Some Issues in Accounting for Disasters

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Abstract

Disasters such as Superstorm Sandy generate demands for estimates of their costs. Disaster costs encompass both physical damage and the cost of reconstruction, along with temporary disruptions to output. The Sandy experience highlights how the official statistics system supplies no estimates at the subnational level, and confines the national physical estimate to a somewhat limited set of assets. Estimates of output losses are very fragmentary. Extrapolating these from observations of disruptions to daily routines may be problematic. It is suggested that estimates of tangible assets at the state level may be helpful in gauging the relative scale of disasters, and that research on worker time use could help to improve estimates of output losses.

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Some Issues in Accounting for Disasters

How should we estimate the cost of disaster such as Superstorm Sandy? This paper explores some of the conceptual issues and some of the practical concerns in making such estimates, and offers a few suggestions about data that may be useful to acquire and report.

Categorizing Disaster Costs

The initial issue is defining what is meant by a disaster and its costs. For simplicity, a disaster may be viewed as an event that renders unavailable for some noticeable period—or destroys—a noticeable portion of the inputs of a fairly well-specified area.[1]

Disasters affect people and areas. A disaster affects the wealth of the people residing in the area (for simplicity, wealth moves are assumed to correspond to welfare moves), while also impacting production in the area.

The wealth of the residents of the area may be expressed as

$$(1) \qquad \int (w_t LR_t + TRANS_t) e^{-rt} dt + NHW_0$$

Where

w_t =Hourly wage received by workers who were residents of the affected area at the time of the disaster.

LR_t =Aggregate hours worked by workers who were residents of the affected area at the time of the disaster.

$TRANS_t$=Net transfers to persons who were residents of the affected area at the time of the disaster.

NHW_0=Nonhuman wealth of residents of the affected area at the time of the disaster.

A disaster will alter the time path of the hours worked by residents, surely reducing it in the short run. Wage rates will also likely be altered. Residents' physical wealth will also be reduced to the extent they own assets damaged, destroyed, or whose market value has otherwise fallen as a result of the disaster (naturally, nonresident property owners will also suffer losses). A sensible measure of the cost of a disaster to the area's residents is

[1] Much of the literature on evaluating the cost of disasters appears to be oriented to more profound events, such as the Haitian earthquake, which involve severe disruptions to infrastructure over wide areas. Pelling, Özerdem, and Barakat (2002) and Barrito (2008) discuss the impact of profound disasters on national economies. In contrast, this paper is concerned with more limited events which, though, may involve considerable dollar costs. Lists of major US events and estimates of physical damages resulting from them may be found at http://www.ncdc.noaa.gov/billions/events and http://webra.cas.sc.edu/hvri/products/sheldus.aspx.

the present discounted value of the external transfer inflow necessary to restore aggregate wealth of the directly affected population to its initial value.

The value of the output of a region is[2]

(2) $p_{t*}F_t(L_t,K_t,E_t,M_t)+\mu_t$,

Where
F_t=Production technology used in the region in time *t*.

P_t=Price of the output produced in the region in time *t*.

L_t,K_t,E_t,M_t =Labor, capital, energy, and other intermediate products employed in the region.

μ_t=An exogenous shock to the production process.

A disaster will likely alter the time paths of the inputs to production in the region, may be associated with a negative exogenous shock, and may result in changes to the production technology used in the region (a change in the production function, not merely a shift in the factors). The demand for the output of the region may also change, affecting its price. The impact of a disaster on the region's output could be viewed as the change in the present discounted value of production over some fixed period including and following the disaster. It's possible that over some time periods the disaster may have a positive impact.

The distinction between the types of disaster costs illustrates how discussion in the wake of an event can be confused. In the wake of any disaster, such as Sandy, there is a marked focus on the physical damage—how many homes and cars were destroyed, how many businesses suffered serious losses, etc. Physical damage estimates are important since they will be primary inputs, along with private insurance reimbursements, in determining the amount of net transfers required to make whole the population of the affected area.

Of course, physical damage to fixed property in the area of disasters does not equate to the wealth loss of residents. A large portion of the wealth of residents will be the present value of their wages. Furthermore, property in the area may be owned by nonresidents. Sandy's destruction of vacation houses on the Jersey shore owned by nonresidents affected locals only to the extent it affected their employment opportunities, which is a fairly ambiguous issue. Opportunities were created for employment on such tasks as

[2] In this setup spillovers from disasters in one area to production in another area are ignored. Some recent episodes, such as 9/11 and Hurricane Katrina (for its effects on national energy production), saw notable spillovers of this type. Blomberg and Hess (2009) make estimates of the national impact of 9/11; Greenberg, et al (2013) discuss the potential regional (New York and New Jersey) effects of a hypothesized New Jersey railroad disaster.

debris removal and rebuilding, but the timing and amount of income for routine maintenance and repair were also, possibly adversely, affected.

Property owners in a disaster area may also experience wealth losses in excess of physical property damage (defining physical damage as the cost of restoring property to a state allowing it to produce the same time path of physical output with the same physical inputs as prior to the event). The practical difficulties involved in computing such losses may be substantial, since in many instances determining the pre-disaster market value of such assets would be quite difficult.

Physical damages and other losses to wealth resulting from a disaster are reasonably straightforward concepts. More complex to address are the questions about the output effects of a disaster.[3] The answers will always depend on what time interval and region is being asked about. If the questions deal with the region directly affected, any or all of the elements entering into the determination of nominal output in equation (2) may be affected by the disaster:

1. The demand for the production of the region may shift. In the immediate aftereffect of Sandy there were widespread cancellations of 2013 reservations to stay at the New Jersey shore, which may be interpreted as a downward shift in the demand curve for New Jersey shore output, working to reduce its price.

2. The production technology used in an area may change. Following a disaster, the affected region may produce different goods and services, or may produce the same items using different techniques.

3. Various inputs may be more or less available. For instance, liquid fuels and electricity were in short supply in New Jersey and New York just after Sandy, and transportation and other problems inhibited workers' ability to travel to their jobs.

4. The disaster may be associated with a sequence of shocks to the production process—possibly initially negative, then positive. Such shocks should be distinguished from the shifts in the availability of inputs.

A common question asked is when output in the region directly affected (say the Jersey shore, in the case of Sandy) will return to "normal." Presumably, normality means either a return to the pre-disaster level or path of output. Why should there be any particular interest in the short-run fluctuations in output (and employment) associated with a disaster? One reason is that estimates of the loss of output, its total and its timing, from a disaster may be useful to states projecting the potential revenue impact of the event.[4]

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[3] Xiao and Van Sandt (2012) provide evidence from the aftermath of Hurricane Ike on the interrelationship between household rebuilding and business recovery.

[4] There is also an expenditure impact from higher unemployment insurance claims, which encompasses not only outlays to those temporarily laid off, but the potential of a state upshifting to a status triggering extensions of the periods for which the unemployed may collect benefits. The latter was a considerable concern for New Jersey in the wake of Sandy, given the possibility that a sharp rise in new claims for unemployment insurance in November 2012 portended a marked increase in the state's unemployment rate.

This information is not only important for normal budgeting purposes, but is also asked by rating agencies and investors in municipal securities.

In contrast to the numerous estimates of physical damages, there are few estimates of the effect of disasters on the time path of regional outputs. Clearly, a major obstacle to such work is the need for data on the production technology of an area, essentially a model of the region's economy, including its interactions with other areas. [5] Guimaraes, Hefner, and Woodward (1993) use an econometric model to simulate how Hurricane Hugo affected the output of South Carolina. The model was estimated using pre-Hugo data—in effect, as they note, freezing the state's production technology and demand prior to the storm—then inferring the storm's effects from out-of-sample errors. Bram, Orr and Rapaport (2002) estimate the effect of the September 2011 attacks on New York City employment from out-of-sample errors of autoregressions; the impact on aggregate wages (which would be a major component of the impact on output) was then readily inferred. It is clear that both procedures are heavily based on the reliability of the pre-disaster model estimates, as well as other assumptions (Guimaraes, Hefner, and Woodward assumed that the national economic environment was not affected by Hugo, but Bram, Orr, and Rapaport produced estimates that assumed that the U.S. baseline also changed after September 11).[6]

FEMA makes available models that estimate full-blown regional costs—both physical damage and output loss--of various types of disasters (their HAZUS models) but these estimates are clearly heavily dependent on highly specific assumptions about the effects of disasters on specific elements of a region's capital and infrastructure, as well as details of the input-output structure of the affected area's economy and how it may evolve over time. Such estimates may provide some benchmarks supporting requests for aid, and may be useful in thinking about long-term planning for a region, but are not likely to be available to provide especially informative timely estimates of the effect of a particular event.

U.S. Data Systems' Tracking of Disasters

Existing U.S. official economic data systems do not systematically account for the effects of disasters on either regional wealth or regional output, especially in a timely fashion. One shortcoming is the lack of high frequency subnational output data. Even at the national level estimates of output at any higher frequency than monthly are highly problematic, except for weekly unemployment claims and some measures of industry physical production (auto assemblies and the like). State-level data is highly limited at

[5] Cochrane (1997) describes some of the channels though which a disaster affects regional and national output. The literature on the economic effects of disasters emphasizes the need for formal modeling to better calibrate their regional impacts (e.g.; Greenberg, Lahr, and Mantell, 2007).
[6] Greenberg, Lahr and Mantell (2007) review the types of models that may be used to compute the time series of regional economic impacts of disasters.

the monthly level, and is often only available with a significant lag.[7] Clearly the problems are accentuated at the sub-state level. We can observe how payrolls and unemployment claims change in an area in the wake of a disaster but have little else in the way of reliable information that may be related to output.

The situation for national physical damage estimates is better. BEA releases formal estimates of the aggregate dollar value of damage to reproducible fixed assets caused by disasters. These estimates are based on insurance industry and other information, such as FEMA counts of destroyed or damaged structures. Unlike many of the numbers disseminated in the wake of a disaster, these figures are produced in a systematic accounting framework. However, the numbers are national, not regional and even at the national level they are incomplete:

- They are only provided at the national level. For some events, such as 2008's Hurricane Ike (which was confined essentially to Texas) the national aggregate is sufficient. For many others, such as Hurricane Katrina and Sandy, the lack of breakdown at the state level poses an obstacle to understanding the specific regional impacts of the disaster. Ironically, BEA's older treatment of disasters, in which disaster damage was viewed as an increase in capital consumption, allowed for a better analysis of regional effects, since uninsured private damage would directly depress components of quarterly state personal income, especially the rental and proprietors' income series.

- BEA's damage estimates, in line with their usual accounting for capital valuation, are of the decline in the reproduction cost valuation of the depreciated assets. That loss may or may not equal the loss in the market value of (nonhuman) wealth due to a disaster. BEA's estimates also do not take into account the installation costs of replacement assets. This is of particular concern for damaged public infrastructure: The cost of repairing washed-out roads and bridges would likely exceed the value of the loss of the depreciated assets.

- The list of assets included in the accounting is fairly narrow. BEA does not estimate the loss of business inventories from a disaster. These losses would be included in the usual reports on business inventories, and would thus subtract from GDP in the quarter in which they occur. Also, BEA does not estimate the amount of disaster loss to personal property, such as automobiles, furniture, and appliances.[8]

[7]Most notably estimates of state gross product are only available at an annual frequency, and initial estimates for a year—which are based heavily on simple extrapolations of industry wage data—are not released until the middle of the following year.

[8] It appears that as many as 30,000 automobiles were lost to New Jersey businesses and households as a result of Sandy (this total would include autos destroyed on the New York harbor docks, which are located in New Jersey). Apparently as much as 80 percent of these were the property of households. If the average value of household autos lost was $20,000, there was a loss to New Jersey households of roughly $500 million from this source. If the average value of business autos lost-new cars on dealer lots, and those on the docks-was $30,000, the loss would have been roughly $150 million, which would have been treated in Q4 GDP as a reduction in inventory investment at an annual rate of $600 million. Other business

Adding Up Sandy

EQECAT, the catastrophic risk management firm, issued an estimate on October 29, 2012, prior to landfall, that Sandy would inflict $5 to $10 billion in insured damage and total "economic losses" of $10 to $20 billion (http://www.reuters.com/article/2012/10/29/us-storm-sandy-losses-idUSBRE89S0RG20121029). EQECAT updated its estimate after landfall to $10 to $20 billion in insured losses and economic losses to $30 to $50 billion (http://www.businessinsurance.com/article/20121101/NEWS04/121109990?tags=|306|64|305|76|83|302). These estimates were aggregates for all regions hit by the storm. During that following week Moody's Analytics issued detailed estimates of damage ($30 billion) and output loss (approximately $20 billion) by industry and state.

Throughout November 2012 economists throughout the affected region engaged in numerous discussions about gauging the impact of the storm; among the groups involved were the New Jersey Treasury Department, the Federal Reserve Banks of New York and Philadelphia (as well as the Board of Governors), the Port Authority of New York and New Jersey, and some of the universities in the area. These discussions were held while state officials in New York and New Jersey were preparing estimates of damages that were sent to Congress for consideration in the relief legislation that was ultimately enacted in January 2013. On January 30, 2013—three months after the storm and just after the passage of the relief legislation—BEA issued an estimate that Sandy inflicted $44.4 billion in damage. As noted above, BEA's concept of storm damage is somewhat limited, which helps explain why this number is smaller than other damage estimates.[9]

In December 2012 Rutgers University hosted a conference on regional economic issues at which Sandy effects were a major topic. In January economists at Rutgers issued a study of the effects of Sandy (Mantell, et al, 2013); they estimated that the storm directly reduced New Jersey's state output by $11.9 billion in the fourth quarter. This loss-not at an annual rate-would be a quite visible share of New Jersey's product of roughly $500

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inventories would have also been lost to the storm. However, even taking these into account it's a bit hard to think that storm damage accounted for more than a small portion of the approximately $60 billion drop in the annual rate of inventory accumulation between the 3rd and 4th quarters of 2012. The closure of the Port of New York for a period after the storm, and the difficulties in transportation in the region, could well have contributed to the inventory investment decline by reducing the inflow of imports, but such would have no net effect on GDP. Contacts in the logistics industry report that power outages created severe problems at many warehouses and distribution centers following Sandy. It's possible that under such conditions these firms' reports on inventory levels were less reliable than normal, which could have affected the Q4 data.

[9] BEA's estimate can be found at http://www.bea.gov/national/pdf/sandytable.pdf. The updated damage estimate is $44.9 billion. Annual estimates of losses from events such as Sandy are in BEA fixed asset tables 1.7 and 1.8. GDP table 5.10U contains estimates of quarterly capital transfers stemming from disasters.

billion a year.[10] The report also suggested that there was $4.3 billion in rebuilding activity in the fourth quarter, which would have offset a portion of the direct output loss.

The Rutgers study has received a good deal of attention. However, the output loss estimates were apparently based on highly indirect observations. Specifically, the estimates of the direct output loss, prior to any rebuilding offset, were derived under the assumption that the storm interruptions reduced weekly output in the state (averaging a bit less than $10 billion) by 2/3 in the first week, 1/3 in the following week, and 1/6 in the third week. Thus, the state was assumed to lose 1 1/6 week's production, of which none was offset in later weeks after the restoration of power and more normal conditions to the bulk of the state. The assumption about the pace of rebuilding activity was based on the official state estimate that the cost of repairing and replacement the physical damage from the storm was $29.3 billion (http://www.state.nj.us/governor/news/news/552012/approved/20121128e.html; the state also included in estimates of the all-in cost of the storm additional sums needed for future infrastructure upgrades), and that the rebuilding process would be completed in approximately 2 years.

While the basis for the weekly direct output effects was not specified, the most likely motivation was observations on the labor front. Most New Jersey residents missed some work during the week of the storm, and there were ongoing problems for several weeks afterwards, mainly related to power and transportation problems, though in some instances flood damage limited access to buildings.[11] There were 154,476 new claims for unemployment insurance filed in New Jersey in November, which was nearly twice as high as the previous top month in the state's history.

Only a small fraction of the new claims filed resulting in actual unemployment insurance payments, and the November labor market data shows that private-sector employment in New Jersey actually rose slightly in November 2012 (the preliminary numbers, which is what the Rutgers group had available for their analysis, reported a decline of 6,200, or .2 percent). Total payroll employment is estimated to have dropped only 600 in November and for the fourth quarter as a whole employment in the state rose at a higher rate than in either the second or third quarters. Furthermore, BEA has estimated than in the 4th quarter of 2012 wage losses in New Jersey resulting from interruptions caused by Sandy were only 0.7 percent of the state's total—an amount equal to only about $400 million (http://www.bea.gov/newsreleases/regional/spi/spi_newsrelease.htm).

Of course, it is arguable that the employment and wage numbers mask output effects more on the lines the Rutgers group assumed. Possibly hours actually worked, as opposed to hours paid, slumped dramatically as New Jersey residents stayed home in the dark but remained on their employers' payrolls. In effect, productivity may have dropped, bringing down output. Also, remediation and rebuilding activity could have

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[10] At the time the study was prepared the latest estimate of New Jersey's nominal GDP was the preliminary 2011 figure of $487 billion. The current figures are $493 billion for 2011 and $508 billion for 2012.

[11] Of course, some workplaces in Shore towns were destroyed, and employers—if they resumed business—had to find new sites.

offset a larger portion of the depressing effect of the storm than the Rutgers study assumed. Increases in employment in construction and administrative and waste management services in late 2012—two sectors likely to have benefitted from remediation and reconstruction efforts—did more than offset losses in accommodation and food services—a sector heavily affected by the storm.

New Jersey's revenues may also give some idea of the output effect of the storm. Table 1 shows that state revenues in November and December 2012 were roughly $160 million short of the state Treasury Department's targets of over $4 billion, or less than 4 percent short (the storm's negative economic impact was likely more concentrated in November than in December, but numbers of important revenues, particularly the sales tax, are collected with a one-month lag). If the approximately 4 percent revenue shortfall was entirely due to Sandy reducing nominal state output by that amount in those months,[12] the loss of output in New Jersey in the fourth quarter would have been around $3 billion, based on monthly state output averaging roughly $40 billion. This is substantively less than the Rutgers assumption of a total output loss greater than $7 billion (the difference between their estimate of the direct disruption effect and the gain from rebuilding). However, the linkage between current tax collections and current output is fairly loose, so one cannot immediately use the revenue results to dismiss the Rutgers estimate.[13] Still the combination of little or no employment loss and only modest revenue losses suggests that the Rutgers number could have been an overstatement of the output loss from the storm, even taking into account the possibility that remediation and reconstruction activity stepped up briskly in its aftermath.

Table 1

New Jersey
State
Revenues
(thousands)

	Targeted Revenue	Actual Revenue	Variance	Percentage Variance
September 2012	$2,363,300	$2,288,177	($75,123)	(3.2)
October 2012	$2,003,000	$1,914,170	($88,830)	(4.4)
November 2012	$1,703,600	$1,519,912	($183,688)	(10.8)
December 2012	$2,342,100	$2,367,424	$25,324	1.1

[12] This is a strong assumption, because revenues shortfalls in September and October also averaged about 4 percent. It could well be that state output was less than (implicitly) projected in all four months, but the revenue figures do not by themselves suggest that the average gap was wider in November-December than in September-October.

[13] For example, revenues in December 2012 and January 2013 probably were affected by late-2012 realizations of capital gains and dividend income, and accelerated and magnified payments of estimated tax, by upper-income residents reacting to the scheduled January 1, 2013 federal tax increase. Also, February 2013 revenues were affected by delayed income tax filings, and a low outflow of refunds, reflecting IRS delays in updating forms in response to the change in federal law.

January 2013	$2,982,200	$3,057,682	$75,482	2.5
February 2013	$1,648,300	$1,804,608	$156,308	9.5

Notwithstanding the apparent signals of only modest negative effects suggested by the employment and revenue numbers, the reality was that for a large portion of November much of the state was without power and there were considerable transportation problems, stemming from gasoline shortages and closed commuter rail lines.[14]

One potential reconciliation of the scale of the disruptions with the possibly surprising employment and revenue numbers is provided by the observation that approximately one-third of New Jersey's state output is produced by industries whose quarterly output (and employment) would be relatively insensitive even to a marked interruption: real estate, education, health care and social welfare, and government.[15] Real estate output is, of course, primarily the shelter services of the housing stock, which, except for the homes destroyed or heavily damaged by the storm, was sustained through the period (the discomfort people felt sitting at home after the storm was due to lost power). In education, health care, and government, services unprovided during the storm were likely fairly quickly regained: classes were rescheduled, as were doctor's appointments, permits and drivers licenses were issued as offices reopened, back mail was delivered, etc. In many instances it is clear to imagine that much of the lost activity could be recovered without a particular extension of hours.[16]

It is conceivable that employees did a good deal of work at home during November 2012, despite the loss of power.[17] Fundamentally, utilities are an intermediate input to production. A loss of an intermediate input implies a reduction in multi-factor productivity. A decline in multi-factor productivity does not automatically entail a decline in output; the same amount of output can be produced, with some loss of efficiency, by substituting other inputs for the one whose scarcity has increased. In November 2012 it is quite possible that many New Jersey workers were able to do much

[14] While the majority of rail commuters in New Jersey likely travel to out-of-state workplaces, there are considerable numbers commuting to localities such as Newark and Jersey City.

[15] In 2011 these 4 industries accounted for $173.4 billion of the state's total output of $493.2 billion.

[16] For example, university faculty may have devoted more time to research during the storm, allowing for a pickup in teaching in the immediate aftermath without extending hours.

[17] U.S. Department of Energy figures report that November 2012 was the only month in the period from October 2012 through January 2013 in which New Jersey electricity usage was higher than a year earlier! This is scarcely believable, and may be an artifact of utilities' inability to gather meter readings in a timely fashion. Still, the scale of electricity usage declines in the state in the period around the storm does not appear to be consistent with an output loss of the magnitude suggested in the Rutgers report.
Another crosscheck on output losses is provided by the Federal Reserve Bank of New York's survey of New York state manufacturers report that only 36 percent of downstate firms experienced revenue losses due to the storm (http://www.newyorkfed.org/survey/empire/empire2013/2013_06Report.pdf). The average revenue loss in this fraction was 7.2 days, or perhaps 3 percent of a year's total. This suggests an aggregate loss of revenue for the manufacturing sector in the New York state region most affected by the storm of roughly 1 percent of a year's total. Assuming that this ratio can apply to output, and would be applicable to all New Jersey businesses, these results suggest an output loss to the state on the order of $5 billion. However, as noted, it is unreasonable to believe that all sectors were affected by the storm, suggesting that the actual loss could have been smaller

of their work from home using their own technology.[18] In effect, labor (home time), and capital (home technology) may have been substituted for unavailable inputs (office technology and power, and transportation).

Unfortunately, the data are not available to explore hypotheses about the nature of production workarounds during disasters. To gain more understanding on this issue, it may be useful to undertake time studies during such periods: what, exactly, did New Jersey residents do when their workplaces were closed and power out? If it is inconvenient to do such studies during the aftermath of a disaster, a follow-up as soon as possible when conditions normalize may be desirable.

Such information would have several uses. First, of course, it could help government, business, and household preparations for a disaster: precisely how much work can a person do at such times, and how are the problems addressed? What sort of equipment proves to be useful?[19] Second, getting an idea of how much immediate output disruption occurred as a result of a disaster would help local officials get a grasp of the revenue impact.

<u>Further Information Needs</u>

Receiving more timely estimates of the extent of physical damage would be useful, especially in framing requests for aid in rebuilding. Regional officials were well-aware that the optimal time for requesting national assistance was in Sandy's immediate aftermath. Such requests necessitate some idea of the dollar volume of the need. Also as noted, expanding the menu of damage estimates distributed by BEA or other federal agencies to include losses of personal property and business inventories would further aid the process of developing area needs.

Another enhancement in grasping the scale of the physical cost of a disaster would be more complete data on the proper comparative metrics. Obviously, the sheer current dollar cost of the physical damage caused by a disaster is a somewhat inadequate gauge of its significance; what may be more salient is (aside from the usual issues about deflation of nominal costs) the relative burden thrown upon an area. At the current time the most comprehensive measure of a state's economy is GDP. It seems likely that the total dollar damage from Sandy was not radically out of line with that arising from Katrina, but a comparison of volumes of aggregate activity in New York-New Jersey with Louisiana-Mississippi clearly indicate that the regional impact of the events were very dissimilar.[20]

[18] Utility outages were not an insurmountable obstacle. Virtually all residents had access to places such as public libraries where power was available and, of course, many residents acquired home generators (though obtaining gasoline for the generators was a major headache in large parts of the state).
[19] A windup emergency radio/flashlight with smart phone charging capability is astonishingly useful and fairly cheap, though it can't seem to completely charge a phone.
[20] BEA's estimate of the physical damage caused by Katrina is $110.4 billion, or about 2 ½ times their estimate for the damage caused by Sandy. The combined nominal GDP of New Jersey and New York was $1644.7 billion in 2011 while the combined GDP of Louisiana and Mississippi was $278.3 billion in 2005.

Comparing damage to the stock of physical assets to the flow of GDP is conceivably a bit deceptive. A more meaningful comparison might be the ratio of damage to the value of reproducible assets in the affected region. Unfortunately, there are no series that report such asset values on a consistent basis. However, it seems that from other existing data reasonable approximations can be produced. For example, Table 2 presents an estimate of the value of reproducible capital in New Jersey at the end of 2011. It is assumed that the value of reproducible capital used in a New Jersey industry is the same fraction of the national total as is the industry's output (the industry list includes real estate, which incorporates owner-occupied housing).[21] The value of durable goods owned by New Jersey residents is assumed to be the same fraction of the national total as is New Jersey residents' share of the national total of net earnings by place of residence plus transfer payments to persons.[22]

With these assumptions, the value of reproducible capital in New Jersey at the end of 2011 is estimated to be $1775 billion (the corresponding national total was $51 trillion; in other words New Jersey is assumed to have a bit over 3% of the nation's stock of reproducible capital, which is, not surprisingly, comparable to the state's share of national output). . It appears that the value of the physical damage caused by Sandy (including additional costs that will be incurred in the course of reconstruction and upgrading) was something over 1 ½ percent of the value of the capital in the state. While the estimate of New Jersey's capital stock is, of course, very approximate, it's clear that the value is not under $1 trillion or higher than $3 trillion. This very approximate estimate probably gives a better idea of the scope of the damage than does mere dollars, or even a comparison to state GDP.[23] The sudden loss—or sudden need to rebuild—1 ½ percent of the capital stock for a state is a major event, and for a state as large as New Jersey it's noticeable on the national scale, even before adding in the damage to New York and other states (which appear to have been in total somewhat larger than New Jersey's).

[21] Garofalo and Yamarik (2002) and Yamarik (2013) provide similar estimates of state private nonresidential capital.

[22] Overall personal income, an obvious candidate for such a scaling, includes the imputed rent from owner-occupied housing. Since owner-occupied housing estimates are implicitly in the industry counts, it's logical to use a less comprehensive series for the scaling for durable goods. Net earnings by place of residence include out-of-state earnings, which in New Jersey is a significant item.

[23] The method used to allocate the value of reproducible capital by state actually amounts, in effect, to distributing the 2011 national capital figures by the distribution of industry wages, since this is the main way national industry output is distributed to produce initial estimates of state GDP. The GDP methodology is, by itself, fairly imperfect, thus magnifying the potential imperfections in the capital stock estimate. Also, since, BEA's reproducible capital figures by industry are based on ownership, not actual usage, so there is some further inherent error associated in allocating its regional distribution by output. Still, given the aim to provide a usable estimate of the capital stock the procedure seems plausible. Of course, the pending categorization in the NIPA of R&D spending as final demand will swell capital stock estimates at the national and state levels. In many ways this will be useful in accounting for the scale of losses in disasters. In the last analysis, R&D capital is knowledge. Knowledge is essentially not lost in disasters, unless there is wide-scale loss of life.

Table 2

New Jersey Reproducible Capital, Year-End 2011

(billions of dollars)

Business and government capital, total	1604.3
Real Estate	817.5
All other private	461.7
Government	325.0
Consumer Durables	170.4
Total Reproducible Capital	1774.7

Conclusions: Tracking Disasters

The Sandy experience suggests the following:

- It's important to clarify what is meant by the "cost" of a disaster. For welfare purposes, physical destruction of reproducible assets is important and likely the main component. From the point of view of near-term income and revenues in the affected area, output interruption and loss may be the more useful metric. Adding the two together is useful for some purposes—for instance, insurance covers business interruption as well as physical damage, and other forms of disaster relief will ameliorate both problems—but they are conceptually different.

- We have little understanding of the size of output interruptions, and, most importantly, how they may correlate with rough measures of labor inputs. It's conceivable that some effort to track actual work effort through mechanisms such as time surveys would help in getting a better idea of actual worker experience in such periods.

- More timely estimates of damage estimates would certainly assist in understanding the dimensions of the event and framing requests for assistance.

- Small steps to enhance regional data systems would also aid in understanding the relative size of events.

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