Managing complexity by understanding multiplex networks

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Drucker Forum, Vienna Nov 14, 2013
To manage a system means that you are able to predict the possible outcomes of actions you take

If you cannot predict the outcome of management actions – you do neither manage nor control the system: you are subject to luck, fate, external events and developments
What can you predict?

The future? Developments of markets? Sales of competitors?

certainly not...

... but it would be great if one could predict outcomes of your actions

It helps if you know what your firm is: *know thyself*
What kind of systems can you predict?

- Very small ones: physics of a few bodies
- Very large ones: describe laws of physics with laws of statistics
- Managing CS has been out of scope since beginning of mankind
Why is it so hard to predict complex systems?

- Mathematical and statistical tools break down (inter-connected)
- They are evolutionary
- Not enough data available
- No concept of the backbone of CSs – networks
What are Complex Systems?

CS are co-evolving multiplex networks!

(1) States of individuals/firms change as a function of network interaction

(2) Network changes as a function of the states of the agents

point (1): physics
point (2): makes it a complex system: society, eco-system, market, firm ...
The game changer: computer + new math + new data

- Network theory: quantify causal processes on networks
- Big-data availability: electronic fingerprints everywhere
- Novel statistics for strongly connected systems – superstatistics

If not all of the above → back to start: you can NOT manage CS!

Our claim: If you can map a CS into a dynamical NW → can manage CS

Theory of CS: combination of dynamical (evolutionary) systems and NWs
What is a firm?

- **Traditional view:** Firm produces something, chemicals, cars, cameras, etc.
  
purchase – production – sales and distribution – administration

- **Less ancient view:** A firm is a network of information flows

To illustrate the point: **What is a conference?**

Sequence of talks and coffee breaks? Or Network of information flow?
A firm is a co-evolving multiplex structure
Why CS methods in firms or corporations?

- Corporation is an evolutionary network of communication flows
- Management controls flows and tries to re-arrange the NW
- With and without management: the network evolves = re-arranges

→ CS tools assist to:

- know the network (reality check)
- find ways to re-arrange it (optimize)
- monitor its change after managerial intervention

Note: it is not easy to tell a network how to re-arrange!
Imagine new CEO entering a firm with say more than 1000 employees

- Knows organigram. Knows what departments should do + hierarchy
- **Does not know:** what departments are in reality
- Are departments structured in reality as the CEO thinks they are?
- How hierarchical is the firm in reality?
- Do re-structuring interventions work?
- Do optimal solutions to organization structure exist, given real structure

→ **Answer to this:** communication flows
Optimal network?

- The right people should communicate with each other (departments)
- Information flow should be direct
- Information flow should not be clustered
- Information flow should be redundant (how much?)
Communication: the nervous system of a firm

- Telephone bill: every call = one line

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<th>ID caller</th>
<th>dpt caller</th>
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<th>duration</th>
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- emails: log-files on server: every mail = one line

<table>
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<tr>
<th>ID Sender</th>
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</table>
email networks of firm (historical data)

week 4

week 15

with kind permission from Günther Weiss
emails-projections → departments 2011
emails-projections 2013

week 4

week 15
Network measures: quantify change
Network re-structuring over time

![Graph showing changes in network structure over time with metrics for average connectivity (avg con), average clustering coefficient (avg clu), and average path length (avg P−L).](image)
Why?
Danger of Buerocratization: Parkinson’s Law

C. NORTHCOTE PARKINSON’S DATA:
Bureaucracy grows even though its reason for existence vanishes

### ADMIRALTY STATISTICS

<table>
<thead>
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<th>Year</th>
<th>Capital ships in commission</th>
<th>Officers and men in R.N.</th>
<th>Dockyard workers</th>
<th>Dockyard officials and clerks</th>
<th>Admiralty officials</th>
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<tr>
<td>1914</td>
<td>62</td>
<td>146,000</td>
<td>57,000</td>
<td>3249</td>
<td>2000</td>
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<tr>
<td>1928</td>
<td>20</td>
<td>100,000</td>
<td>62,439</td>
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<td>-67.74%</td>
<td>-31.5%</td>
<td>+9.54%</td>
<td>+40.28%</td>
<td>+78.45%</td>
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### COLONIAL OFFICE

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<td>372</td>
<td>450</td>
<td>817</td>
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2 Principles

1) the buerocrat produces work for her colleagues

2) the buerocrat maximizes the number of his subordinates

Can compute: when does buerocratic infarction occur?  
(Infarction = more internal work is produced than can be worked off)

Input: communication flows + true hierarchical pyramid
Summary usefulness of CS tools for management?

- Complexity arises through inter-connectedness: networks
- If can map CS to dynamical co-evolving NW → technically manage it
- Conceptualize firm as a multiplex network of communication flows
- Questions to the firm network
  - actual structure of the firm? departments, hierarchies, ...
  - effective communication flows?
  - relate efficiency with network structure
- Monitor outcomes of mgmt decisions on communication network
  - re-structure departments
  - monitor re-structuring events
  - identify core-employees
  - identify ineffective comm. flows (cycles) → try to break cycles