Trade and Economic Growth

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The exchange of services, goods and capital across international territories existed throughout history. This exchange among nations of the world, the international trade, represents a significant share of the *Gross Domestic Product* (GDP) which is a measure of the economic performance. In recent decades, the economic, social and political importance of the international trade has risen.

The impact of trade on economic growth is an empirical question. In theory, the impact of trade liberalization on economic growth is absent. However, since liberalization leads to reduced prices and hence improved welfare, its impact on the long run rate of economic growth is positive. Although an appropriate aggregate measure of welfare in an economy is uncertain, technological progress, in other words research and development, is widely used to determine the growth. In this project, we aim to extract insight over the growth and robustness of the world economy based on the world trade network.

Globalization and its consequences is a main concern in trade networks. A historical analysis of the trade network shows that the world became globalized between 1959 and 1996 due to the development of the countries in the middle strata [7]. *World Trade Network* (WTN) has become more dense but decentralized as a result of globalization. Globalization is described as an increase in interconnection and interdependence between countries in terms of scope and intensity. Its economic aspect denotes a worldwide participation in economic exchange. The *Preferential Trade Agreements* (PTA) increased rapidly among subsets of countries. Since many PTAs are based on the geographical regions, this effect is labeled are regionalization.

Globalization is not contradictory to regionalization as the world became regionalized simultaneously. Trade regionalization is not a recent phenomenon. Since the ancient times, geographical proximity has been a primary condition for commodity exchange due to distance acting as a barrier to trade. Adjacent regions do not meet a simple boundary but rather merge across borders. The intra-regional trade density is greater than the inter-regional density therefore intra-regional ties are stronger than the inter-regional ones [7]. Transportation and communication advances have significantly neutralized the importance of geographical distance. However, there is still a significant *home bias* in the international trade network. Quantitatively large informal trade barriers may lead to explain the home bias in international trade. Community enforcement of sanction that may deter contract violations can promote international co-ethic networks. Co-ethnic networks, like ethnic Chinese networks, promote bilateral trade by providing market information and by supplying matching and referral services [6].

The world trade has been globalized and regionalized simultaneously since both the overall network density and the intra-regional density have increased. The fact that the intra-regional density increased concurrently with inter-regional density proves that globalization and regionalization are complementary rather than contradictory.

In this research, we look at the regionalization in terms of the co-ethnicity, adjacency and PTAs. Since we have a more up-to-date world trade data, we analyze, if any, the changes to the density and tie strengths in inter- and intra- regional countries.

In this work, we use World Trade data from 2008 to 2014 to classify and examine the interactions between "rich" and "poor" countries. We implement detailed import and export data into a network representation allowing us to use network analysis to see otherwise hidden patterns.

We examine the aggregated exports between countries above and below a cutoff threshold as well as the effect of changing that threshold. This enables us to define "rich" and "poor" transactions and countries.

We implement our data into a network of weighted and directed edges, allowing the calculation of edge and node weights as well as other network metrics. We pay special attention to community structure and its evolution in time.

We analyze the relation between the trade and economic growth of a country to see how the economic growth is affected by being well connected to the outside world or by having a huge variety of goods flowing in/out the region. Consider a world with two similar, developed economies. The economic integration can cause a permanent economic growth. In a trade network, each product subject to export or import can be thought as a tree [1] where the set of all the products forms a forest. The economic growth implies moving from a poorer part of the forest to the richer parts, the so called *tree monkeying*, as such from the periphery to the core of the product set. Historical analysis shows that the creation and transmission of ideas have been extremely important in the development of modern standards of living [8]. Building an analogy, we look at the so called *rich club slider* where there is a crossing between the "poor" and the "rich" countries. Similar to the transition dynamics of two-level quantum-mechanical systems, a transition from a poor to a rich club/community is observed, which also resulted in more developed economies.

1 World Trade Networks

Trade has been studied in the networks framework for the first time recently [3] where an empirical characterization of the trade relationships between different countries worldwide is presented using the properties of the complex networks. The common properties of a world trade network such as scale-free degree distribution, the small-world property, a high clustering coefficient, and, in addition, degree-degree correlation between different vertices make it a complex network, which is far from being well described through a classical network description [3].

A natural way of representing the trade flow between two countries is by means of an arrow pointing the direction of the flow and connecting two points that represent the trading countries. We can attach a value to the arrow indicating the strength of the flow. When we do this for all countries in the world we obtain a network, the so called WTN for international trades with vertices being the trading countries and links being the trading flows.

A network representation of the trade flows gives emphasis on the relationships between the countries and the structure of the network itself. Therefore, it is fruitfully used to address the issues of the international

trade and its dynamics. Using the multiplex nature of the complex network systems, the reflections of the international trade on the world economy can be analyzed as well.

There are a number of recurrent structures and measures of WTNs. In a WTN, the countries with many trade partners are usually connected with countries holding few partners. Therefore, on average WTN has a disassortative pattern [3]. Furthermore, well-connected countries are less interconnected that poorly connected countries [9]. The structural properties of WTN remained remarkably stable over time [10]. The historical data shows that the node degree is negatively correlated with the average nearest-neighbor degree [12] and with the clustering coefficient [13].

The network is weakly disassortative when treated as weighted. In a weighted WTN the majority of the existing links are associated to poorly connected countries. Moreover, the countries holding intense trade relationships are more clustered [2].

2 Data Collection & Network Implementation

In our research, we perform a weighted network analysis in order to take into account the existing heterogeneity in the capacity and intensity of the connections.

We obtained the GDP data from the World Bank Repository and the global trading data from the Observatory of Economic Complexity. The trading data set contained import and export records of around 6000 different goods between around 260 countries from 2008 to 2014. Such a data set lends itself naturally to a network representation. Countries are represented by nodes and imports and exports are directed, weighted edges. The depth of the data set means that we have the freedom to view the WTN in several different ways, like a network of average import/exports, or net imports/exports for a particular year, etc...

However, this same depth implies that the idea of "node degree" has little meaning. Since most countries deal in some small way with many other countries, the interesting quantity is the volume of imports/exports, or "node strength." (Fig. **??**) We summed the imports and exports between

any two countries across all 7 years, and then calculate for each node the in-degree as well as the in-strength (net imports.) As expected, there is no clear structure in the degree distribution while the net imports is heavy tailed.

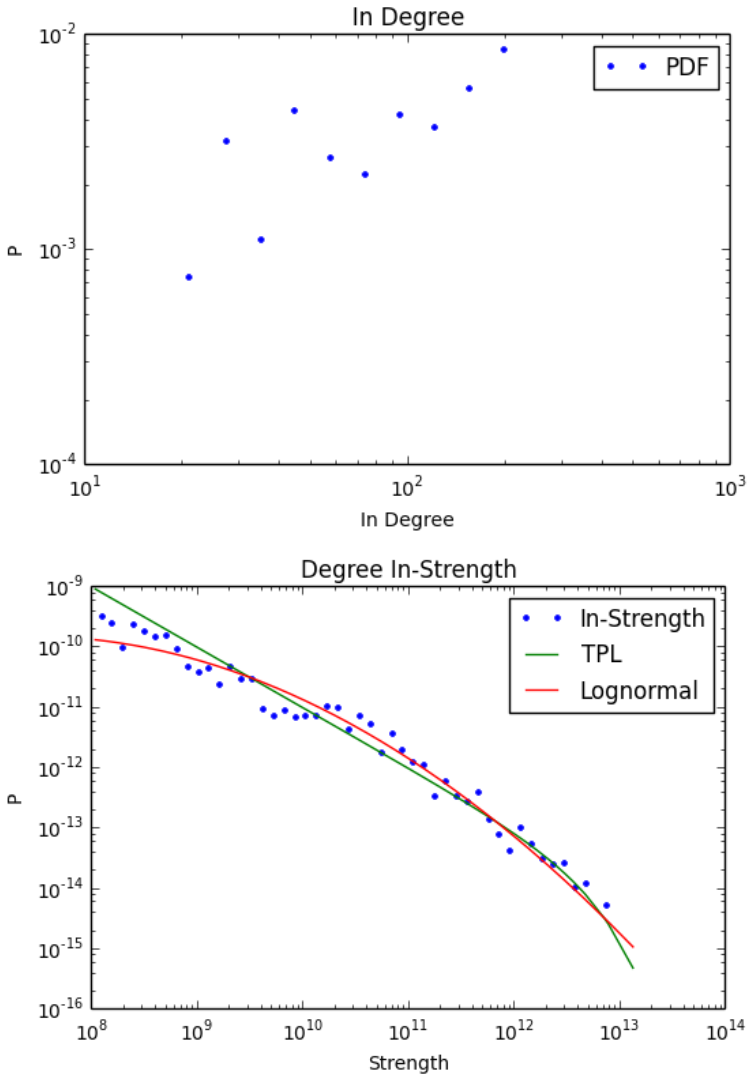

Figure 1: The PDF of the in-degree of countries offers little insight, while the in-strength is structured and indeed heavy-tailed

We also evaluate various network metrics, including centralities and

assortativity. The heterogeneity in goods and values of goods implies dissaortativity in the trade network which is also seen in our analysis. (Figs. **??** & **??**)

3 Community Analysis

In the light of the created WTNs, we analyze the community structure. With the network implementation, it is possible to examine community structure as the network evolves in time. We look at the sum of all imports/exports between countries for each year. Using iGraph, we are able to look for community structure based on a node's betweenness, accounting for weights and edge direction (Fig. **??**). We notice that in all years there is one "giant community," but it may be that the actual members of this community change as time goes on.

3.1 Intra-Community

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3.2 Inter-Community

We look at the interaction between the so-called "rich" and "poor" countries/nodes. To this end, we classify transactions as rich and poor based on a tunable cutoff value and examine the aggregate value of transactions in either group. This type of analysis is possible for node degree/net wealth in addition to the transactions/weighted edges shown in Fig. **??**.

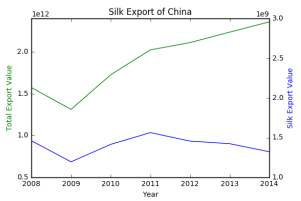


Figure 2: China's Silk Export

Figure 3: Russia's Steel and Iron Exports

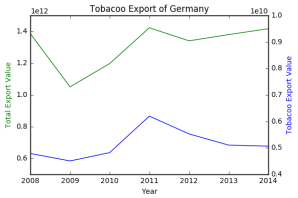


Figure 4: Germany's Tobacoo Export

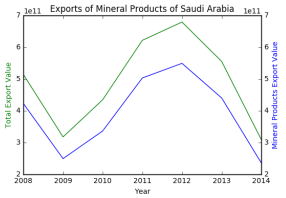


Figure 5: Saudi Arabia's Mineral Product Export

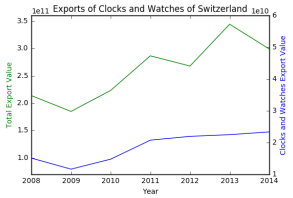


Figure 6: Switzerland's Clock and Watch Export

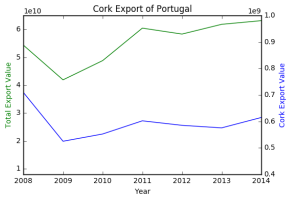


Figure 7: Portugal's Cork Export

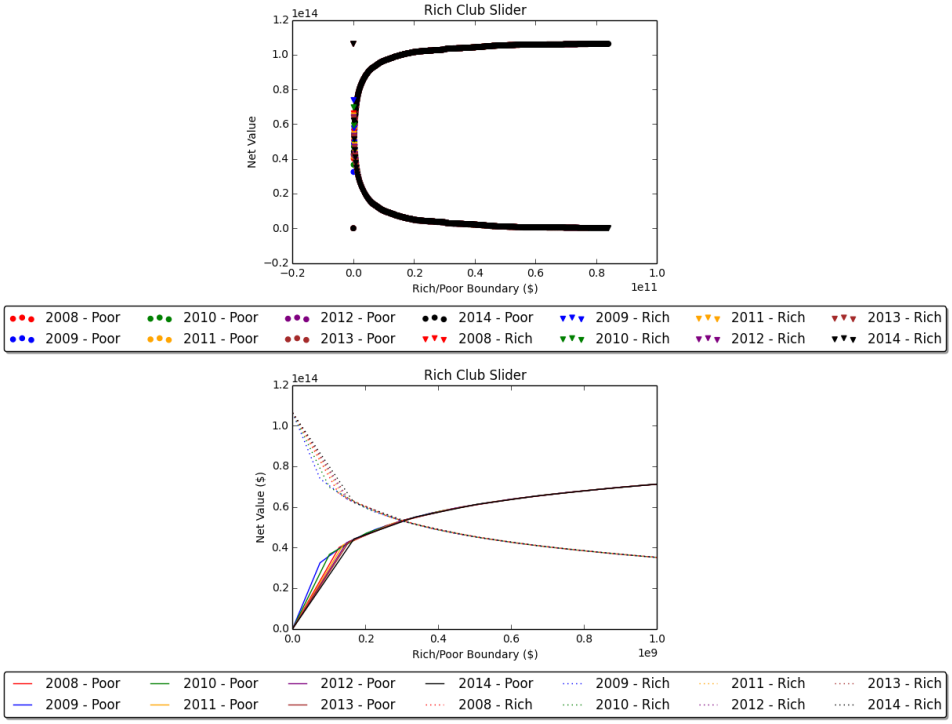
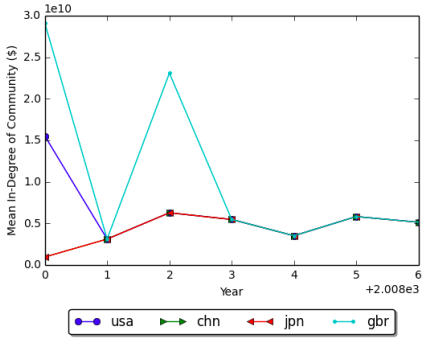
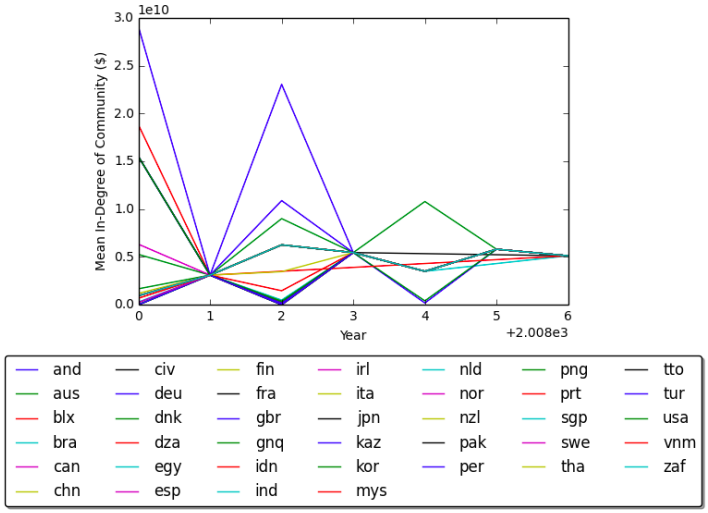


Figure 8: The net amount in dollars above (rich) and below (poor) a threshold value. We can tune our definition of "rich" and "poor" transactions in this way. Notice that the behavior is very similar for all years.





4 Conclusion & Future Work

Using a "heatmap" approach, we hope to plot the amount of exchange between any two countries in a grid (warmer colors for higher export values) and sort the countries based on community structure. If the rich/poor dichotomy exists as we expect it to, then the "heatmap" and community plots will reflect this. We also hope to perform similar analysis on a global finance network (debts and assets instead of exports and imports.) However, direct comparison between the two suggests compatibility hurdles in the python implementation (i.e., country ID codes, etc...) We also hope to perform a multiplex network-style analysis between the two, but we need to identify

a meaningful metric that properly reflects a country's standing in either network.

With the availability of high resolution global trading data, we thought that a network implementation would be an insightful and natural way to examine it. Using various network metrics and analysis techniques, we have searched for interactions between characteristically different countries, particularly by "rich/poor" classification. Using community structure and various measurements of the aggregate interactions between countries, we hope to see consistent evidence of differing country "wealth" and use this to gain insight on the changing financial standings of countries by examining their evolution in time.

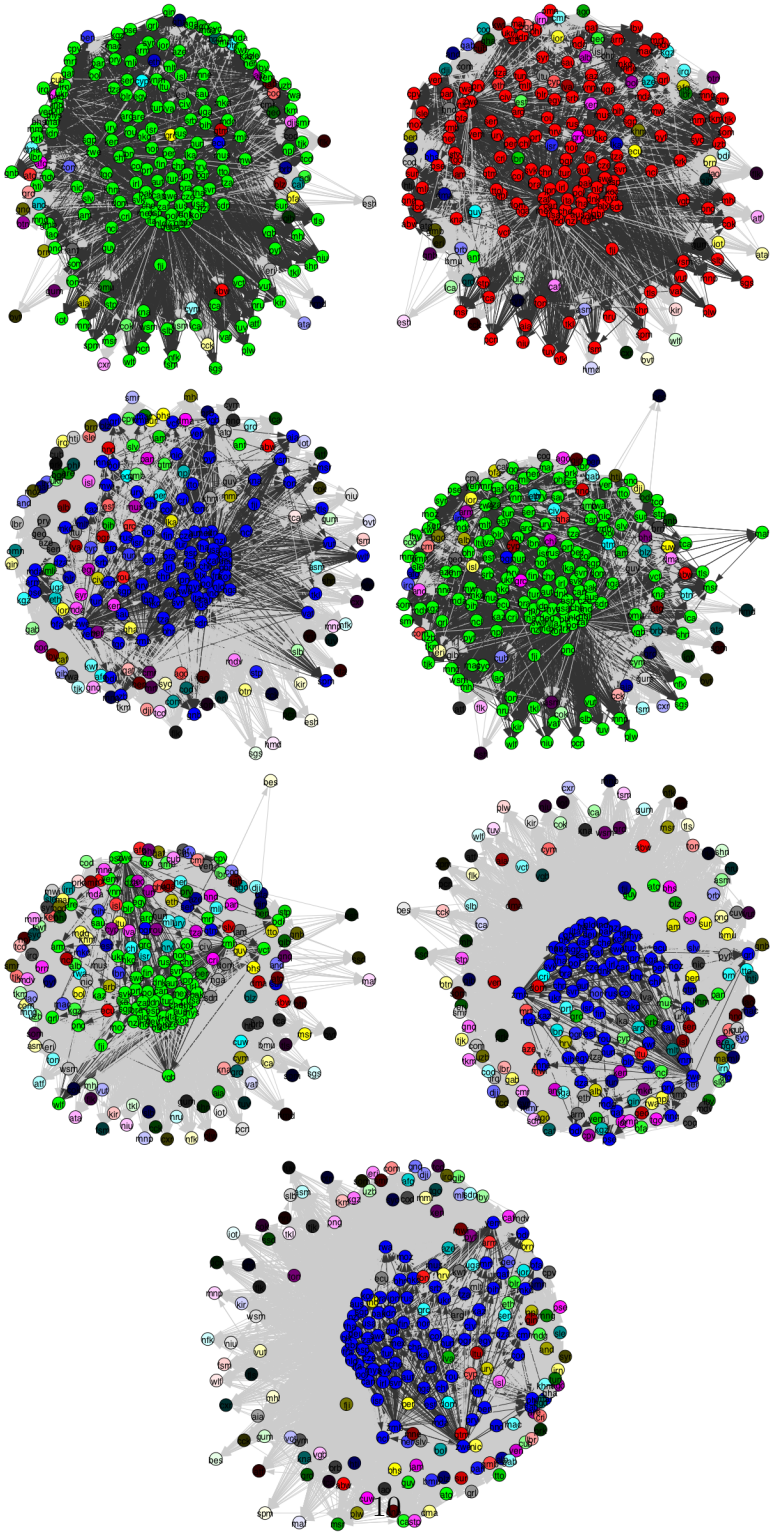
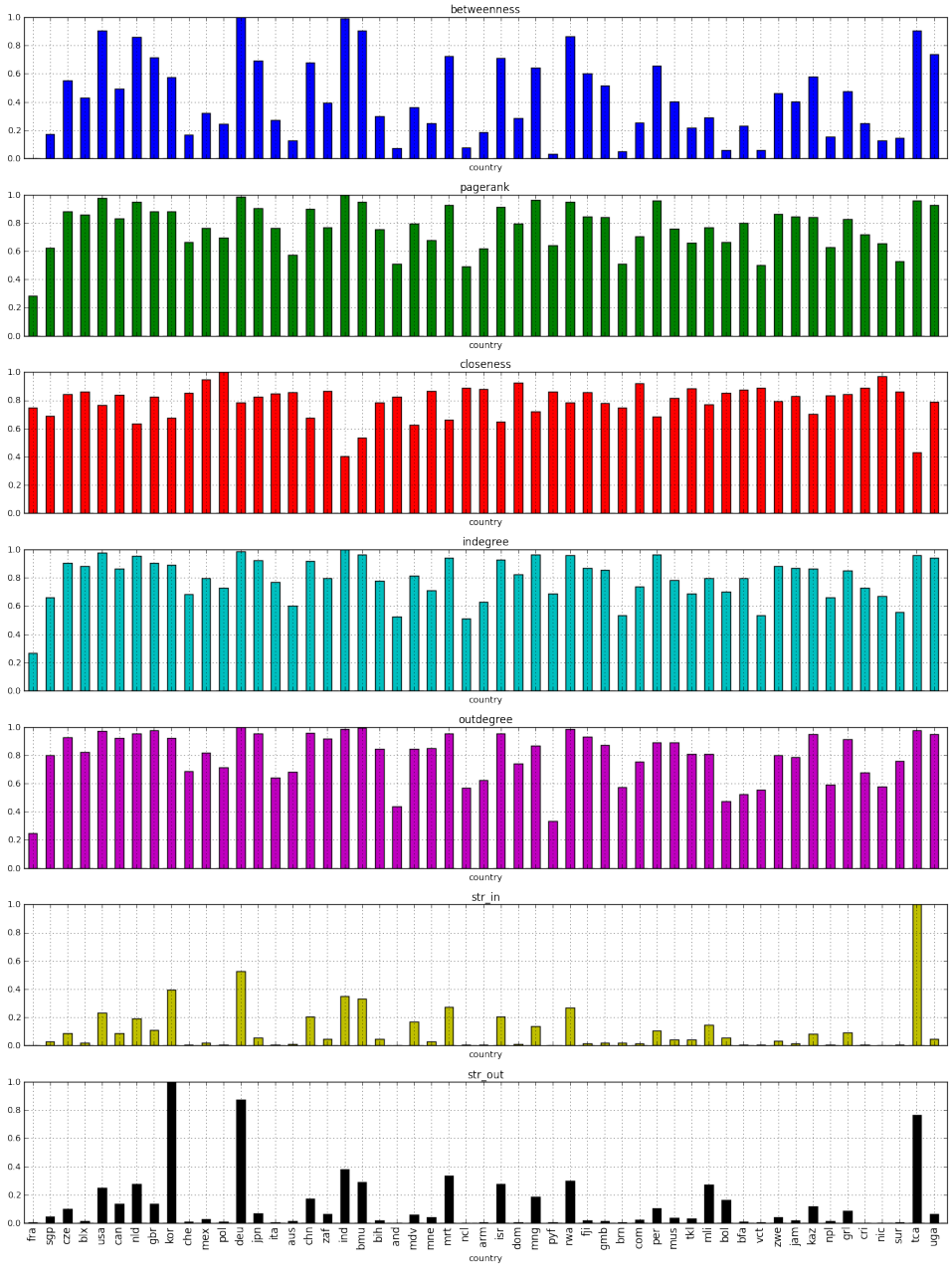


Figure 9: Net Import/Export network community structure for 2008 - 2014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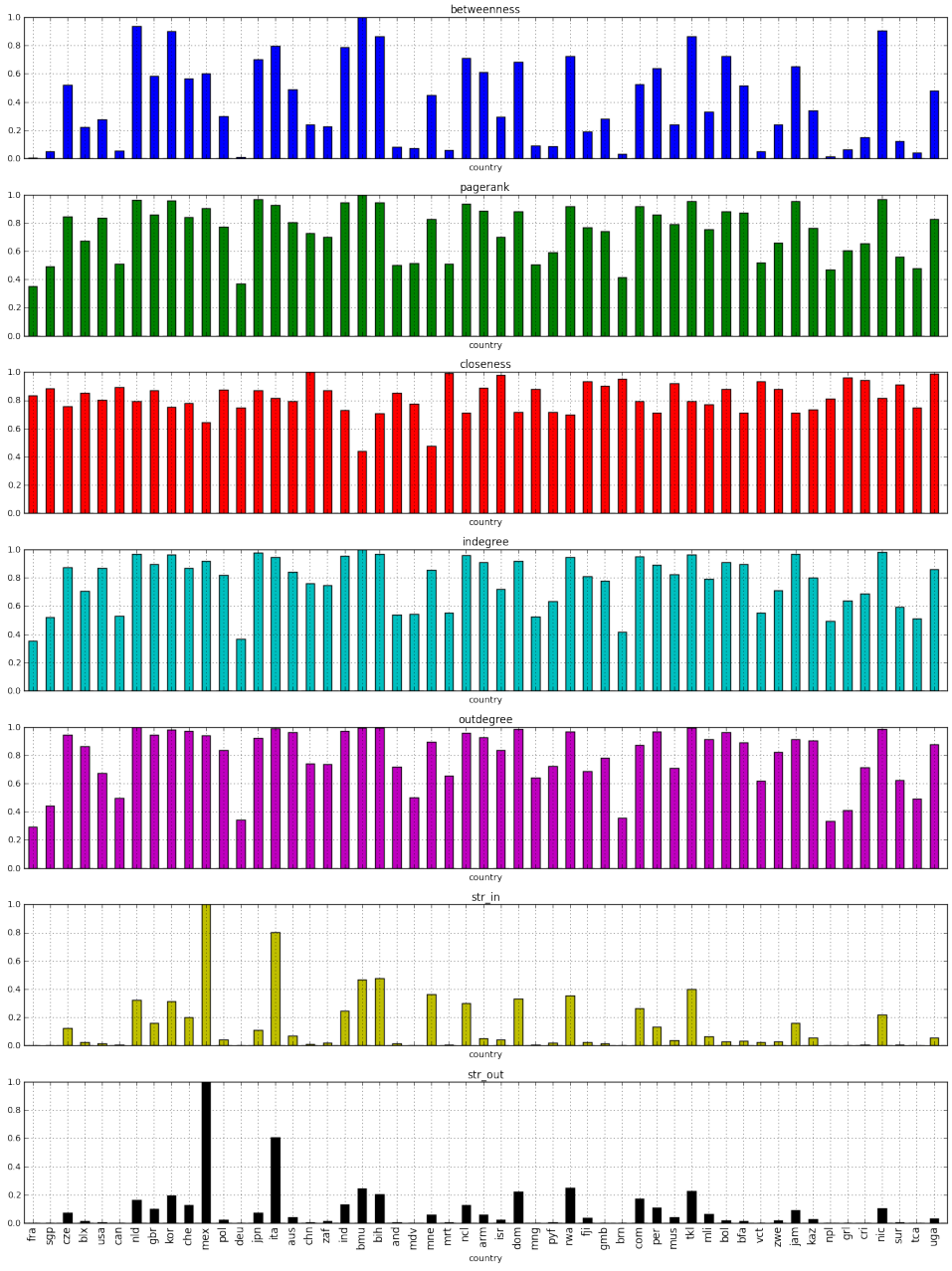
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