AMERICAN UNIVERSITY

Complexity Based on a Firm's Control Hierarchy

Robin L. Lumsdaine

Santa Fe Institute, March 15-16, 2018

KOGOD SCHOOL of BUSINESS

Disclaimer

Views and opinions expressed are those of the speaker and do not necessarily represent official positions or policy of any institutions with which she is affiliated.

Introduction

- Our research is motivated by the definition of Systemically Important Financial Institutions (SIFIs):

  "SIFIs are financial institutions whose distress or disorderly failure, because of their size, complexity and systemic interconnectedness, would cause significant disruption to the wider financial system and economic activity."

- Regulators often rely on size-based thresholds => "too big to fail"
- Large literature using network analysis to examine interconnectedness
- What about complexity?

KOGOD SCHOOL of BUSINESS

Complexity of Individual Firms

- We approach from a lens of governance
- “High complexity” => corporate control structure that presents challenges for a firm’s senior management or supervisors, resulting in lack of oversight
- Allows subsidiaries to operate in relative obscurity within the organization
- Related to large literature on opacity (lack of information transparency)
- Poses risk to financial system when coupled with high degree of interconnectivity

Organizational Structure Literature

Connection and Communication

- **Control hierarchy represents *intra*connectedness of a firm (Coase 1937)**
- **Organizations tend to be siloed (Kleinbaum et al., 2013)**
  - **More communication occurs along connected than unconnected lines**

Risk

- **Complex organizational structures may contain undetected hazards**
  - **These may fester into systemic risks (Lumsdaine et al., 2015)**
- **Hampers authorities' ability to resolve an institution in financial distress.**

Organizational Complexity

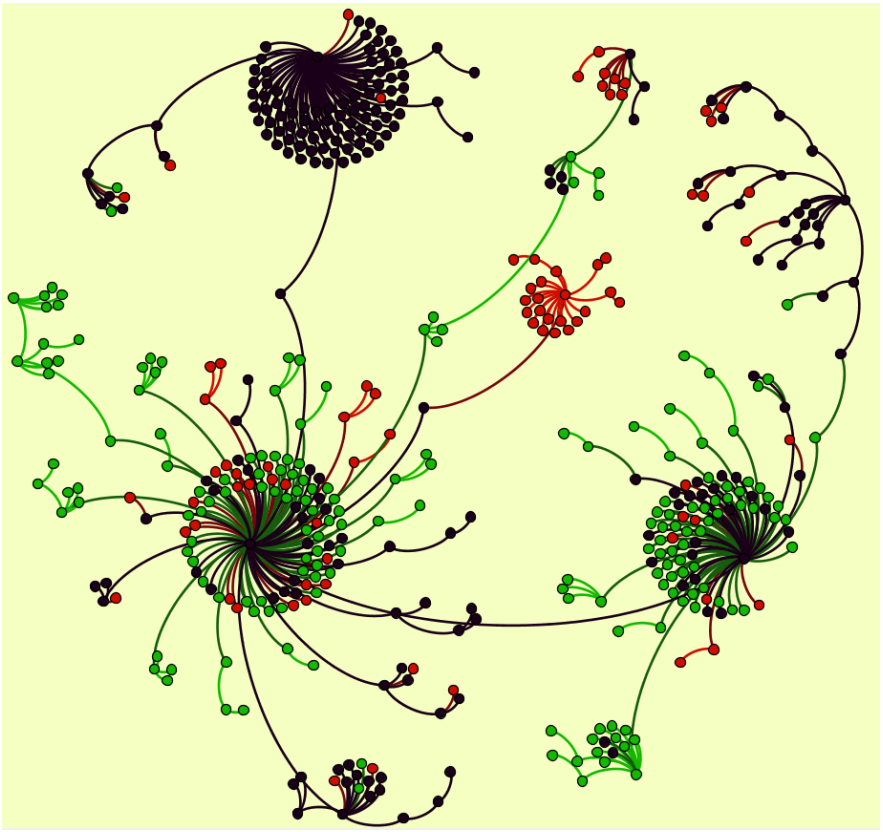
- **Complexity is usually interpreted in a counting (size-based) context**
  - **See: Grant et al., 2000; Carmassi & Herring 2013; Cetorelli & Goldberg 2014**
  - **This likely understates true risk**

Measurement

- **Need for comparison across firms**
  - **Robust to very different organizational structures**
  - **Distinct from size-based metrics (as in Lumsdaine et al., 2015)**

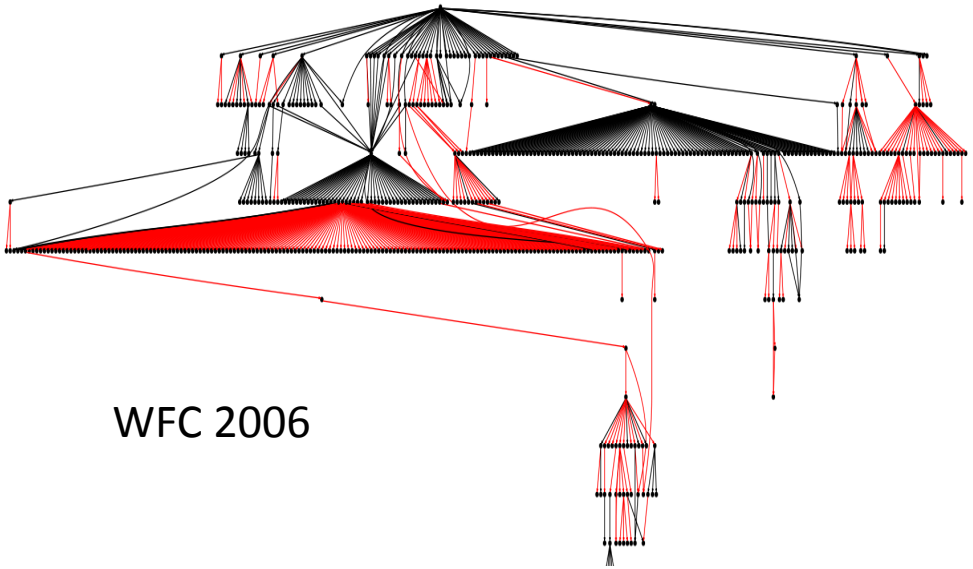
The Organizational Structure of a Major Bank

- Wells Fargo BHC, between 2006 and 2010
  - New since 2006
  - Gone since 2006
  - Always present
- Large number of entities
- Dynamic

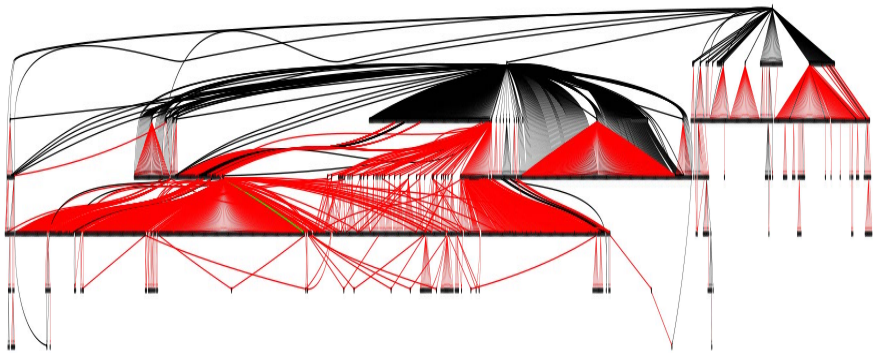


KOGOD SCHOOL of BUSINESS

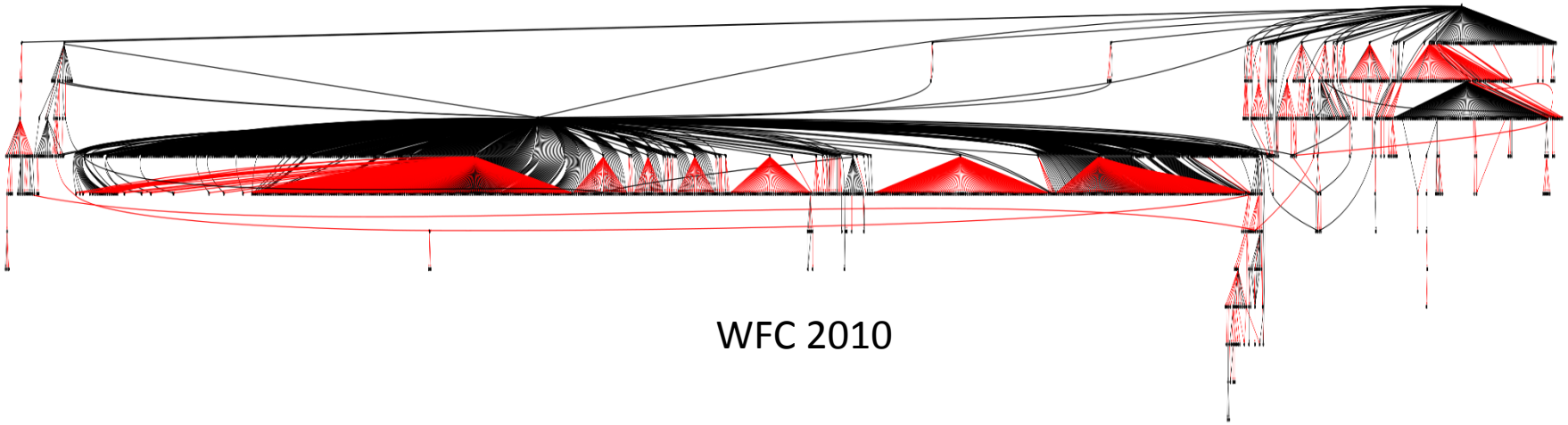
The Organizational Structure of a Major Bank



WFC 2006



Wachovia 2006



WFC 2010

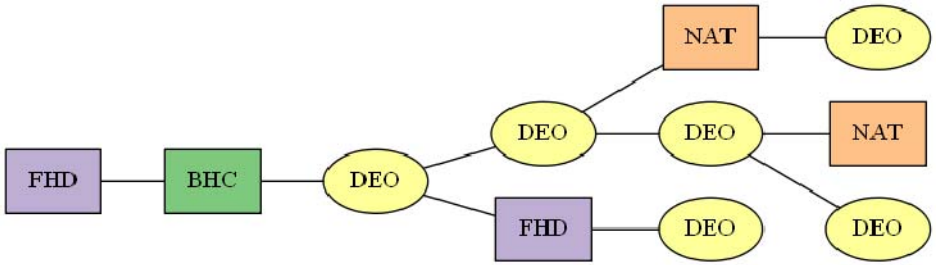
KOGOD SCHOOL of BUSINESS

Network Structure and Graph Quotients

Graph quotient for BHC hierarchies

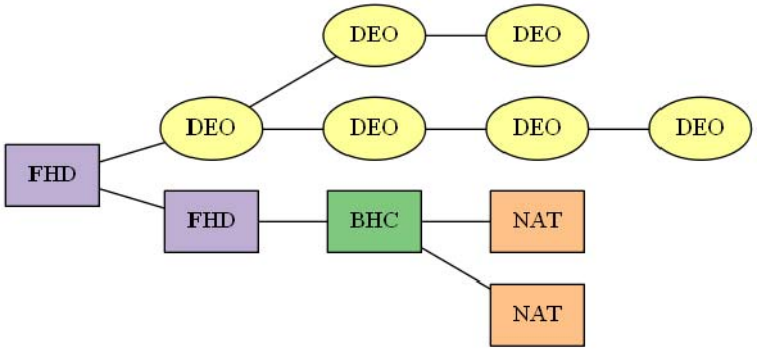
- **Partition subsidiaries into "types"**
- **Find edge cycles among the type clusters**
- **Algebraic counts of legal relationships to sever**
    - **Excising all entities of a given type from the holding company**

Hypothetical examples – isolating Domestic Entity Other (DEO)



DEO subsidiaries dispersed

DEO subsidiaries isolated



KOGOD SCHOOL of BUSINESS

Image source : OFR analysis

The Resolution Challenge

Main premise:

- **Quantitative measures of resolution complexity should capture the burden of coordinating across national / regulatory environments**

Goal:

- **Illuminate resolution plan design for bank holding companies (BHCs)**
- **Help to assess BHC's legal entity (organizational) structure**

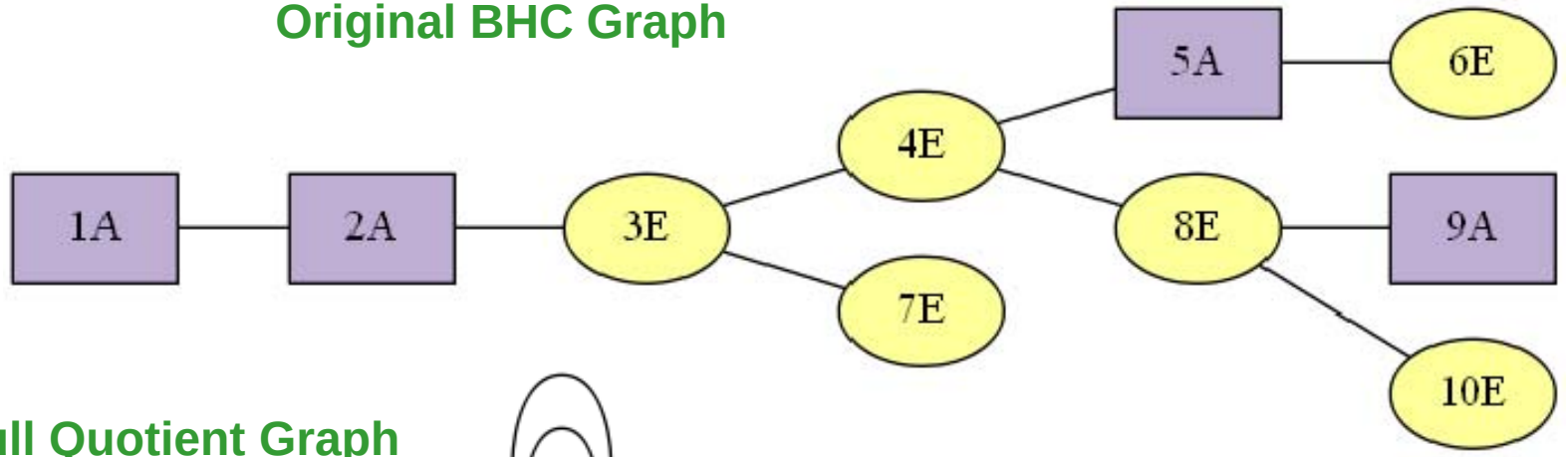
Tools:

- **Fundamental methods of network theory**
  - **BHC ownership structure as a graph**
- **Topological quotient**
  - **Partitions the BHC graph into clusters of similar subsidiaries**
- **Cycle rank of the quotient**
  - **Counts links of ownership and control to be severed to extract all subsidiaries of a given type from the BHC**

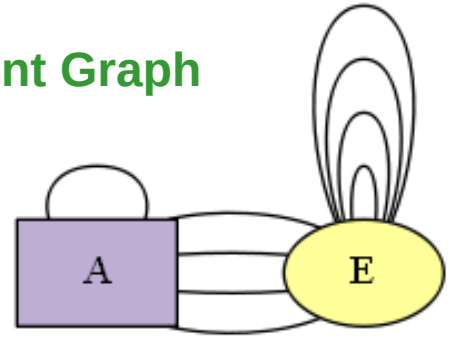
Quotienting Intuition

- **Homogeneous versus heterogeneous edges**
- **Find equivalence classes (by country, charter type, regulator, etc.)**
- **Define a vertex in the quotient for each equivalence class**
- **Each connection in the original graph carries over to the quotient**

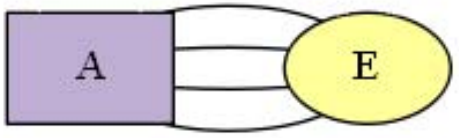
Original BHC Graph



Full Quotient Graph



Full Quotient, No Self-loops



KOGOD SCHOOL of BUSINESS

Image source : OFR analysis

Patchwork on a BHC tree

Edge contraction – shrinking edge to "fuse" adjacent vertices

- **Edge contraction of a tree results in another tree**
  - **Full quotient graph does not, in general**
- **A subgraph of *G* is *homogeneous* if all its edges are homogeneous**
- **If *G* is a tree, the union of all connected homogeneous subgraphs containing a given vertex is a *maximal homogeneous subtree* of *G***
  - ***G* is the union of *M* maximal homogeneous subtrees**
  - **Each member of *M* connects to the others by heterogeneous edges**
- **Given a fixed set of subsidiaries, the number of homogeneous "patches" that must be stitched together measures its complexity**
  - **This is the number of edges that must be severed to split the firm into homogeneous patches, each resolvable by a single regulator**
  - **We call this number, (*M*–*N*), the *dispersion complexity***

Conclusions and future research

Calls to end "Too big to fail" have focused on size and interconnectedness aspects of the SIFI definition with relatively little emphasis on complexity

Size and complexity are not synonymous

We propose metrics based on a firm's control hierarchy that we hope will help assess complexity

- **Identify potential coordination challenges for supervisors**
- **The implications of severing a subtree or grafting a new subtree**
- **Particularly applicable in assessing the potential difficulty of a resolution**
- **Not yet fully tested – this is a topic of ongoing research**

These measures are

- **Mathematically grounded**
- **Intuitively sensible**
- **Easy to implement**

Future research: are patterns "unusual"?

- **Examine other BHCs**
- **Consider dynamics over time**

Thoughts for discussion

- We define complexity using topological properties of organizational hierarchy
- In our context, tools of analysis differ from those where there is no delineation of hierarchies
- Substantial dynamics (no ‘steady state’ hierarchy)
- Connected to opacity (obscuring of information) => what is the ‘optimal level’?

Two papers

- Lumsdaine, Rockmore, Foti, Leibon, Farmer, “The Intrafirm Complexity of Systemically Important Financial Institutions,” available at www.ssrn.com/abstract=2604166

- Flood, Kenett, Lumsdaine, Simon, “The Complexity of Bank Holding Companies: A Topological Approach,” available at www.nber.org/papers/w23755

KOGOD SCHOOL of BUSINESS