges and tunnels to cross into and out of New York City, and ridership on the commuter rail system averages 559 thousand people daily. An additional 7.3 million passengers take New York City transit subways and buses. A severe weather hazard could potentially impact hundreds of thousands of commuters and users of the transportation system, not only by preventing individuals from arriving at their destinations, but also by affecting sales by vendors in and around these transportation hubs.

Last year, according to news reports, an estimated 367 flights into and out of the New York area were canceled in the presence of a high probability severe winter storm forecast, stranding thousands of passengers at area airports, and reducing overnight hotel stays, and consequently, related consumer spending for close to two days. Tropical Storm Floyd in 1999 caused widespread flooding in the New York metropolitan area and led to power outages for over 300,000 homes.

Following the simulation in Table 3, suppose that a hazard forecast led to a reduction in restaurant spending by consumers (visitors and commuters leaving early) of $45,000 (1500 meals at $30), reductions in hotel/lodging of $150,000 (1000 visitors at $150 per room), and reduced spending on theater entertainment of $24,000 (300 tickets at $80). Overall loss to output from the forecast are $216 thousand in direct impact, $70 thousand in indirect impact, and $77 thousand in induced impact, for a total of $364 thousand. The loss in output would also translate into a loss in employment of 4.2 people, $145 thousand in personal income, and $26 thousand in indirect business taxes.

These losses occur regardless of whether the hazard actually occurs or not. In the event that the hazard actually impacts the area at or above the predicted level of severity, additional losses may occur. Concomitantly, some of the losses may be offset by spending on the part of households, government, and firms for precautionary measures, undertaking repairs, and other possible activities.

It would be possible as well to assess further losses by tracing through the direct, indirect and induced impacts of the an actual hazard. The level of these impacts, though, would depend on the severity of the hazard event, as well as the areas affected by the event. Given the aggregated nature of the I/O model, it would not be possible to assess the impact by specific geographic impact area.

5. Conclusions

Natural hazards affect a community by affecting the behavior of residents and decision-makers as well as by their direct impact. Forecasts of hazard events have the ability to cause economic impacts similar to those caused by an actual hazard event through their effects on behavior, especially in the short run. Assessing the long run effects of hazard forecasts, and natural hazard on the economy, and the New York Metropolitan area are beyond the capabilities of the I/O model used here, and require a much greater amount of data.

The I/O model provides a useful starting point for assessing some of these impacts, but is limited by the scope of its assumptions, and static nature of an unchanging economic area. Overtime, human behavior will adapt to the hazardous situation, and the economy will evolve requiring a more dynamic framework for assessment.

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