

## A Network Analysis of Frontier Capital Markets

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**Abstract.** The study of frontier capital markets provides a unique opportunity to examine the network-based intersection of human behavior and economics. The individual motivations, information availability, transaction systems, and cultural realities in these markets provide a rich context of study. A social network analysis reveals interesting insights about how interrelationships among actors and organizations affect market operations and development. Network analysis provides both a visual and mathematical representation of the relationships and information flows between people, organizations, and functions enabling us to describe capital market structure and function in innovative ways. This research focuses on the capital markets in three frontier markets: Ghana, Tanzania, and Trinidad and Tobago providing insights to economists seeking to understand the interconnections between economic actors and their affects on financial markets and economic conditions.

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## **1. Introduction**

Extensive research has recognized that well-functioning financial markets are associated with economic growth [1]. However, some basic assumptions underlying macro-economic and financial theory are increasingly subject to debate including concepts such as rational expectations, representative agent, and efficient markets [2]. Economic research focused on modeling the behavior of networked, diverse economic agents is emerging to address limitations in traditional economic theoretical foundations [3]. Analyzing the structure, dynamics, and unique characteristics of the capital market network in which individuals operate is vital to understanding how capital markets evolve, especially in developing economies where individuals make reciprocal exchanges and clan or family interests are as important as individual self-interest or social norms, institutions and legal frameworks. Our network approach is revealing existing qualities of market behavior that do not adhere to traditional economic assumptions providing insights to the study of network science, economics, and capital markets.

## **2. Frontier Market Network Analysis**

Our focus is on frontier markets, the smallest, less developed, less liquid investable markets. Well-functioning capital markets enable developing economies to attract domestic and international investment needed to support entrepreneurs, expand economic opportunities, and foster economic growth. Frontier markets have smaller scope and fewer institutional controls, and social connections and human behavior have a greater impact. Thus, the study of frontier capital markets provides a unique opportunity to examine the network-based intersection of human behavior and economics. The individual motivations, information availability, transaction systems, and cultural realities in these markets provide a rich context of study.

A social network analysis reveals interesting insights about how inter-relationships among actors and organizations affect market operations and development. Network analysis provides both a visual and mathematical representation of the relationships and information flows between people, organizations, and roles enabling us to describe capital market structure and function in innovative ways. Our research focuses on the capital markets in three frontier markets: Ghana, Tanzania, and Trinidad and Tobago. We collected extensive data about the actors in these markets and used mathematical techniques to identify and evaluate the nodes in the network. Initially focusing on stock exchange personnel and government regulators, we expanded the networks to encompass public companies, banks, brokers, and key personnel in

government.

We recorded individual résumé data including the businesses, clubs and professional organizations with which agents were associated. We documented nationality, educational attainment and university affiliations, and conducted interviews with key agents at the stock exchanges, banks, brokerage firms, and government organizations. We then assigned individuals up to three functions such as commercial banking, conglomerate, or parastatal that best described their expertise. In order to favor current roles over prior roles, we weighted current functions twice as heavily as past functions. For example, an individual currently serving on the board of an oil company, who had formerly been a member of parliament would have two functions: industrial with a weight of two and government with a weighted of one.

Using Organizational Risk Analyzer network analysis software developed by the Center for Computational Analysis of Social and Organizational Systems at Carnegie Mellon University [4], we constructed functional networks for each country depicting how functions are connected with other functions through individuals and generated descriptive statistics and topologies of the networks. We identified which functions, individuals, and organizations serve as central hubs and power brokers. We also noted potential points of failure, the nodes on the shortest paths between nodes that exhibit the most influence on other nodes, and the nodes on the periphery, lacking information or resources.

### 3. Results

These network topologies enabled us to classify, compare and contrast three capital market networks. Figures 1-3 depict the functional networks in Ghana, Tanzania, and Trinidad and Tobago, respectively.

Table 1 contains ORA-generated comparative measures. Tanzania had the highest network density, 65% versus Ghana's 56%. Higher density is associated with greater information sharing which is characteristic of learning organizations. Ghana's functional network had the shortest path length, meaning information flows more directly in its network. The clustering coefficients for Trinidad and Tobago and Tanzania were similar; however, Ghana's was 11% - 14% lower. Ghana's network shows the highest degree centralization, almost 1.4 times that of Tanzania. Closeness centralization was dramatically different among the networks with Tanzania's measure almost three times that of Trinidad and Tobago and 1.4 times higher than Ghana's. Eigenvector centralization, which measures the connectedness of functions to highly connected functions, was 1.6 times higher in Trinidad and Tobago than in Tanzania.

Figure 1: Ghana Functional Network

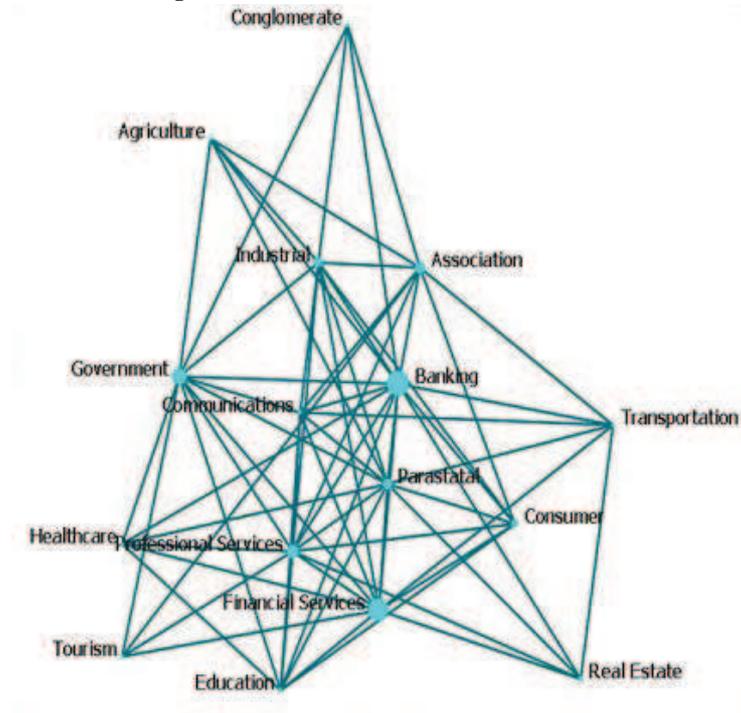


Figure 2: Tanzania Functional Network

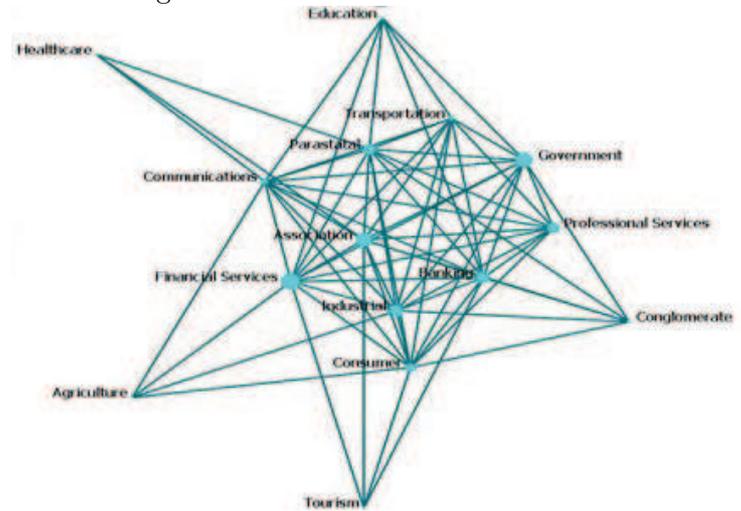


Figure 4 highlights the most prominent functions or key nodes in each of

Figure 3: Trinidad and Tobago Functional Network

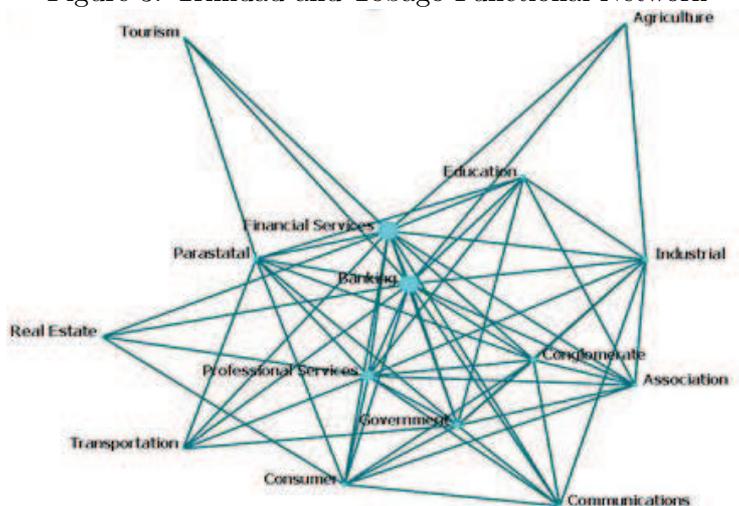
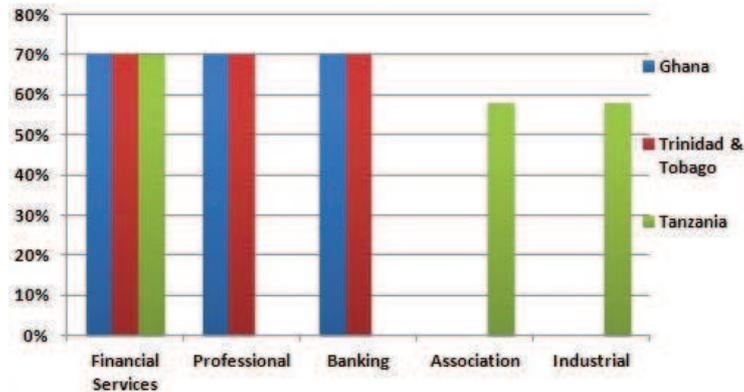


Table 1: Comparative Network Measures

Average Measure	Ghana	Trinidad and Tobago	Tanzania
Link Count	67	62	68
Density	0.5580	0.5900	0.6480
Characteristic Path Length	5.4670	7.3520	7.8000
Clustering Coefficient	0.7120	0.8200	0.8560
Degree Centralization	0.2450	0.2090	0.1710
Betweenness Centralization	0.2790	0.1520	0.3020
Eigenvector Centralization	0.5780	0.6010	0.3780
Closeness Centralization	0.1610	0.0750	0.2230

the networks based on ORA's summary of centrality measures. The top three nodes for Ghana and Trinidad and Tobago were identical in the weighted networks with financial services (such as broker dealers and asset managers), professional services (including attorneys and accountants) and banking, each recurring in 70% of ORA indications. In Tanzania, financial services was as important as in the other capital markets; however, association and industrial functions each had a 58% rate of recurrence and banking was not prominent. We conducted similar comparisons of functions based on eigenvector, betweenness, and closeness centrality.

Figure 4: Most Prominent Functions



#### 4. Conclusions

This capital market network research generated functional network topologies and descriptive statistics for three frontier capital markets. We identified similarities and differences in the capital market networks using three different centrality measures as a technique to compare and contrast capital markets. This research comprises one pillar of a unique, quantitative methodology for classifying capital markets.

Tanzania's functional network was the most dense, while Ghana's network registered the lowest density. Lower density indicates that power is shared more equally among the functions. The networks also exhibited quite different levels of closeness centralization with Tanzania registering a value three times that of Trinidad and Tobago and 1.4 times that of Ghana. This analysis indicates that the functions in Tanzania's network are more interconnected and tightly knit, while Trinidad and Tobago's functions may be more distinct and specialized. Measures of closeness centrality confirmed this assessment, as Tanzania registered much higher levels than Trinidad and Tobago, while Ghana's measures in between.

In order to distinguish the quantitative difference between these three networks, we suggest that additional analysis should focus on those top ten functions that are distinctively different in each capital market's functions network topology. As would be predicted in a study of capital markets, the key functions in each of the weighted networks were financial services, professional services, and banking. However, associations and industrial functions were quite important in Tanzania.

Differences in results based on the selected metric can potentially lead to

the discovery of influential functions that might not be readily apparent at first observation or conversely, might not appear to be as influential as initially supposed. When considering those functions that are connected to other highly connected functions (eigenvector centrality), Tanzania's associations and industrial organizations were quite prominent. Tanzania's economy may be still be influenced by its manufacturing base and powerful trade unions. Those agents who served in communications roles were most important (based on betweenness centrality) in Tanzania and Ghana confirming the importance of the Internet and phone infrastructure in evolving economies. Education and government functions were also power brokers in Ghana, while industrial roles were bridges in Trinidad and Tobago.

Researchers are also conducting a network analysis of an emerging market, the Czech Republic, to enable a vertical comparison. Such a comparison will reveal similarities and differences in the network structures of developing versus emerging markets furthering an understanding of the types of social networks that have fostered economic growth. These models will offer insights to economists seeking to understand the interconnections between economic actors and their affects on financial markets and economic conditions. This research will also inform governmental and non-governmental organizations that are creating economic development policies, enabling decision-makers to focus on aspects of the network that will generate results efficiently.

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