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EMPIRICAL FINDINGS ON CRITICAL INFRA-STRUCTURES DEPENDENCIES IN EUROPE

If a critical infrastructure (CI) disruption cascades across CI boundaries, the potential for multi-infrastructural collapse and catastrophic damages may be high. However, how to rate this cascading risk remains unclear. In order to provide a more sound empirical base for understanding cascading effects, TNO developed and maintains a CI-disruption event database. Our analysis of the collected data shows that most cascades originate from only a limited number of critical sectors (energy, telecom) and that interdependencies occur far less often than most theoretical studies assume.

The database

TNO's CI disruption database contains 2650 CI disruptions in 164 nations and their 1090 cascading outages (September 25, 2008).
CI disruption events are recorded when there is a (potential) serious effect to society. The data is analysed to discover CI disruption patterns across different CI in the world, in Europe, and in the Netherlands. Although the data collection may be skewed, the database is unique as other databases only record sector- or threat -specific events.

European subset analysis results

The analysis regards the subset of 1749 CI failure incidents in 29 European nations. Cascades (29%) are not only events of low probability and high consequence!
The dependency matrix is sparsely populated as cascades are highly asymmetrical. Dependencies are very focused and directional. Energy and telecom are the main cascade initiating sectors (60% and 24%; see Table 1). Transport (5%) and water (3%) follow. The energy sector initiates more cascades than it receives. Interdependencies occur very infrequently: only two weak cases were recorded. Fixed telecom disruptions affect ATMs and electronic payments (financial sector), the mobile phone base stations - base station controller links, governmental services, and internet and telecom services. Within the energy sector, most dependencies (61) occur between power generation, transmission and distribution.

CI Sector	Cascade initiating	Cascade resulting	Independent	Total	Sample size
Education	0	3	1	4	4
Energy	146	76	388	609	590
Financial services	1	26	33	60	60
Food	0	4	3	8	8
Government	2	40	26	68	67
Health	1	16	22	39	39
Industry	5	15	7	27	27
Internet	15	51	95	161	160
Postal Services	1	0	0	1	1
Telecommunications	69	125	114	308	295
Transport	19	128	276	423	422
Water	9	18	51	78	76
Total	268	501	1017	1786	1749

Table 1. Categorisation of number of CI disruption events (number of events).

The domino theory suggests that serious CI disruptions result cascading failures. On average, however, an energy cascade initiating event triggers 2,06 disruptions in other CI; telecom triggers 1,86 disruptions.
One out of two energy sector events cascades.
Two out of five telecom disruption events cascade.
24% (421) of the disruptions are a first level cascade, 4% (76) a second level cascade, and four events are a third cascade. No deeper cascades were found internationally.

Conclusions

Theoretically, dependencies and interdependencies occur between all CI. Our findings show that, according to public sources, they are rarely strong enough to trigger a secondary outage. This questions the validity of the CI Domino theory.

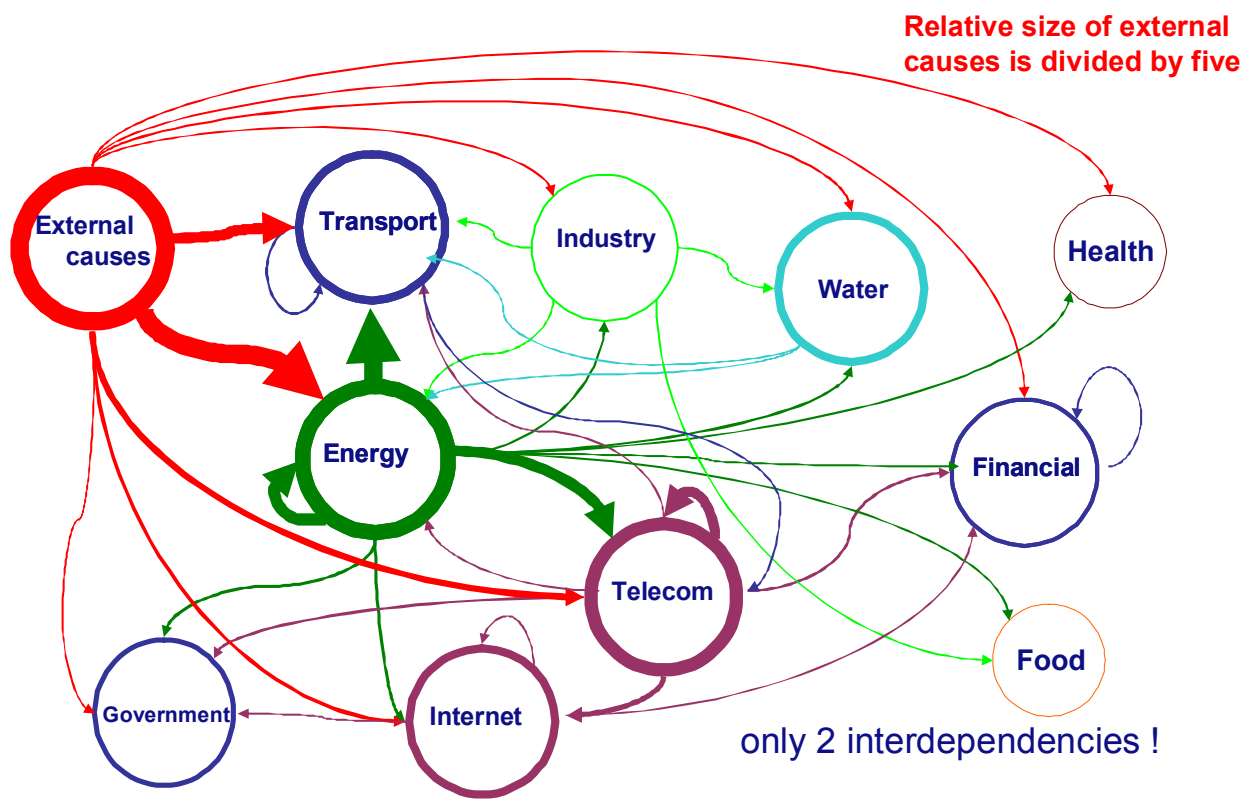
Reported cascades are highly asymmetrical and focused. The overwhelming majority originated within the energy and telecom sectors.
Interdependencies occur far less than analysts have consistently modelled. Only two cases occurred on a total of some 1050 cascading events. Do the CI operators manage their (inter)dependencies effectively or are the dependencies not that powerful to begin with? CI seem more loosely coupled than the Domino theory suggests, or are the cascading CI dependencies are not visible to (news) reports?

CI dependencies do not seem to be "the unmanaged challenge". Even an assumed vast shortfall in governance of the cascading risk does not translate into frequent deep cascades. Dependencies seem to be anything but unmanaged. Nevertheless, governance is needed.

In sum, the sobering conclusion emerges that CI cascading dependencies are focused to a limited number of CI sectors; occur more frequently than expected, and do not often cascade deeply.

Acknowledgments

The research described above was partly funded by the EU Commission as part of the 6th framework programme project IRRIIS under contract number FP6-2005-IST-4 027568 and partly under the Dutch Next Generation Infrastructure (NGI) research programme.



DenV080342