



Network Science Center
at West Point 

A Network Analysis of Capital Markets

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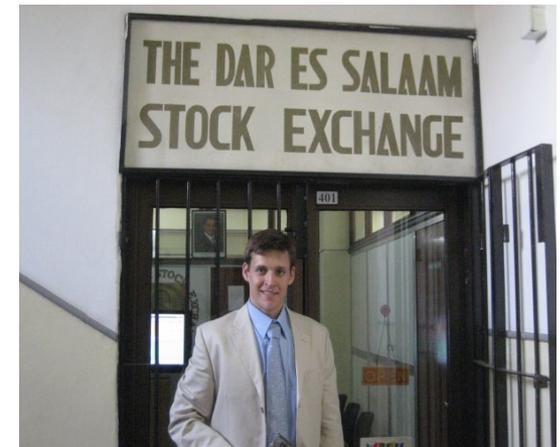
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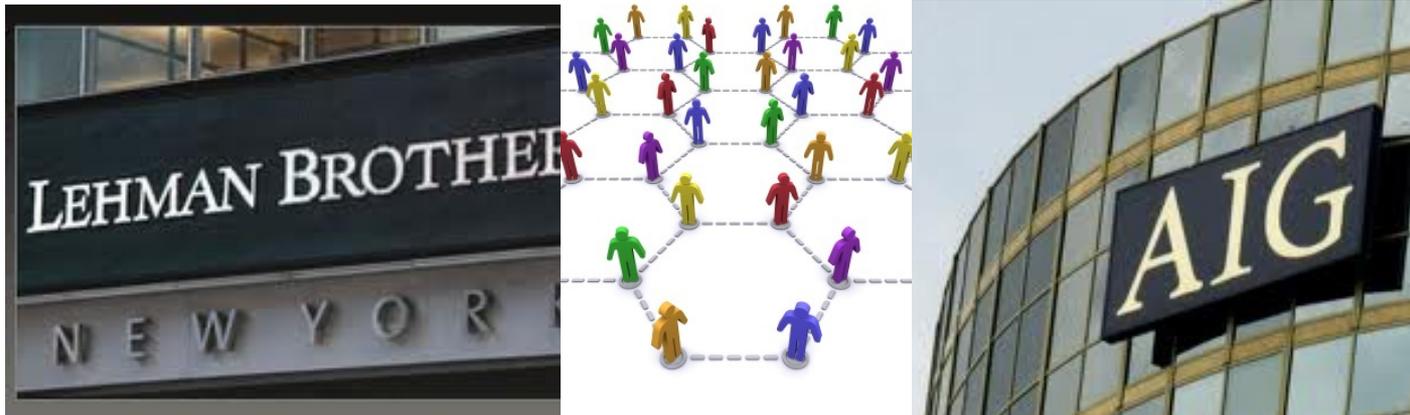
Why Capital Market Networks?

- Link Between Economic Development and Stability
- Problems with Macroeconomic Theories
- Financial Market Linkages and Contagion
- Subjective Definition of Frontier vs. Emerging Capital Markets



Problems with Economics

- Modern economic theory is failing both practitioners and policy-makers

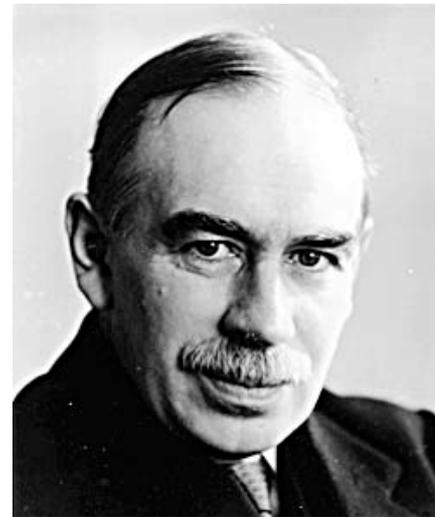


- Today's economic and financial systems can only be understood in a network context.



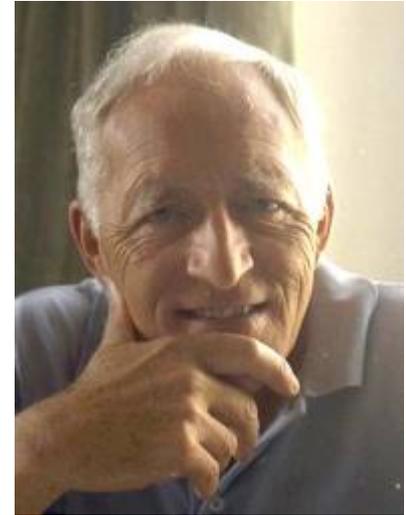
Problems with Economics

- “Homo economicus” assumes rationality
- The representative agent approach assumes away interconnectedness
- Perfect information and the rational man are idyllic concepts.



Problems with Economics

- Questions assumptions such as:
 - Representative agent
 - Stability
 - Uniqueness of equilibria
 - Individual rationality
 - Information availability
 - Anonymous market



- Alan Kirman (2010)

- Macroeconomic theory needs to incorporate:
 - The network of interacting individuals
 - The structure of their interactions
 - The consequences of network activity



Problems with Economics

Financial Contagion:

- Firms act individually to maximize their returns and minimize risk
- Spread increasingly complex financial instruments throughout the financial system
- Unintentionally destabilize the system



Economists & Network Analysis

- “Network structure has significant effects on individual behavior and on social welfare.”
-Goyal (2007)
- “Some network designs may be good at absorbing small shocks, when there can be systemic failure when confronted with a large enough shock. Similarly, some typologies may be more vulnerable to highly correlated shocks.”
- Stiglitz and Gallegati (2011)



Why Capital Market Networks?

- Research on African financial markets, found that “market structure evolves to fit the country’s income level”
-Ndikumana (2001)
- Developed capital markets are correlated with improved economic performance
-Levine and Zevros (1996)
- “An efficient financial system will allow for a higher level of investment by maximizing the proportion of savings that actually finances investment.”
-Pagano (1993)



Research Objective

Mathematically Compare
Networks A, B, C & D
and

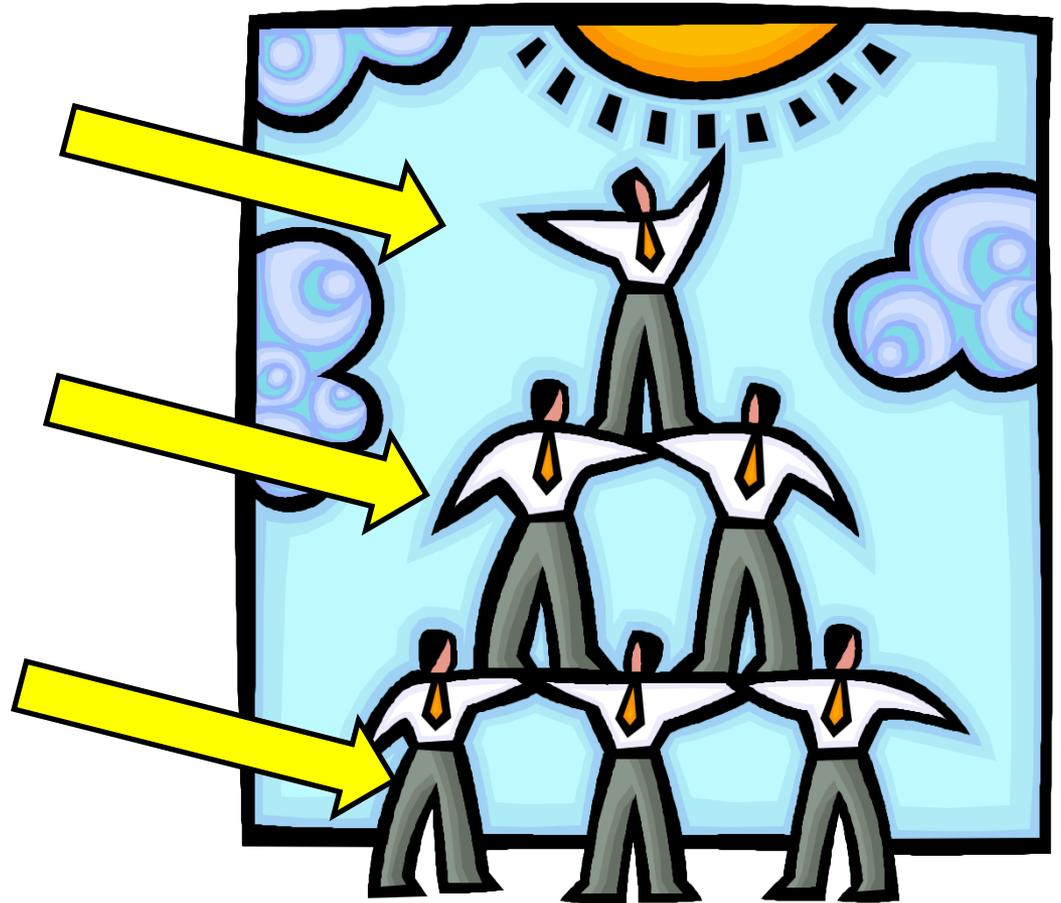


Frontier Capital Markets?

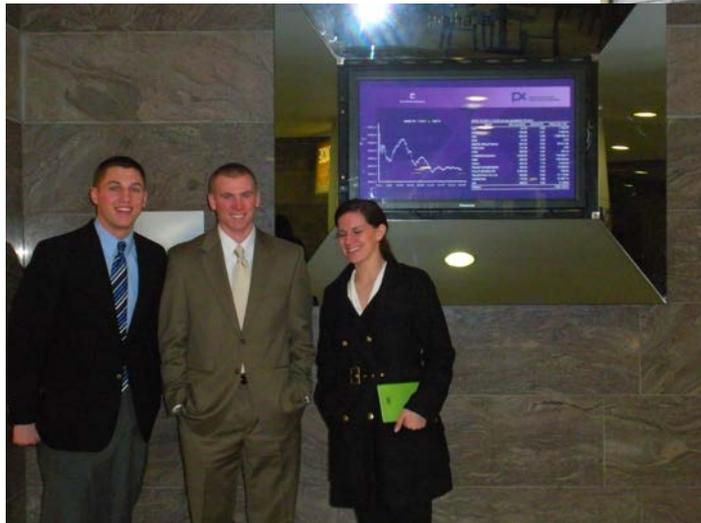
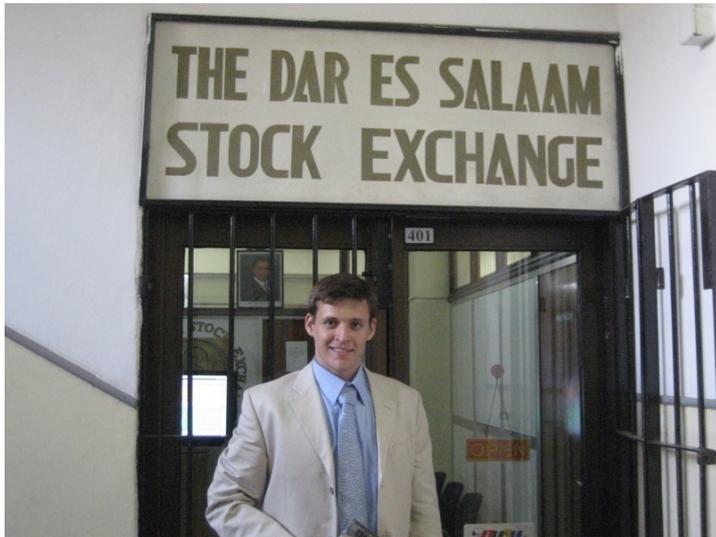
Developed

Emerging

Frontier



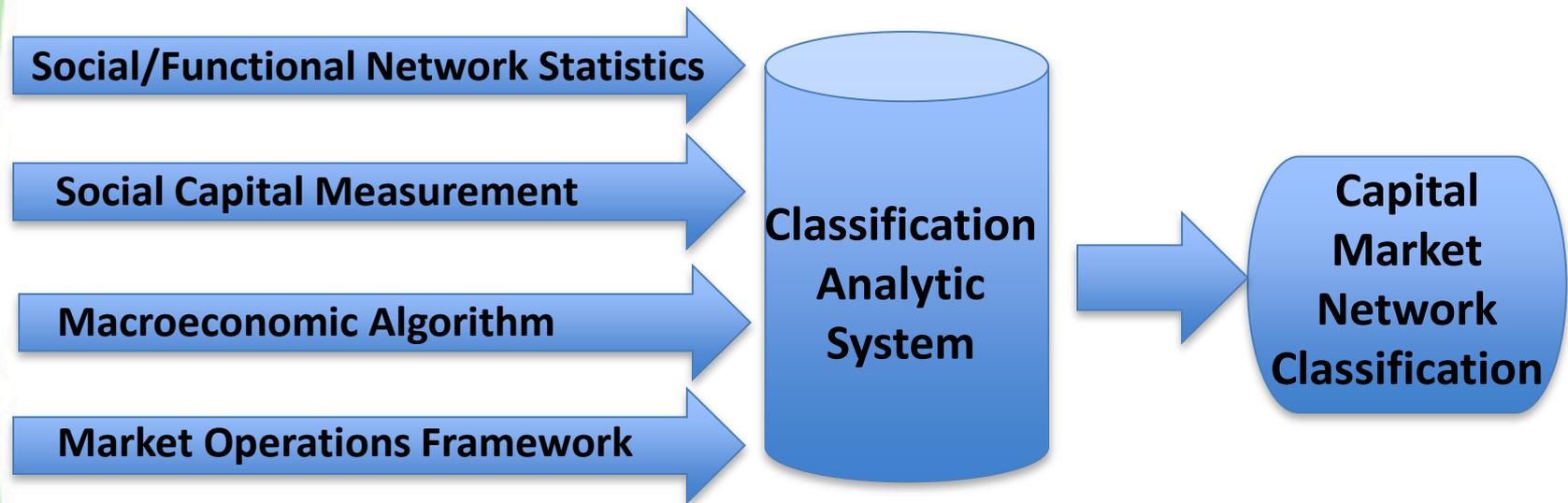
Frontier Capital Markets



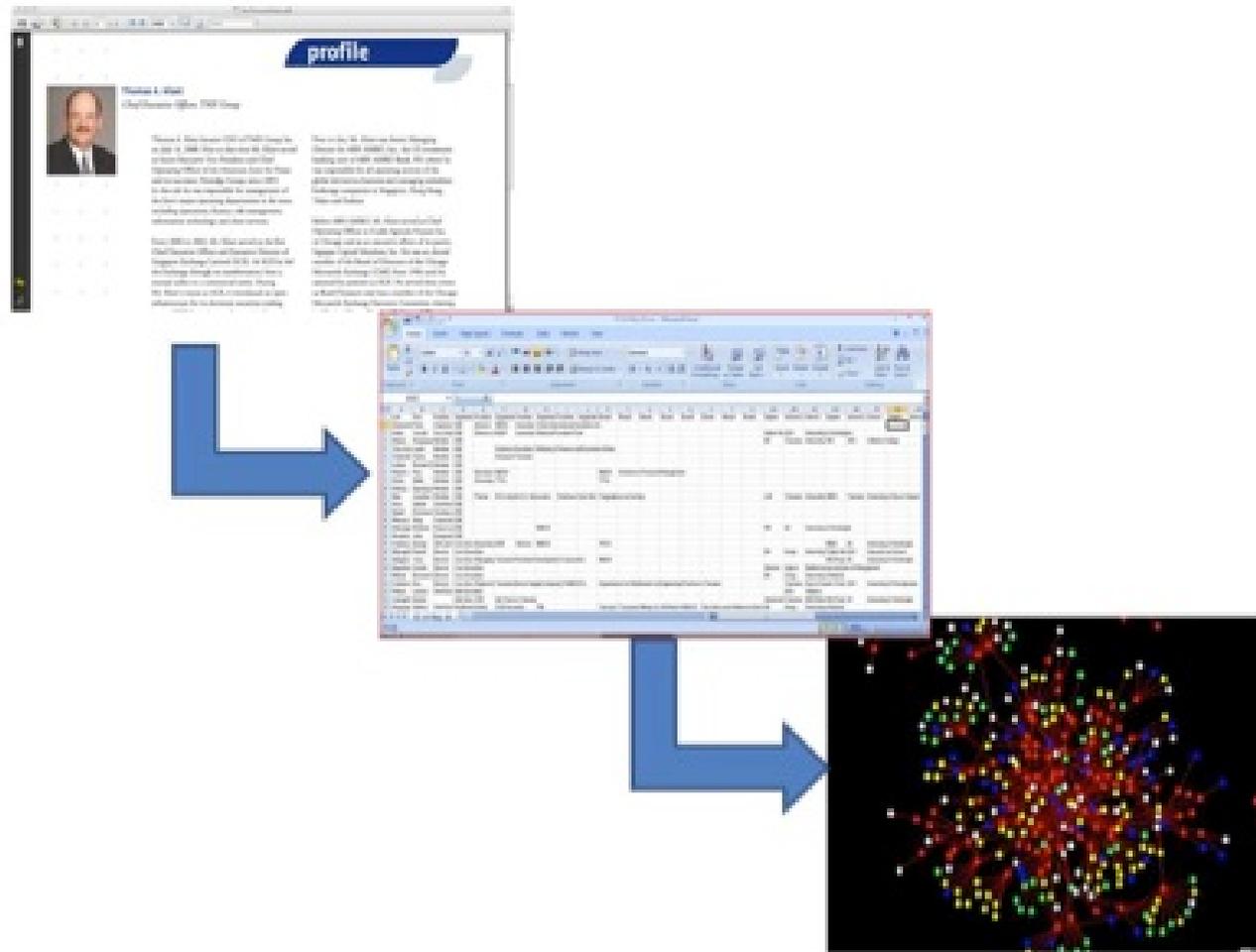
- Tanzania
- Ghana
- Trinidad & Tobago



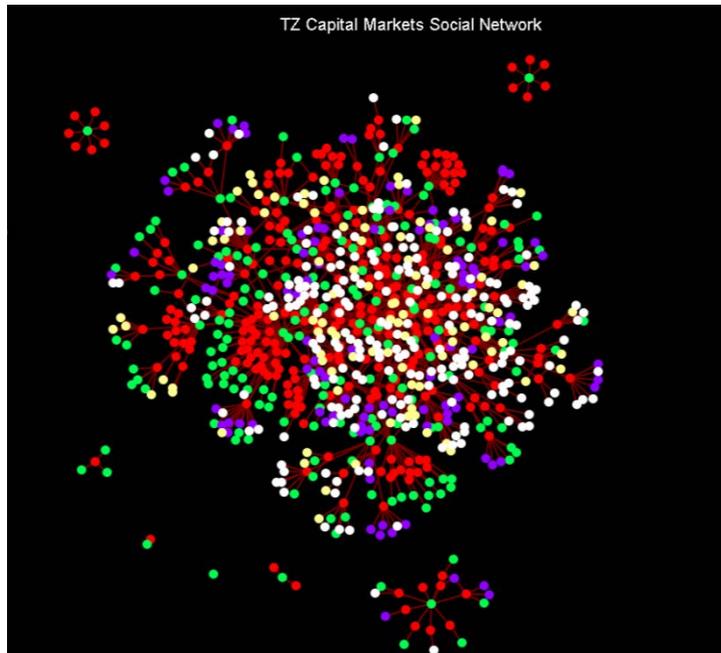
Capital Market Network Research Model



Social Network Development



Social Network Development



$$\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$$

Original
matrix

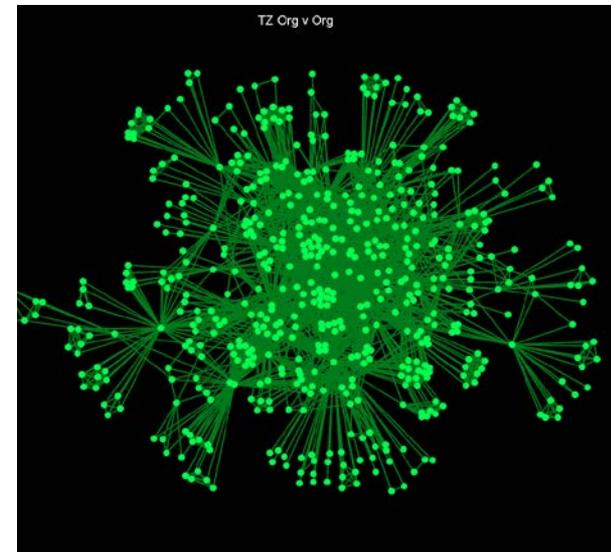
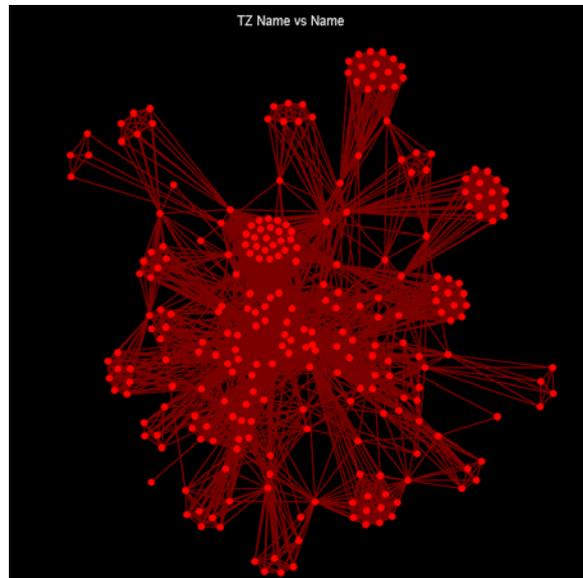
$$\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}^T \Rightarrow \begin{bmatrix} a & d & g \\ b & e & h \\ c & f & i \end{bmatrix}$$



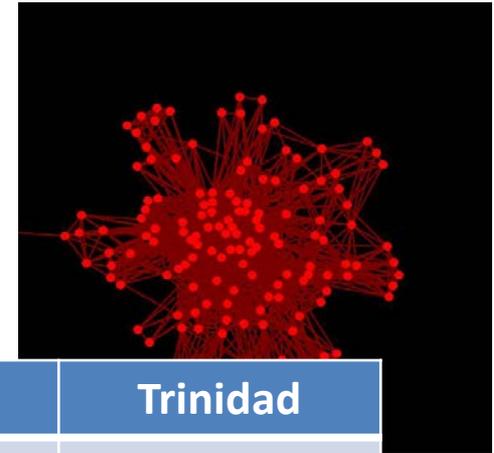
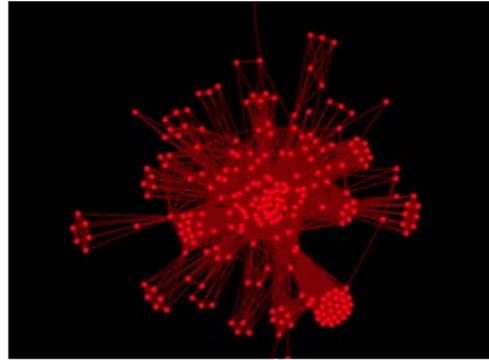
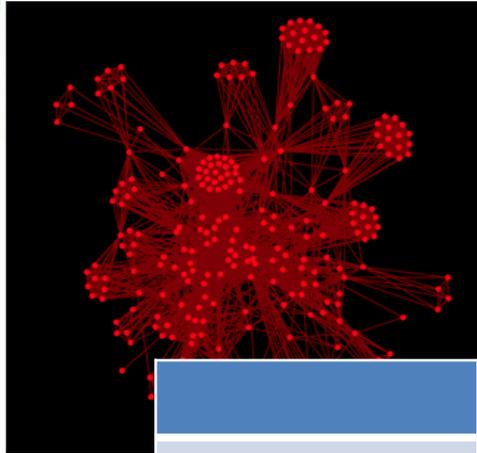
Social Network Development

$A * A^T = \text{Agent vs. Agent}$

$A^T * A = \text{Org vs. Org}$



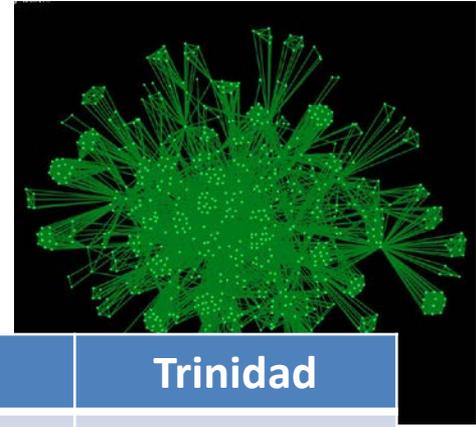
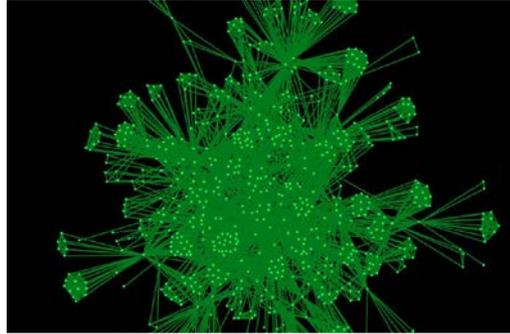
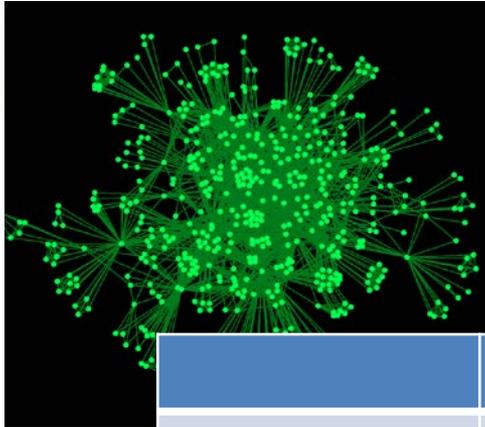
Social Network Development



	Tanzania	Ghana	Trinidad
Link Count	5306	5736	2658
Density	.0633	.0832	.1130
Degree Centralization	.3084	.6382	.7820
Betweenness Centralization	.1133	.0586	.0710
Closeness Centralization	.0074	.0082	.0510
Clustering Coefficient	.8428	.8564	.7890



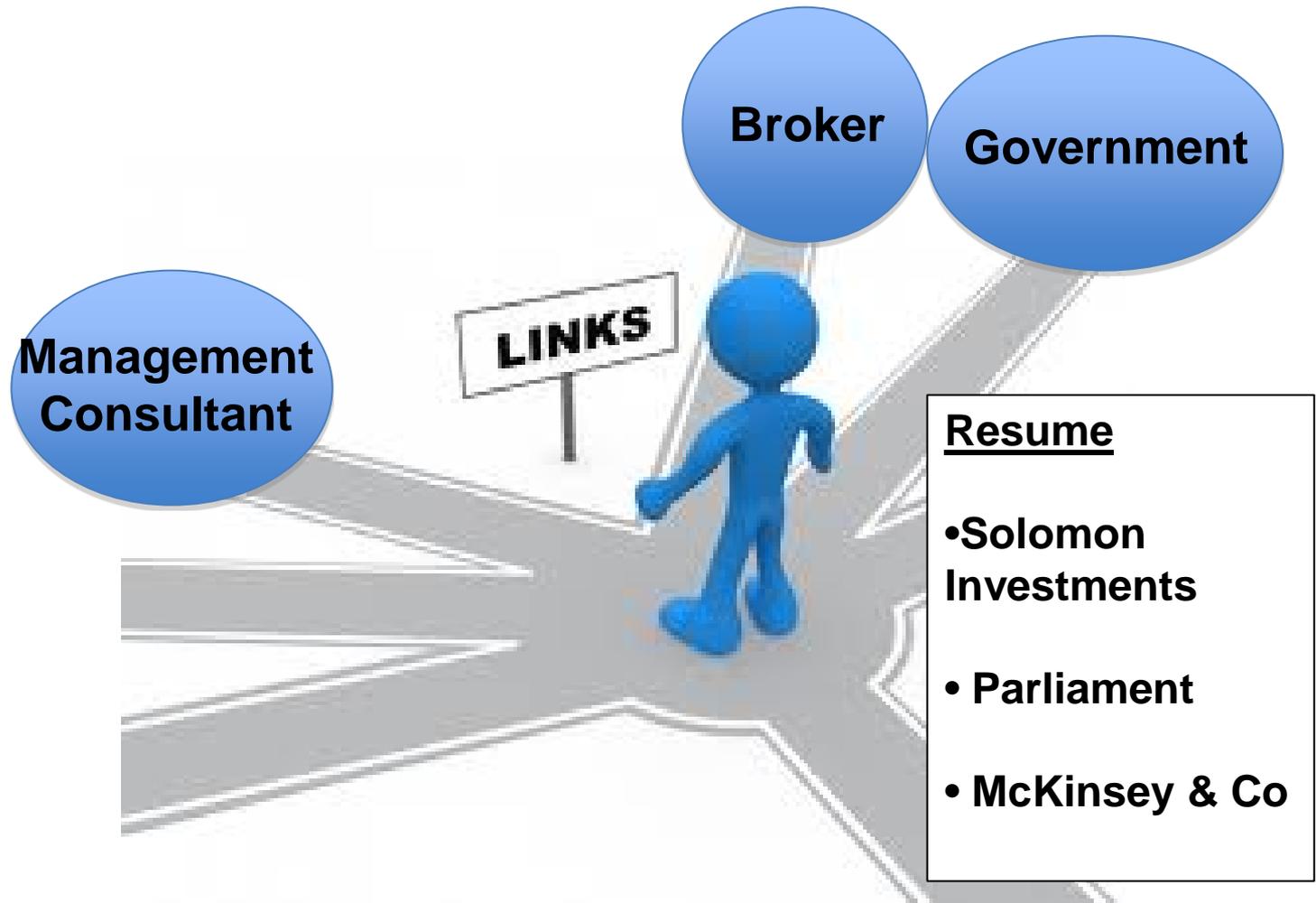
Social Network Development



	Tanzania	Ghana	Trinidad
Link Count	5966	9402	9414
Density	.0179	.0160	.0193
Degree Centralization	.3243	.5901	.5600
Betweenness Centralization	.1945	.5284	.2870
Closeness Centralization	.0212	.0165	.1640
Clustering Coefficient	.9099	.9238	.9270



Social Network Development



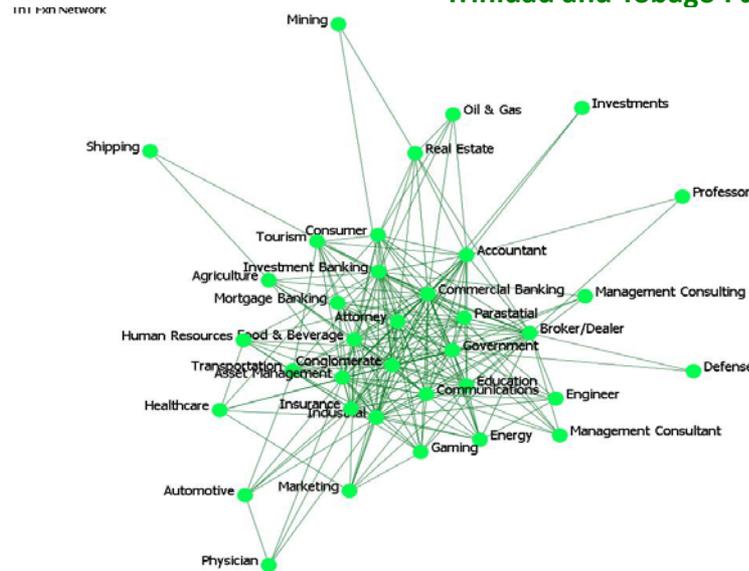
Functional Network Development

Accountant	Healthcare
Agriculture	Human Resources
Asset Management	Industrial
Association	Insurance
Attorney	Investment Banking
Broker/Dealer	Management Consultant
Commercial Banking	Marketing
Communications	Mining
Conglomerate	Mortgage Banking
Consumer	Multinational
Defense	Parastatal
Education	Physician
Energy	Real Estate
Engineer	Tourism
Food & Beverage	Transportation
Government	

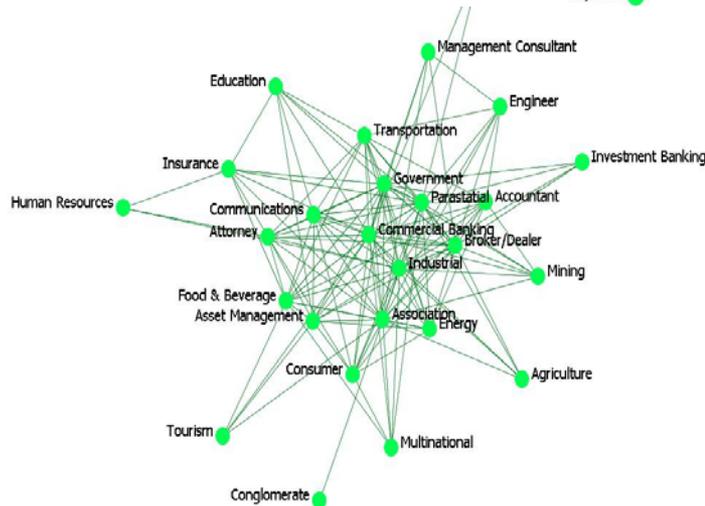


Initial Results-Functional Networks

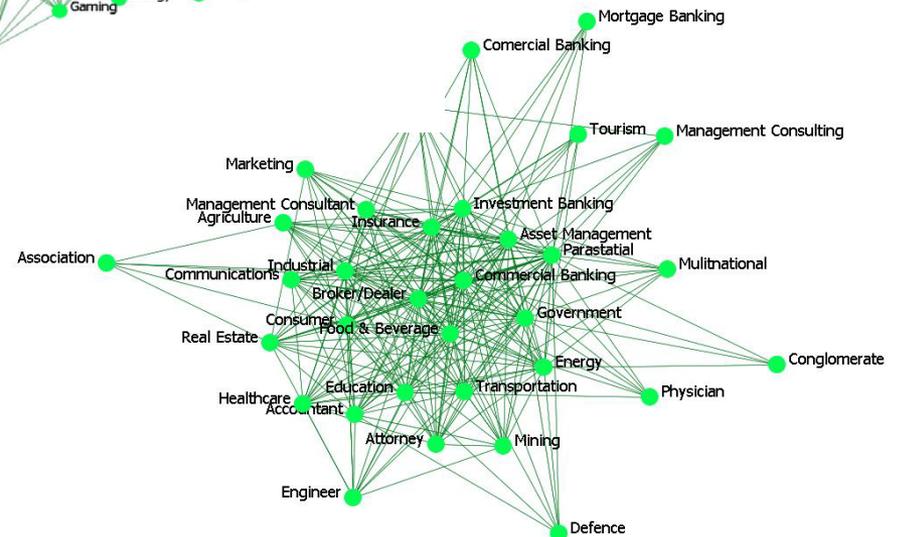
Trinidad and Tobago Functions Network



Tanzania Functions Network



Ghana Functions Network



Initial Results – Functional Networks

Measure – Average	Ghana	Trinidad & Tobago	Tanzania
Link count	532	444	274
Density	0.5038	0.3524	0.4215
Characteristic path length	1.4981	1.7254	1.6031
Clustering coefficient	0.8163	0.8053	0.8084
Total degree centrality	0.28	0.2471	0.2862
Eigenvector centrality	0.1981	0.1808	0.1379
Betweenness centrality	0.0161	0.0213	0.0251
Information centrality	0.0303	0.0278	0.0385
Clique membership count	12.9394	7.8889	6.7692
Simmelian ties	0.5038	0.3524	0.4185



Initial Results-Betweenness Centrality

Ghana	Trinidad & Tobago	Tanzania
Commercial Banking	Investment Banking	Association
Parastatal	Commercial Banking	Commercial Banking
Government	Conglomerate	Parastatal
Investment Banking	Government	Industrial
Insurance	Accountant	Government



Initial Results-Closeness Centrality

Ghana	Trinidad & Tobago	Tanzania
Parastatal	Commercial Banking	Commercial Banking
Commercial Banking	Conglomerate	Association
Investment Banking	Investment Banking	Parastatal
Broker/Dealer	Asset Management	Industrial
Insurance	Industrial	Government



Initial Findings

- **Ghana:** Parastatal organizations are on the shortest paths
- **Tanzania:** Associations are the most critical information sources
- **Ghana and Tanzania:** Commercial banks are highly connected
- **Trinidad and Tobago:** Investment Banks, Commercial Banks, and Conglomerates are the most central organizations. Parastatal organizations and associations play a much less important role.





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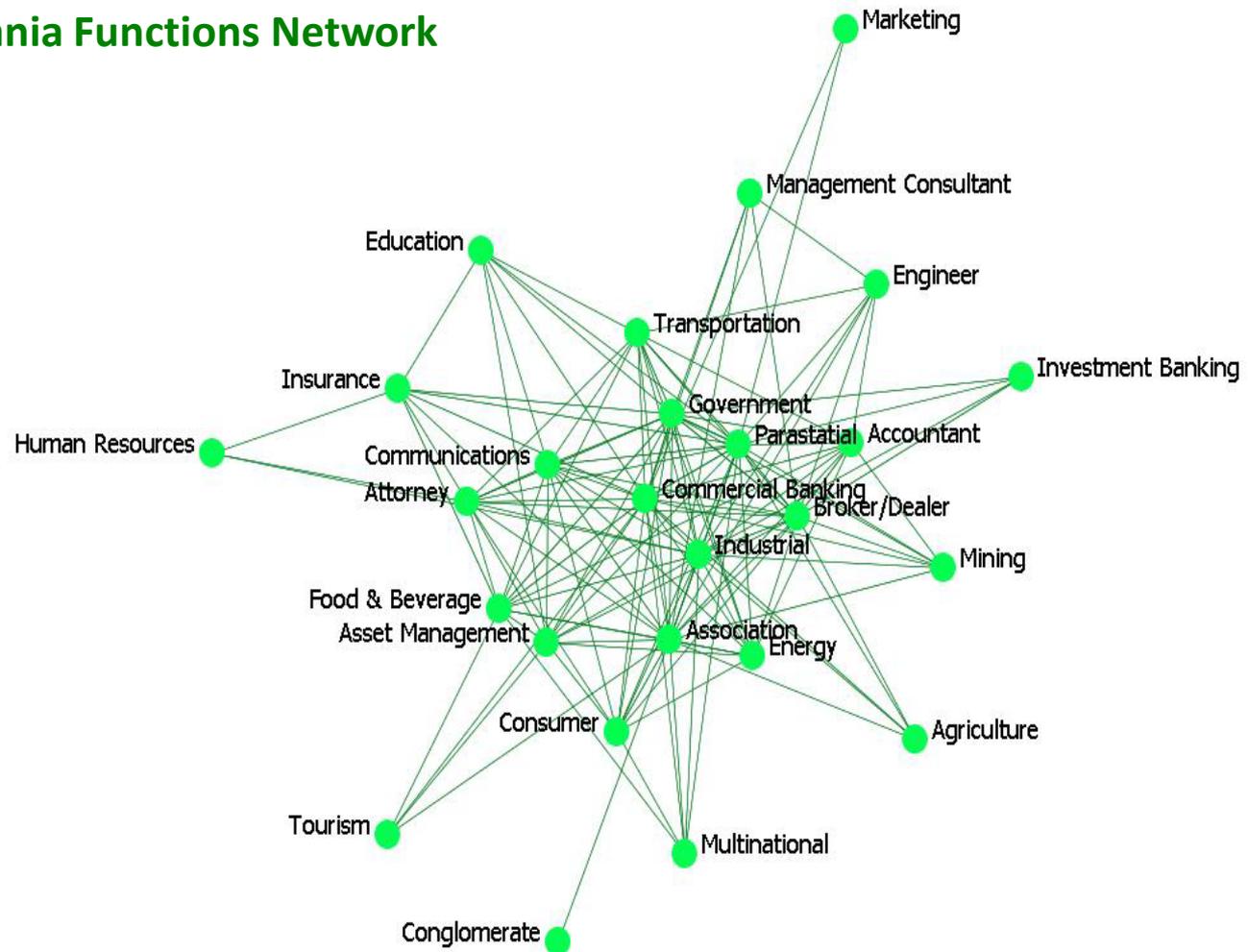
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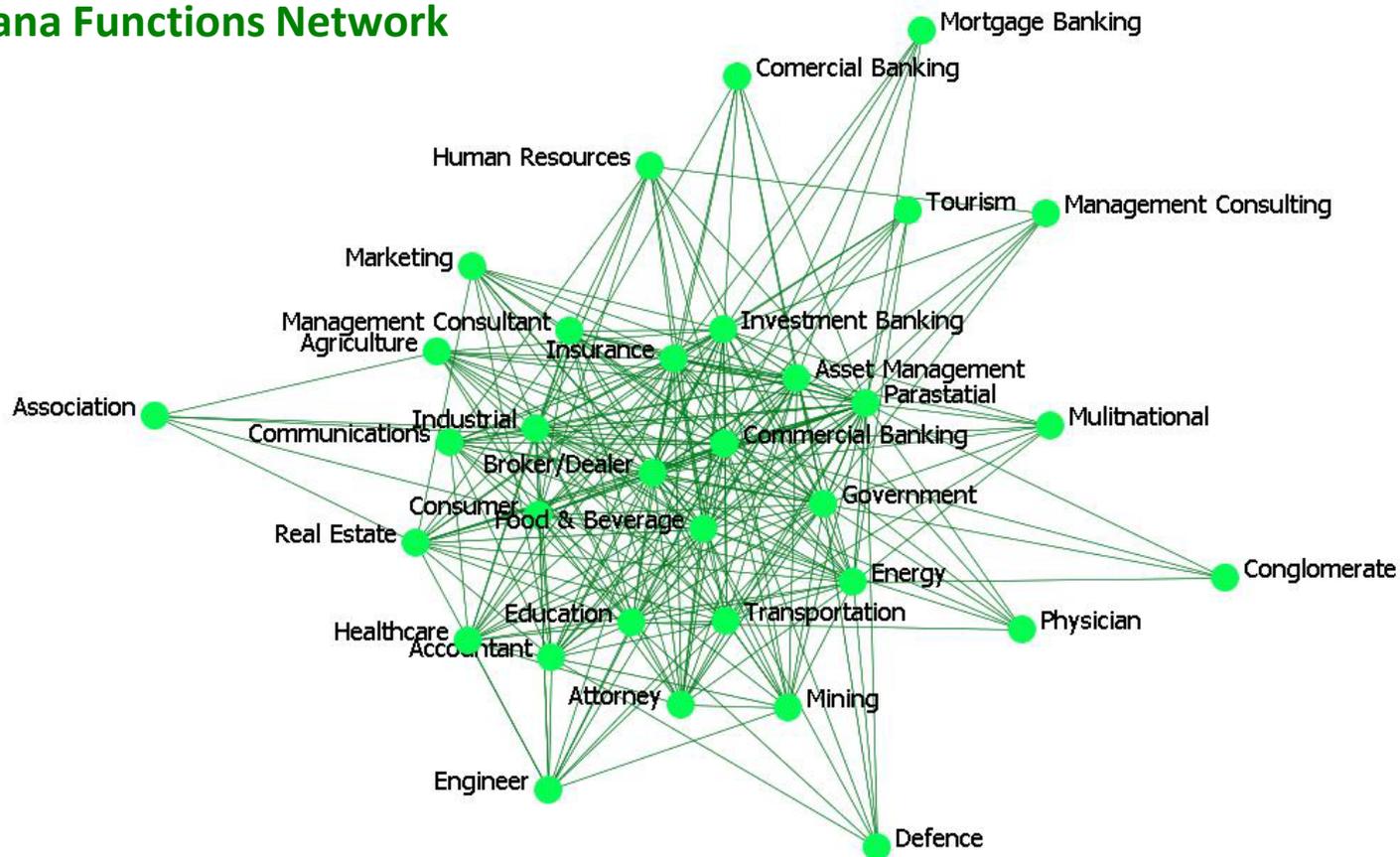
Initial Results-Functional Networks

Tanzania Functions Network



Initial Results-Functional Networks

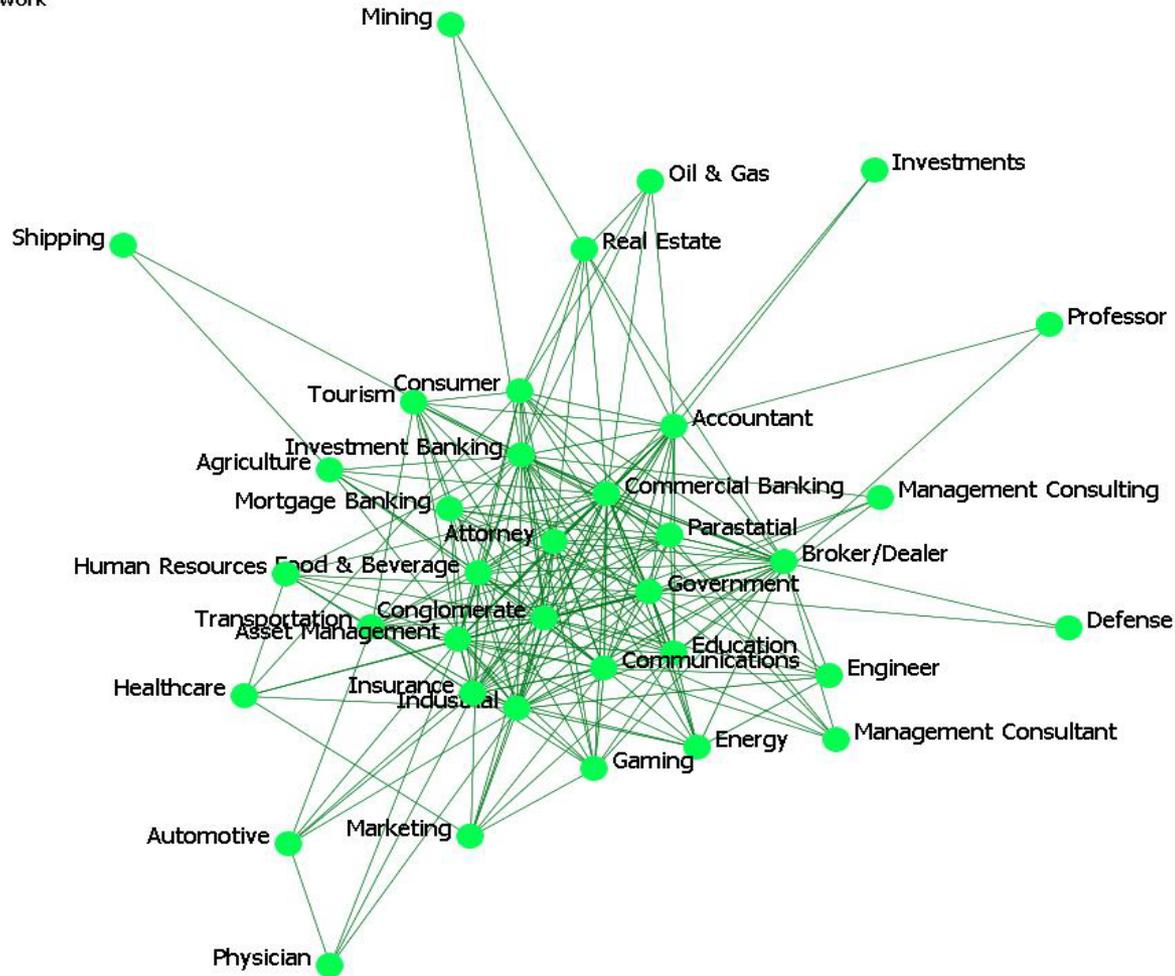
Ghana Functions Network



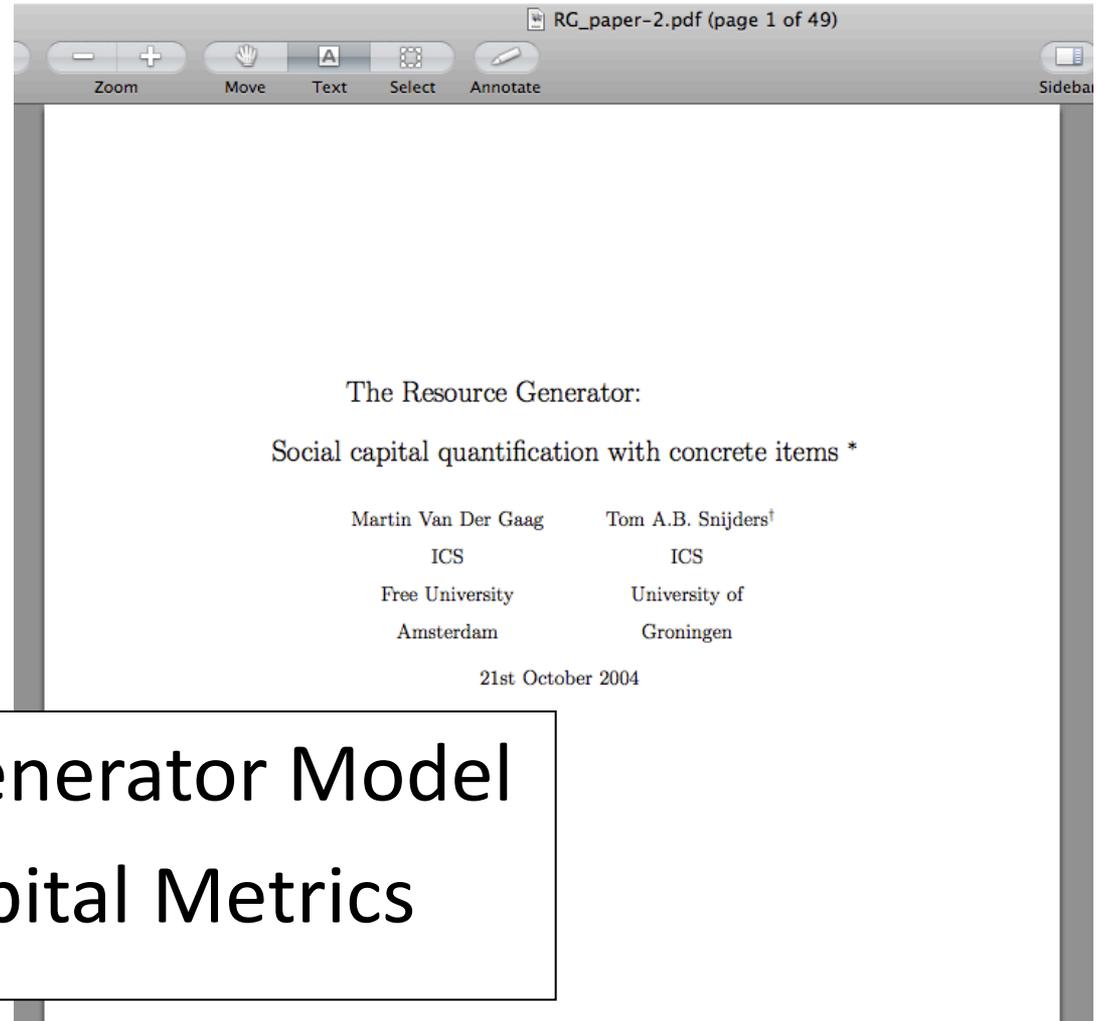
Initial Results-Functional Networks

Trinidad and Tobago Functions Network

INTI FXN NETWORK



Social Capital



Resource Generator Model
Social Capital Metrics



Resource Generator Model

SOCIAL CAPITAL SURVEY: This survey will help to understand how people use social relationships to conduct business and personal matters.

Age (years):

Sex (M/F):

Partner (Y/N):

Living in House:

(Monthly income)

Student

Homemaker

Looking for work

Blue Collar

White Collar

*We define **acquaintances** as people whom you recognize by sight on the street and could start a conversation with, and **friends** are people with whom you have contact at least every two weeks.*

Keeping this in mind, **how many people do you know that you could ask for help who:**



Resource Generator Model

	Family	Friends	Acquaintances
Has good contacts with the media			
Owens a vacation home			
Earns more than \$500 per month			
Graduated college			
Is active in a political party			
Knows about government regulations			
Knows about financial matters			
Could loan you enough money to buy a home			
Has gotten a loan from a bank before			
Invests in stocks and bonds			



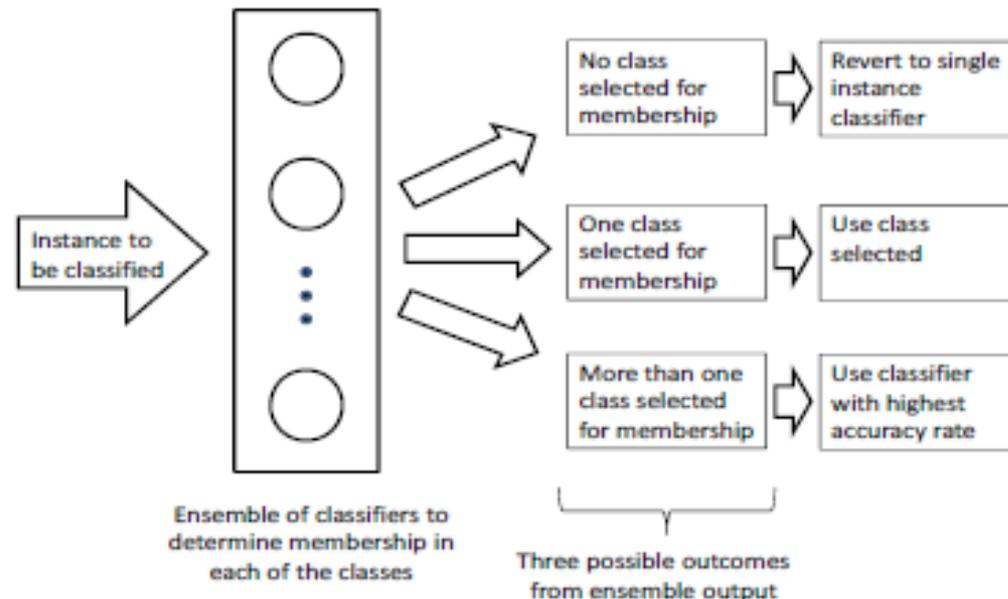
Social Capital: Initial Results

- White Collar has greater access to:
 - “Amount” of Social Capital
 - Diversity of Social Capital
- “Family Ties” are much more advantageous among White Collar than Blue Collar



Macro Economic Classification Algorithm

- Unique binary classifier mechanism that combines three methods:
 1. kNN (k-Nearest Neighbors)
 2. Ensemble creation
 3. Bayesian probability into the model
- Each classifier detects membership in a specific class using a best subset selection process
- Provides the diversity to successfully implement an ensemble
- Ensembles increase classification strength by using the collective output of several classifiers instead of a single methodology



Macroeconomic Metrics

- GDP per Capita
- GDP per Capita Growth Rate
- Consumer Price Index
- Human Development Index
- Population
- % Urban Population
- Infant Mortality Rate

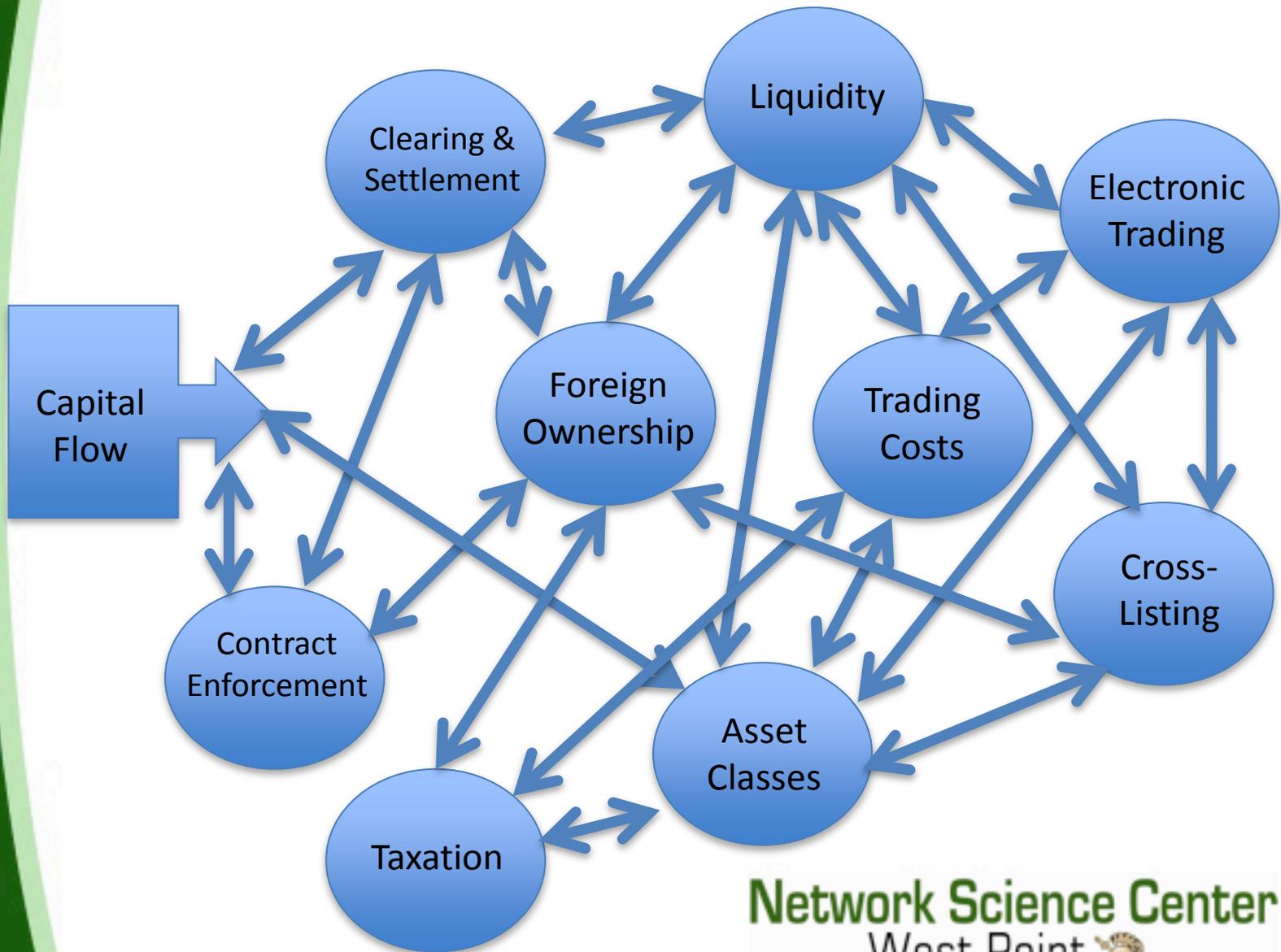


Initial Results-Macro Metrics

Classification	Key Variables
Developed Market	Population % Urban
Advanced Emerging Market	Human Development Index % Urban Infant Mortality Rate
Secondary Emerging Market	GDP Per Capita Growth Rate
Frontier Market	% Urban GDP Per Capita Growth Rate



Market Operations Network



Initial Capital Market Operations Variables

- Market Capitalization % of GDP
- Buy Order to Sell Order Ratio
- Average Turnover to Market Capitalization Ratio
- Market Volatility
- Price/Earnings Ratio
- Foreign Ownership % of Market Capitalization

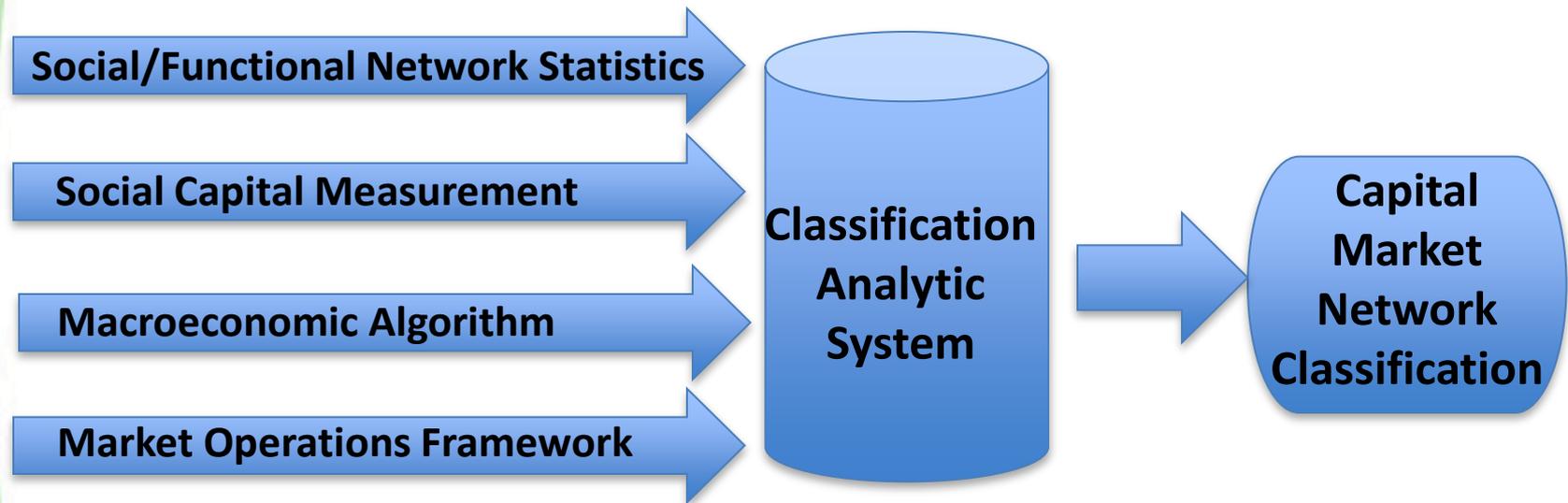


Initial Capital Market Operations Variables

- Trading Infrastructure
- Financial Intermediation
- Legal/Contract Framework
- Sovereign Risk Ratings
- Corruption Index/Black Market Premium



Capital Market Network Research Model



Future Work

- Enhance Functional Network Framework
- Update Data
- Refine Social Capital Surveys and Continue to Collect Data
- Refine Macroeconomic Metrics
- Develop Market Operations Network





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