# CLIMATE CHANGE AND ECONOMIC VULNERABILITY: AN ECONOMIC MODEL TO ASSESS INDIRECT ECONOMIC IMPACTS

ARCADIA FACTSHEET 5

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*Extreme weather events can have both direct and indirect effects on an economy. This factsheet outlines a new Adaptive Regional Input Output (ARIO) model of London's economy which can be used to assess such indirect impacts. Results demonstrate that indirect effects can be on the scale of direct effects. Consideration of only direct economic effects in climate adaptation can lead to incorrect conclusions as to where adaptation resources should be directed.*

## Context

- Climate related damage to one sector of an economy (such as transport) can lead to economic losses in other sectors, even if the latter sectors are not directly damaged.
- Including these indirect economic effects on measures such as GDP can significantly increase the perceived economic costs of climate change, as well as altering selection of strategies to reduce risks through adaptation.
- Gaining a scientifically sound understanding of both the direct and indirect effects of extreme weather events on an economy, and how these can be reduced through adaptation, is crucial to climate policy.

## Method

- Direct economic losses from extreme weather events can be defined as the physical damage to e.g. land, capital and machinery, usually seen immediately. Direct losses can subsequently cause business interruptions, usually seen in the short to medium-term.
- One way of quantifying direct and indirect losses is through Input-Output (IO) analysis. This captures interactions between industries which both produce goods and consumes goods from other industries in order to produce such goods.
- An input-output model of London's economy (ARCADIA ARIO) was developed based on the UK macroeconomic model of Cambridge Econometrics.
- The model reflects interactions between 42 economic sectors.
- The model is used to understand the sensitivity of London's GDP to direct losses from extreme weather events.
- The model estimates the length of time required before the economy fully recovers, which may be several years depending on the scale of original damage (fig. 1).
- The model also allows for simulation of different modes of allocating resources to the recovery effort, with options being to replace production capacity only as demand returns or to stimulate recovery by investing in replacement ahead of demand.

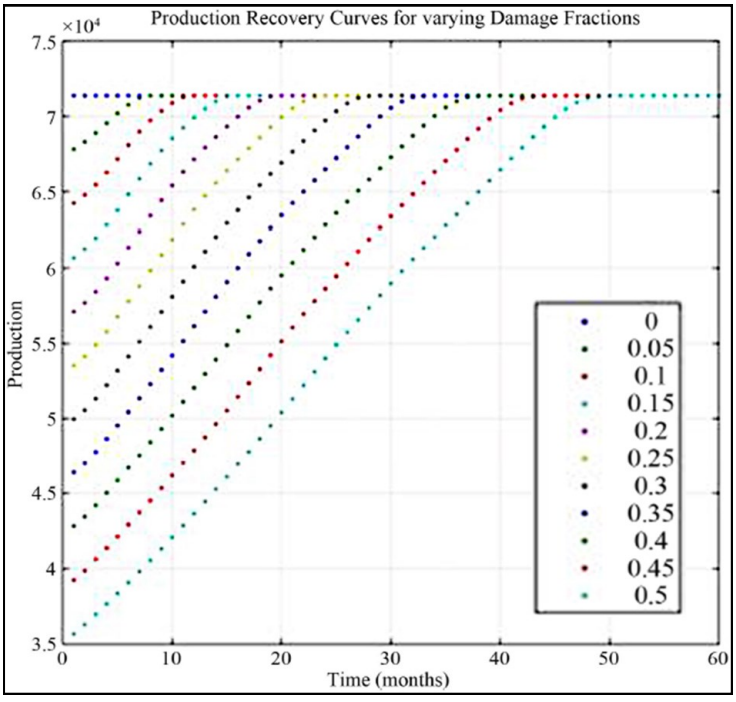


**Fig. 1: Plots showing the recovery of production over time depending on the ratio of direct losses**

## Key economic findings

- Indirect economic effects will generally be on the order of 30 to 50% of the direct effects, rising to 100% in the most extreme cases of damage to production capacity.
- The analysis is useful up to damages of about 50% of the production capacity. Beyond that level of damage, the structure of the economy is likely to change and such models are not reliable guides to understanding economic recovery.
- The length of time for recovery can be significantly shortened by government policies that stimulate the return of production capacity ahead of the return of demand (fig. 2).
- For London, the economy is most sensitive to damage within the Professional Services and Distribution sectors, at least in regard to indirect GDP losses (fig. 3).
- This is due to both to the size of these sectors, and to their crucial roles in many other sectors of an economy such as London's.

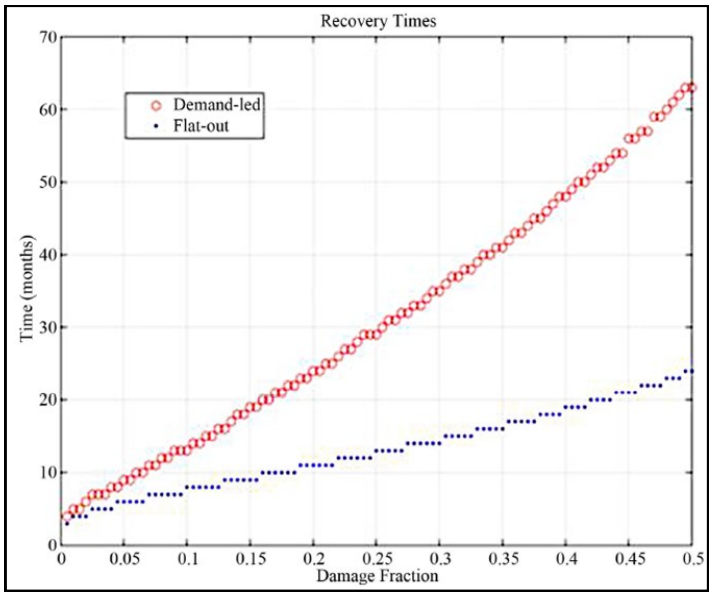


**Fig. 2: Recovery time for London's economy when replacement of damaged production capacity is demand-led (red), and where resources are devoted to recovery in advance of demand (blue). The x-axis shows the fractional direct damage to production capacity due to an extreme weather event.**

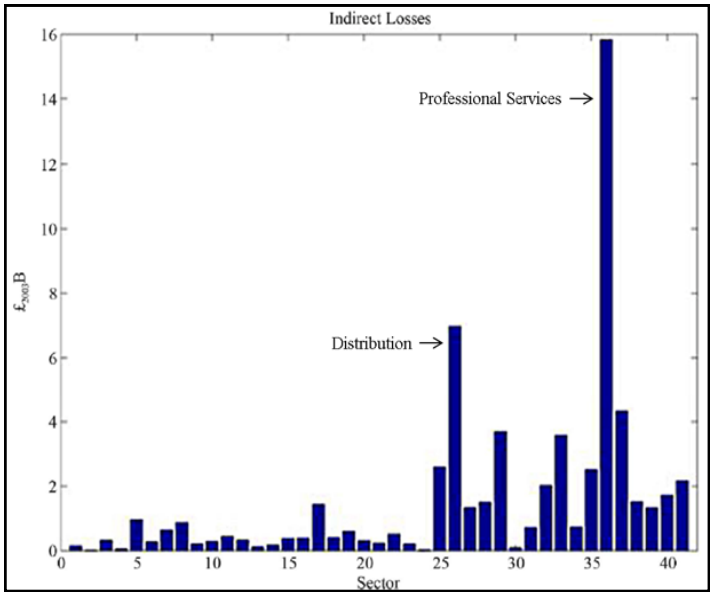


**Fig. 3: The sensitivity of London's economy, in terms of indirect losses (in billion £), when the same percentage of direct losses to production capacity is applied to each of the 42 sectors of the ARCADIA ARIO model in turn, and assuming no other sectors are affected.**

## Linking to other components of ARCADIA

- The ARCADIA ARIO model focuses on the economic damage and recovery caused by damage to production capacity.
- This damage is represented as a percentage change in production capacity following an extreme weather event.
- The model can be combined with results on direct economic damages from extreme weather events, calculated as part of the ARCADIA project.
- The vulnerability of an economy and its economic sectors to extreme weather events can then be determined using the ARCADIA ARIO model.
- For example, the indirect effects of damage to transport infrastructure, disruption of labour and the supply of goods, and damage to physical capital such as commercial and residential buildings.

## Policy relevance

- The modelling approach can provide information to better quantify the full economic impacts of an extreme weather event on a city's economy.
- It highlights the economic sectors where investments in adaptation may be most effective at reducing the vulnerability of the economy.
- It can be used to guide allocation of recovery resources following an event..

### For additional information see:

- ARCADIA website: www.arcc-cn.org.uk/project-summaries/arcadia/
- 4CMR Website: http://www.4cmr.group.cam.ac.uk/
- Crawford-Brown *et al.*, " Vulnerability of London's economy to climate change: Sensitivity to production loss", Journal of Environmental Protection, 2013. http://www.scirp.org/journal/PaperInformation.aspx?PaperID=33120