Worldwide Spreading of Economic Crises

Panos Argyrakis
Department of Physics
University of Thessaloniki
54124 Thessaloniki Greece
panos@physics.auth.gr
http://kelifos.physics.auth.gr

MODEL

- view the world as a network of all countries
- each country is a node ~ 200 nodes
- connection between nodes: economic relations
- fully connected network? answer = no
- all connections are one-way, with specific weight
- k-shell decomposition method to rank countries
- start a crisis on a single node
- allow the crisis to propagate throughout the network
- use simple propagation model, e.g. SIR model
- monitor countries that are affected

DATA

- **CON (Corporate Ownership Network):**

  4000 world corporations with the highest turnover with 616000 direct or indirect subsidiaries: network of 206 countries
- **ITN (International Trade Network):**

  Detailed information about international trade (import-export) between 82 countries

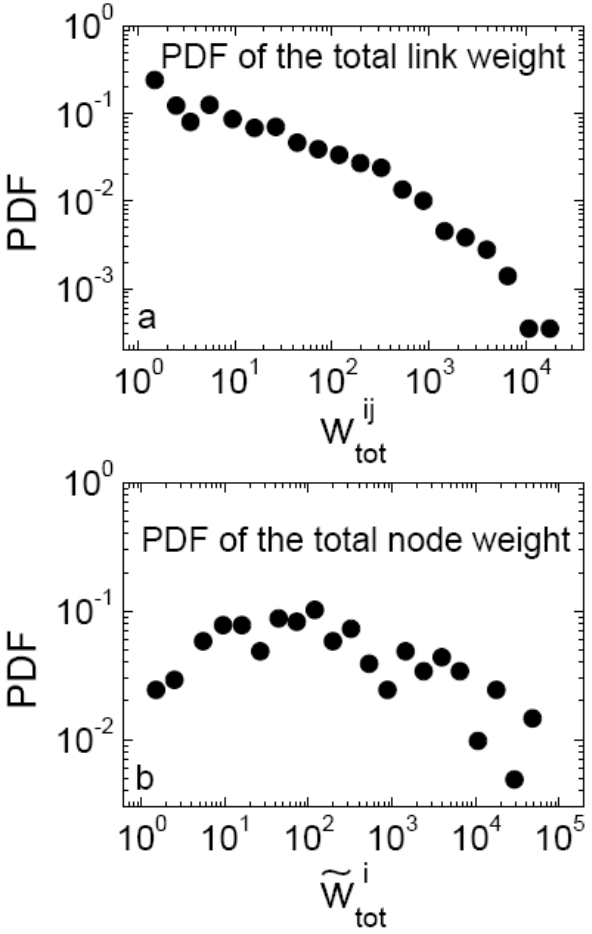
CON network

- Total link weight

$$w_{tot}^{(ij)} = w_{ij} + w_{ji}$$

- Total node weight

$$\tilde{w}_{tot}^{i} = \sum_j w_{ij} + \sum_j w_{ji}$$

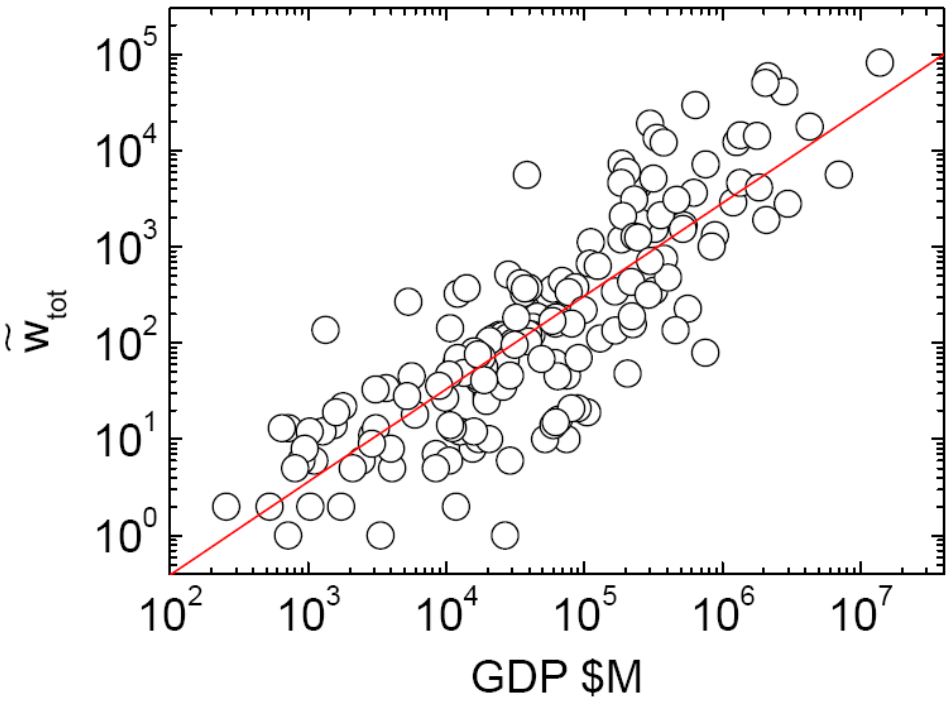


GDP vs Weight

- total node weight of a node *i* $\tilde{w}_{tot}^{i} = \sum_{j} w_{ij} + \sum_{j} w_{ji}$ versus its GDP

- linear relation:

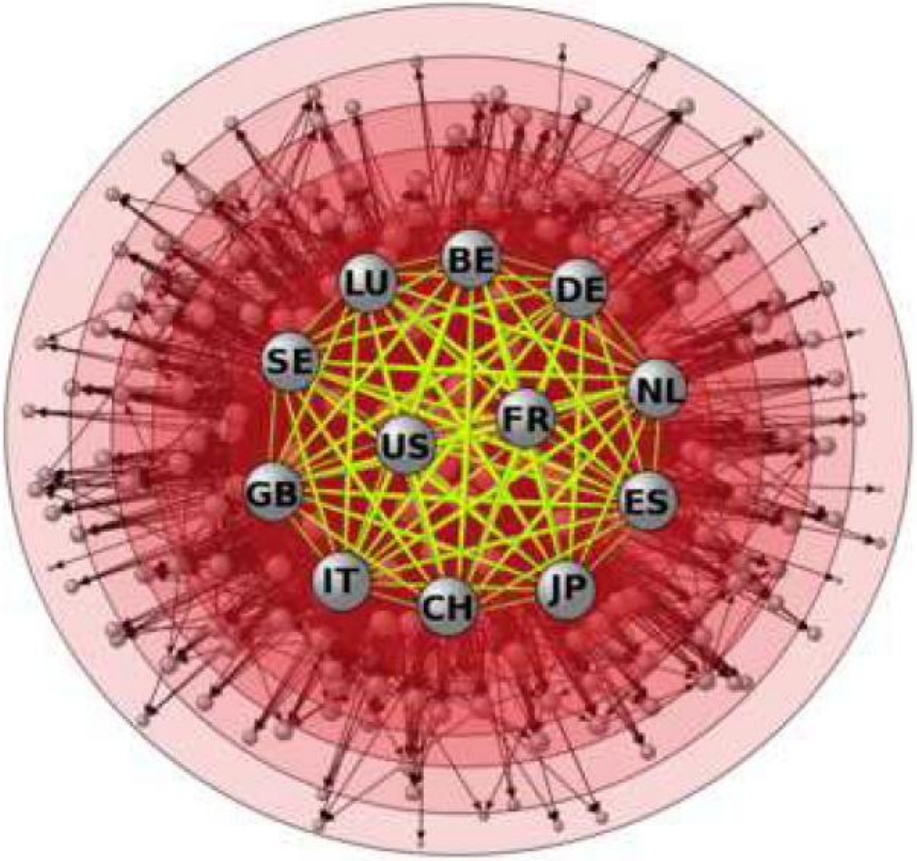
  Nodes with high GDP have high weight



The k-shell decomposition method

- Start with the actual network
- Identify all nodes that have k=1, and remove them.
- Repeat until we are left only with nodes that have k>=2
- These nodes constitute the shell k_s=1
- Similarly remove all nodes with k=2, in order to find the nodes with k_s=2, etc.

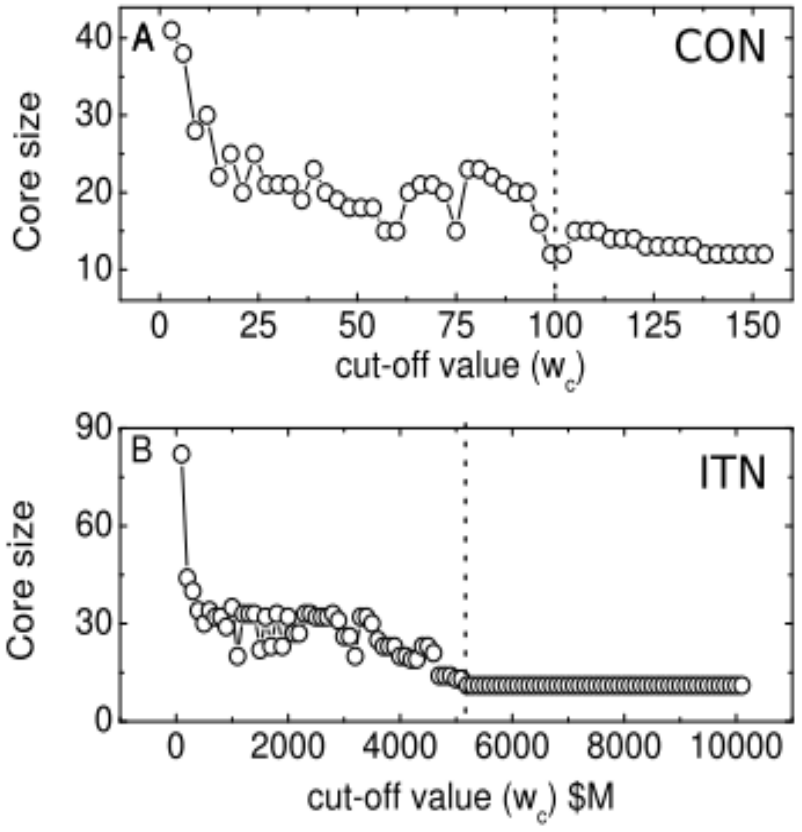
Illustration of the layered structure of the network



The core shown is the actual core obtained for CON

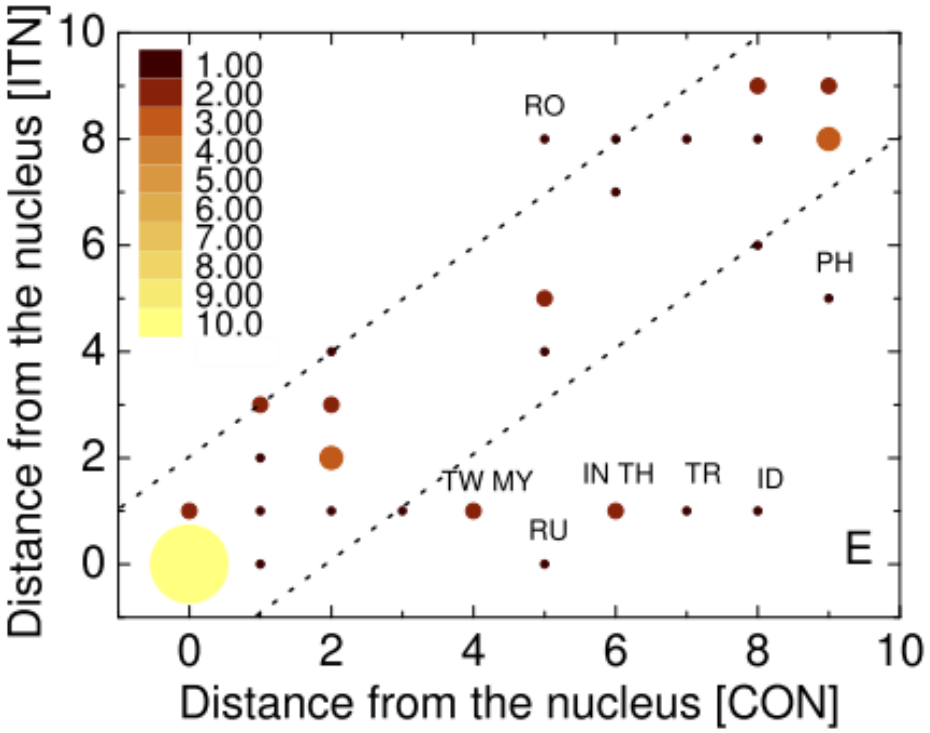
Identifying the core using k-shell decomposition

- We need a cut-off parameter for the weights of the network in order to identify the most internal core.
- We choose one that leads to a stable core



Change in the k-shell ranking

- Most countries (82%) are located in almost the same distance from the nucleus for both CON and ITN



Cores

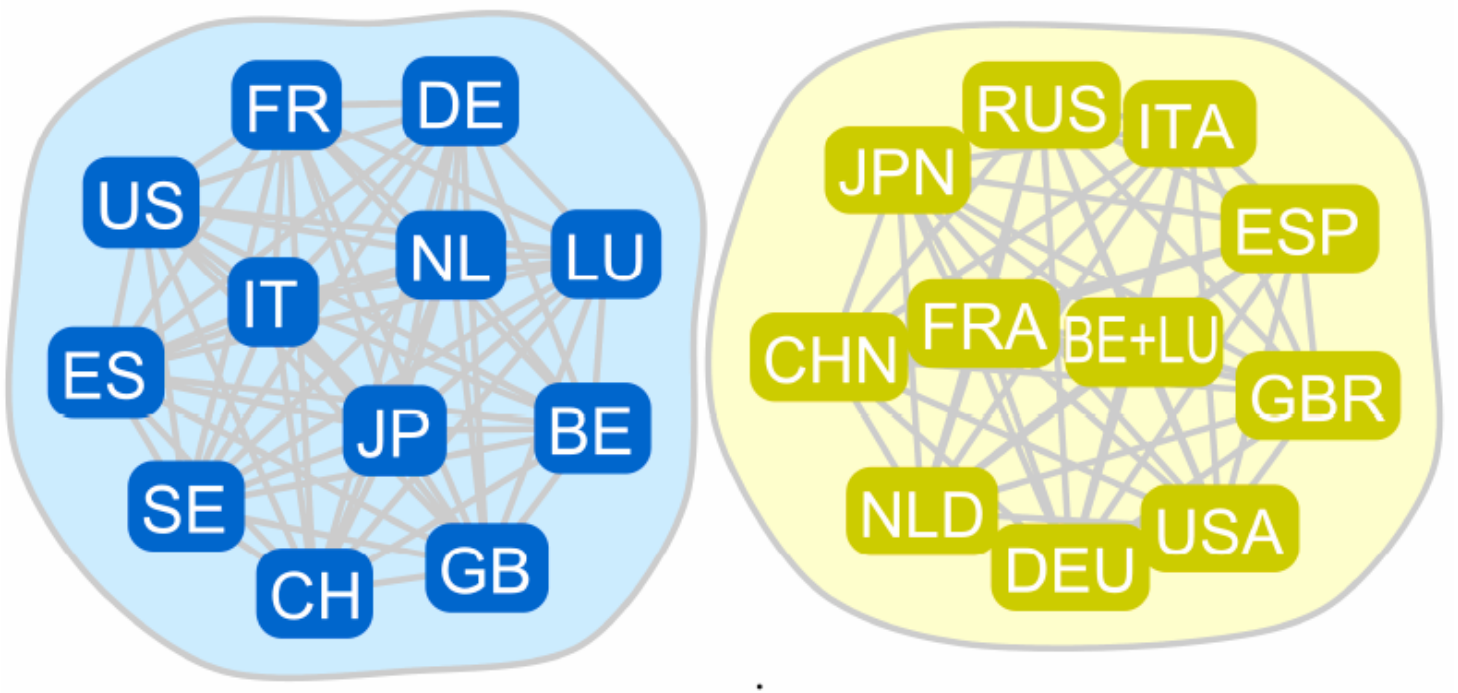
- **CON:**
  USA (US)
  United Kingdom (GB)
  France (FR)
  Germany (DE)
  Netherlands (NL)
  Japan (JP)
  Sweden (SE)
  Italy (IT)
  Switzerland (CH)
  Spain (ES)
  Belgium (BE)
  Luxembourg (LU)

- **ITN:**
  USA (US)
  United Kingdom (GB)
  France (FR)
  Germany (DE)
  Netherlands (NL)
  Japan (JP)
  Italy (IT)
  Spain (ES)
  Belgium (BE)
  Luxembourg (LU)
  China (CN)
  Russia (RU)

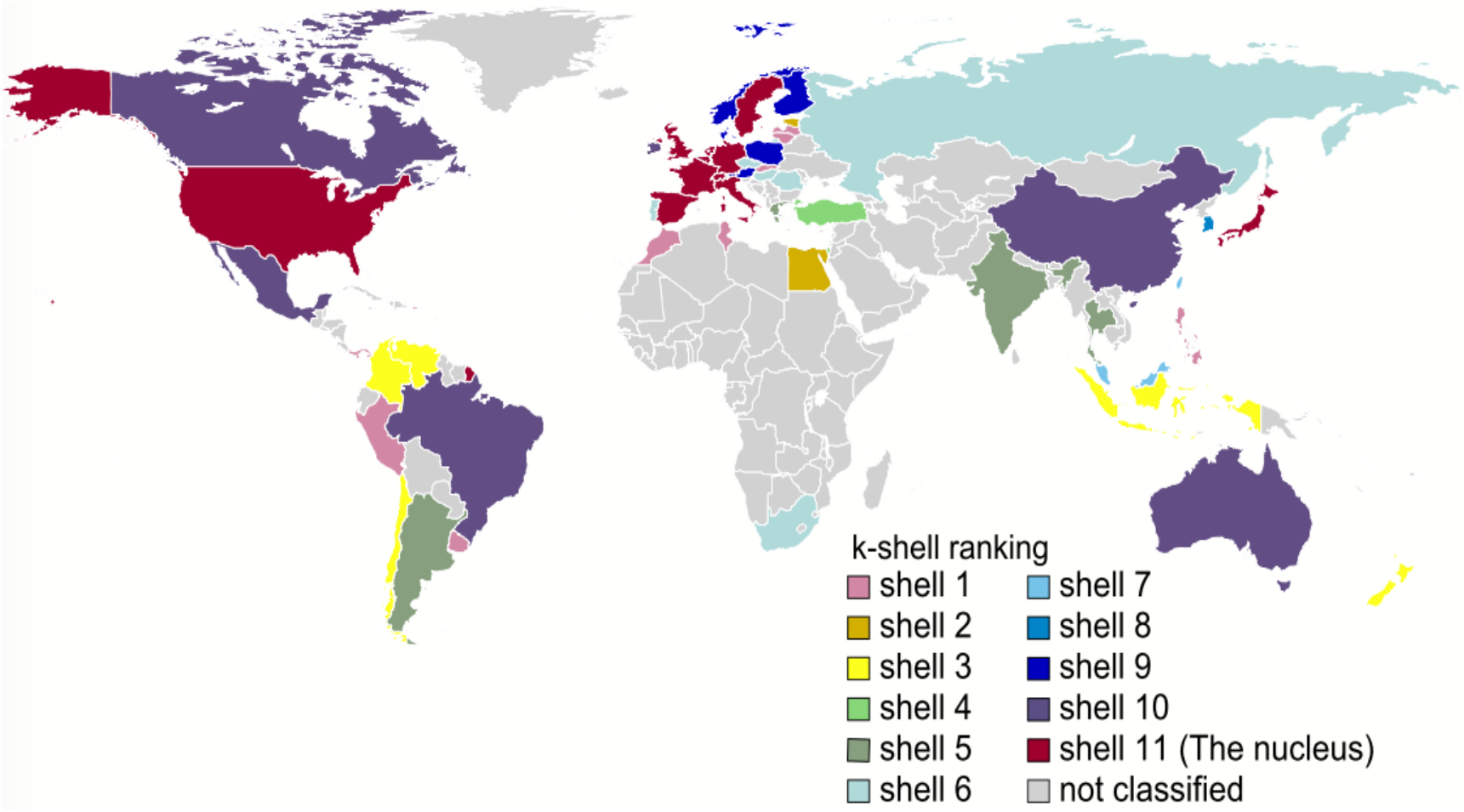
Clique Percolation Method (Palla et al)

CON

ITN



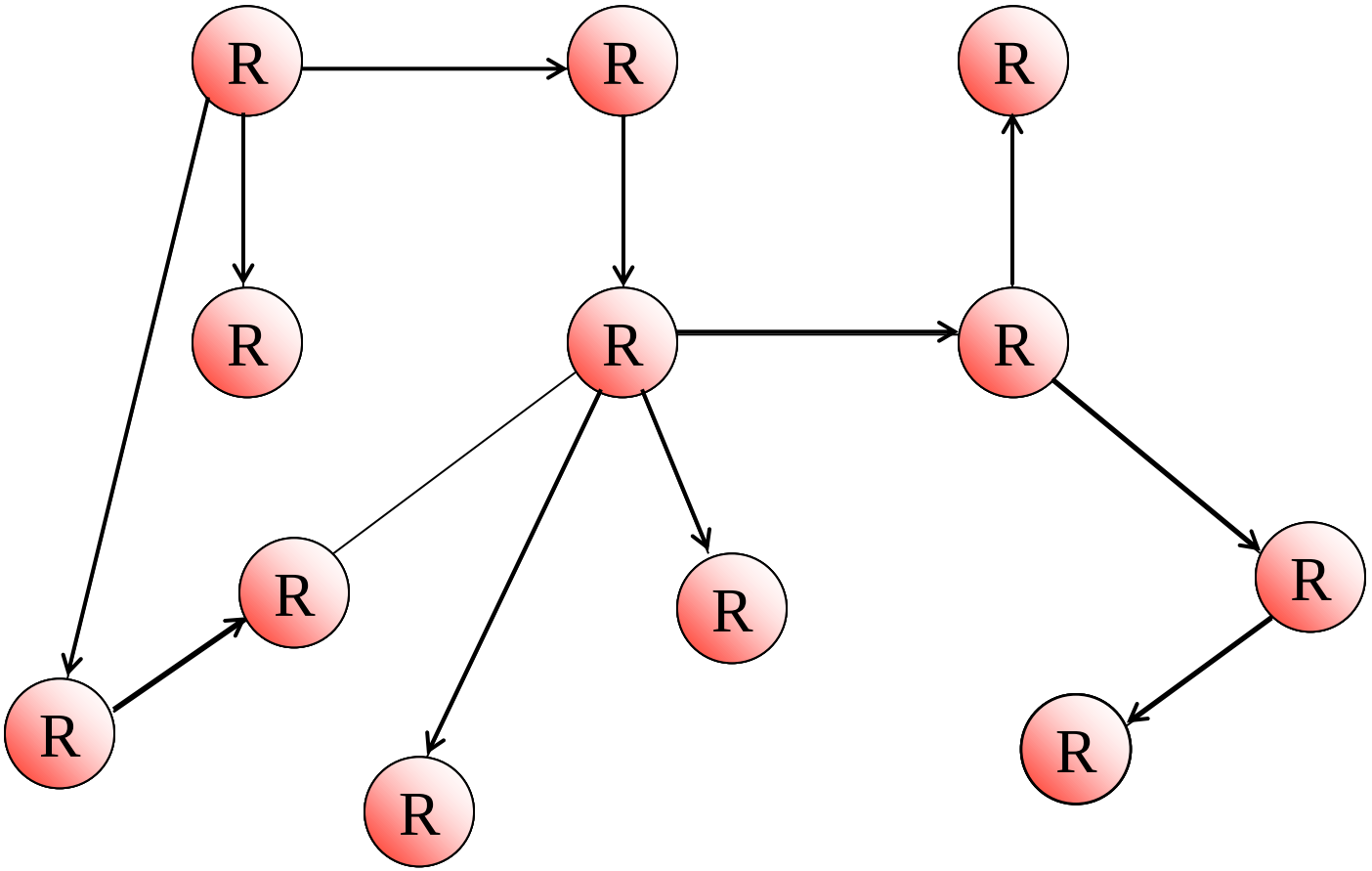
k-shell ranking of countries



The SIR model

- SIR (Susceptible, Infected, Removed),
- q=probability of infection
- Initially all nodes are susceptible (S)
- Then, a random node is infected (I)
- virus is spread in the network, all “I” nodes become “R”
- This process continues until the virus either
  - has been spread in the entire network, or
  - has been totally eliminated
- M=infected mass
- Duration

SIR



S Susceptible

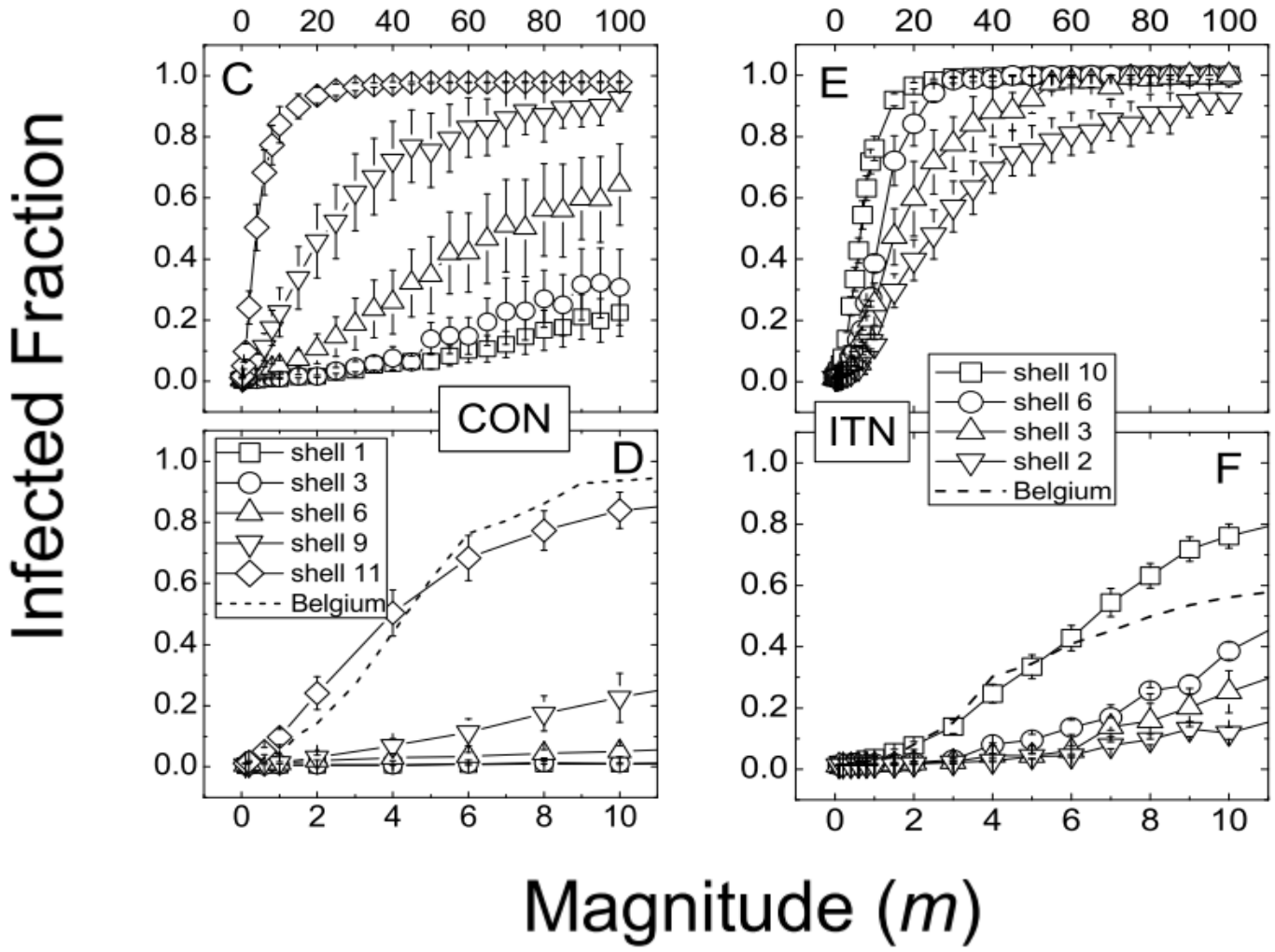
I Infected

R Recovered (or Removed)

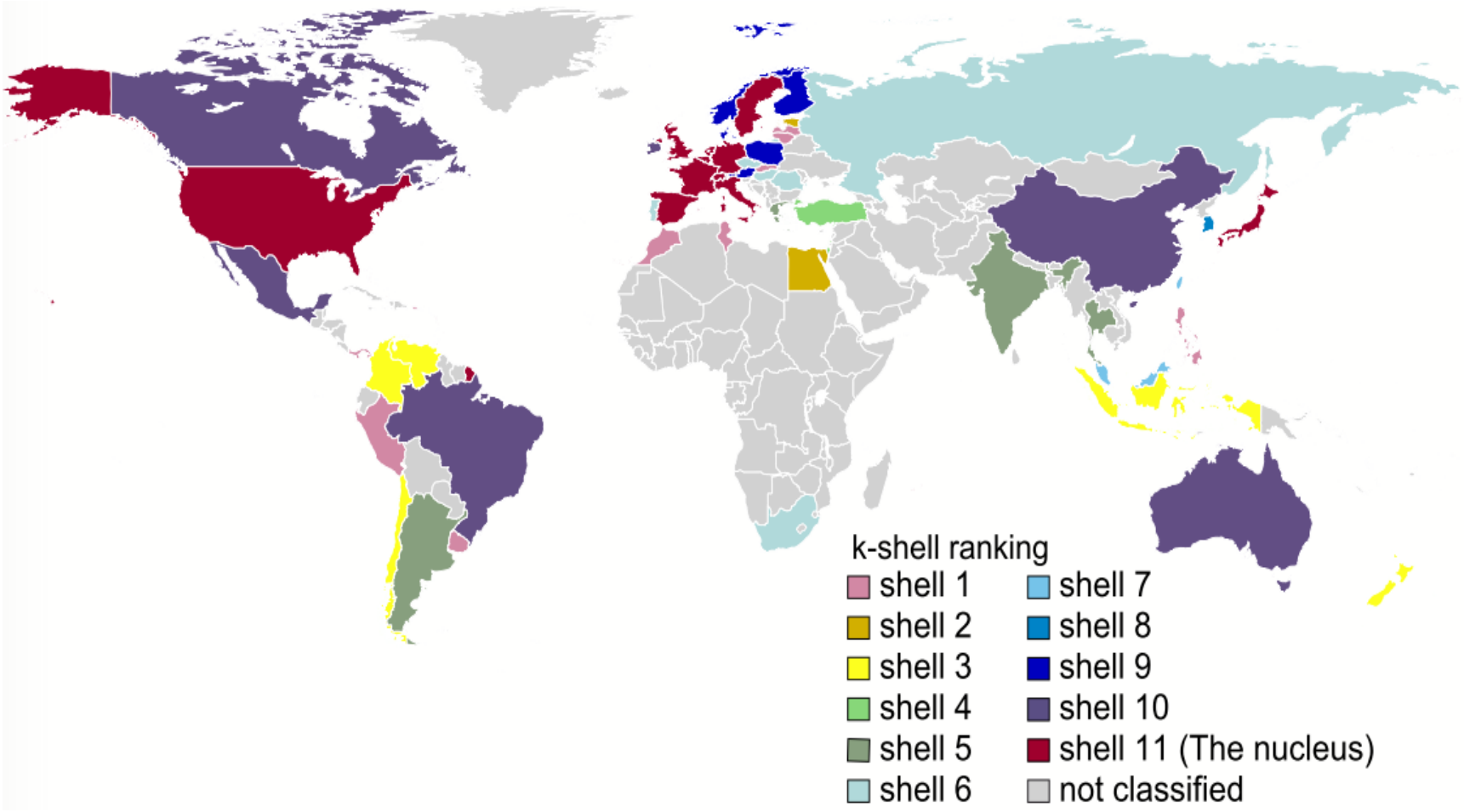
Modeling crisis spreading: SIR

- Infection probability: $p_{ij} \propto m \cdot w_{\mathrm{tot}}^{(ij)} / \tilde{w}_{\mathrm{tot}}^{j}$
- $w_{\mathrm{tot}}^{(ij)} / \tilde{w}_{\mathrm{tot}}^{j}$: the economic dependence of country “j” on country “i”
- m : the strength of a crisis

Infection depends on the shell where the crisis originates



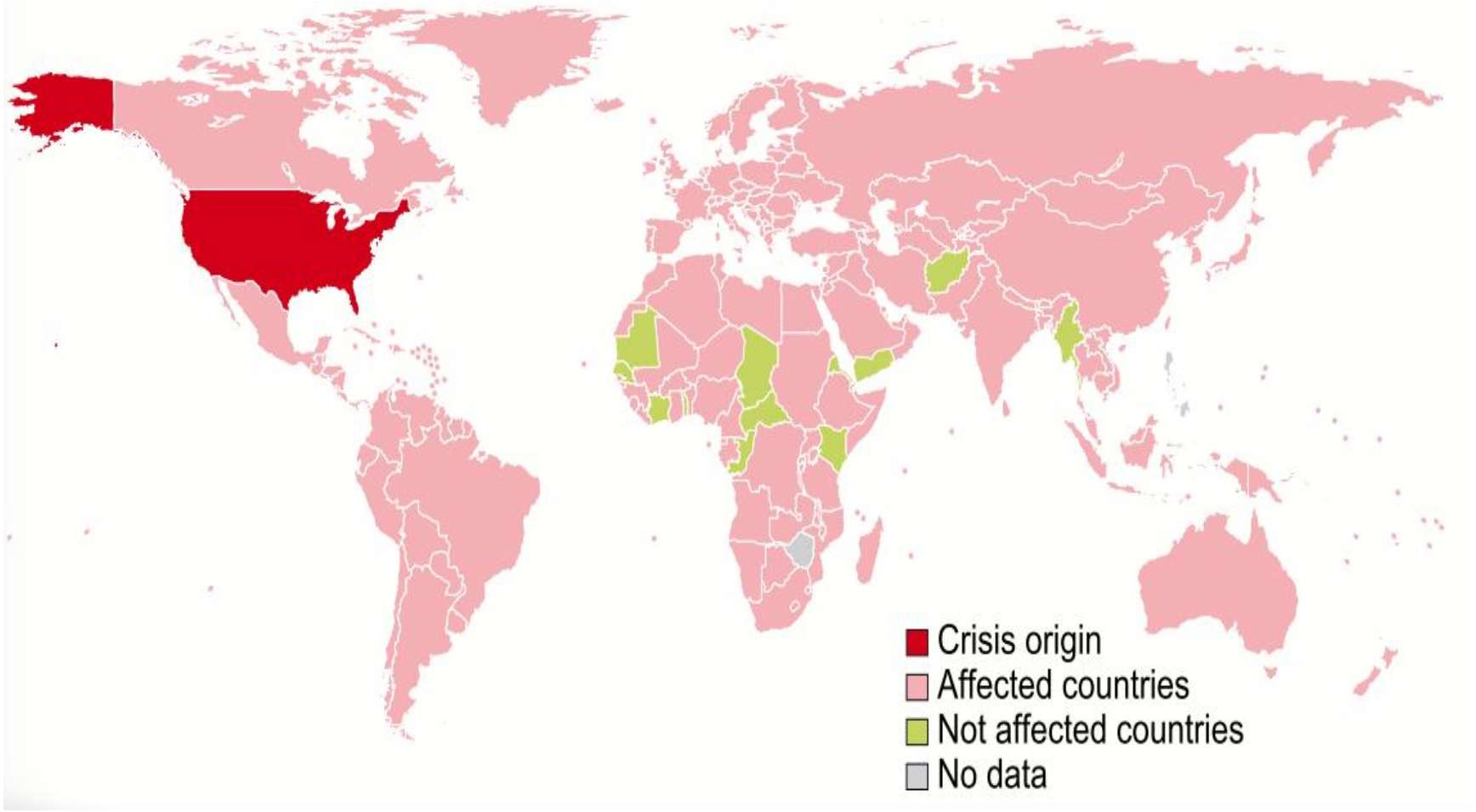
k-shell ranking of countries



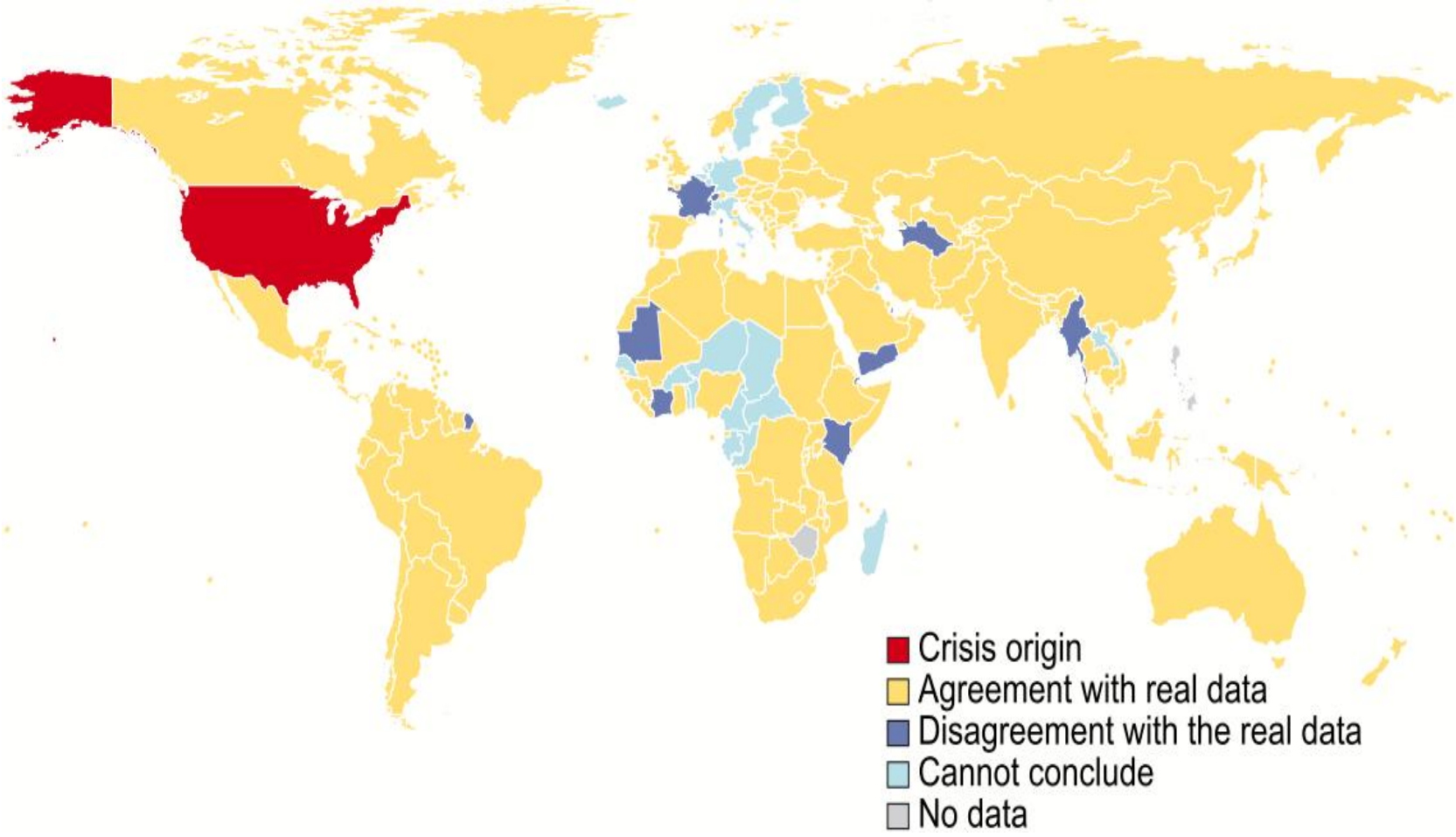
Determining if infected or not:

- Perform 1000 realizations of SIR
- Use arbitrary range
  - 0- 200: not infected
  - 200- 800: can not tell
  - 800-1000: infected
- If crisis starts in nucleus (inner core)
  - 90.6% of countries infected
  - 96.6% worst case scenario
- If crisis starts shell k=6
  - 3.3% of countries infected
  - 18.9% worst case scenario

Countries affected by the 2008 economic crisis



Model results: a crisis starts in US and spreads through CON



Example: Belgium

- 29th in the world in GDP
- Start a crisis with m=4.5
- Will affect 60% of world (average of 50 runs)
- Worst case senario: maximum value of the same 50 runs. Will affect 95% of world

Conclusions

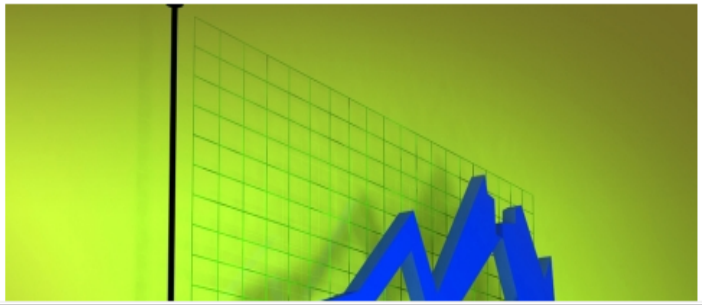
- Spreading of a crisis
- we used a NETWORK approach
- we used real data (companies, impo-expo)
- k-shell decomposition method
- SIR spreading mechanism
- a small number of countries (12) is critical
- not necessarily the largest economies

Luxembourg could trigger financial meltdown

27/08/2010, by Stephen Lowe

When Belgium sneezes, the world catches a cold

What's new in physics — By Lena on November 25, 2010 at 9:48 am




World money meltdown can start in surprising places, physicists say - Windows Internet Explorer
http://www.world-science.net/exclusives/100825_crisis.htm
Restore Down
File Edit View Favorites Tools Help
WEB SEARCH
DAEMON Tools Lite
Astroburn Lite
Weather
Translate
Facebook
Calendar
Map
NewsStand
Preferences
Search
Issues
Help
TV & Video
HOT Shows
Top Story
NBC
Like
E-mail Notifier
PANDORA.TV 4HD
Search
KMPlayer
CNN
YouTube
Facebook
Games
Amazon
Word of the Day
Options
Google
Search
Share
Check
Translate
AutoFill
Sign In
Favorites
World money meltdown can start in surprising pl...
Page
Safety
Tools
Ads by Google
Tell Your Senators
Our KC-45 will create thousands of new jobs right here in America.
kc45now.com
President on Jobs
Pres. talks to the US Chamber of Commerce today about economy.
www.c-span.org
Bernanke's Secret Plan
Free Report Reveals Debt Solution To End The Global
WORLD SCIENCE
"Long before it's in the papers"
January 18, 2011
RETURN TO THE WORLD SCIENCE HOME PAGE
World money meltdown can start in surprising places, physicists say
Aug. 25, 2010
Special to World Science
A small group of countries—including not just the mighty United States but also tiny Luxembourg—have the dubious honor of being able to spread an economic crisis globally once it sprouts on their soil, five physicists say.
The researchers say they arrived at the finding using concepts from "statistical physics" and available data that quantifies trade and business ownership ties among almost all nations. The scientists, from Greek, Swiss and Israeli universities, also used special formulas meant to estimate the probability of an effect, such as a disease, spreading between links in a network.
On Home Page
LATEST
Birds may attract mates with "scary movie" effect
Why do men use silly pickup lines?
EXCLUSIVES
From brain science, new questions about free will
Scientists explore whether some apes shake heads for "no"
It seems we're all more human than average
Baby temperament found to predict adult brain structure
MORE NEWS
What hit the Moon? New crater makes a splash
Tracks may tell tale of reptilian land conquest
Planets found sharing strange dances
Newfound stars seen shattering known size limits
Sign up for e-newsletter
your email
send
subscribe
cancel
Internet | Protected Mode: On
100%

Contributed to this work:

- Antonios Garas (now at ETH, Zurich)
- Shlomo Havlin (Bar-Ilan, Israel)
- Celine Rozenblat, Lausanne, Switzerland
- Marco Tomassini, Lausanne, Switzerland