Empirical Network Approach to Labor Markets
The Case of Academic Economists

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Abstract: In this paper we use information collected on top two hundred economics departments in the world and their faculty to study labor markets from the perspective of social networks. We do so by collecting information on where each faculty obtained his or her degree. Using this information we construct the network created by education and employment decisions on the part of individuals and universities. The network is composed of universities educating and employing graduates. We examine this network finding what most readers will be familiar with: higher ranked departments employ more faculty and produce and place more graduates. Thus, one could conclude (another common belief) that the academic labor market for economists is hierarchical. However, we show that is not the case by showing this network is a small world – it is connected, has a small characteristic path length, and has a higher clustering condition than an equivalent random network. Hierarchical networks are not small worlds.

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1. Introduction

A frequent advice that college graduates and job seekers in general receive is the importance of "networking." They are told to establish as many relationships as possible within and outside their profession as such ties will not only help in performing better at their job, but will also provide potential leads when looking for new positions. Most studies of job search or mobility in labor economics often abstract away the social interaction process through which workers acquire jobs and employers hire workers. Even though personal ability is justly considered one of the main determinants of job mobility, a number of researchers have stressed the key role of social relationships.

Social networks have been shown to be crucial in influencing labor market transitions and their efficiency. Granovetter (1973) noted that most workers found their jobs through personal contracts and argued that social connections are the leading source of information about job opportunities. Montgomery (1991) examined the role of social connections by studying how they influence screening and matching. Relationships formed within and outside of one's workplace frequently help workers acquire new positions. This indicates the importance of network relationships in the social and economic operation of the labor market. The network structure connects different agents and defines the nature of interaction between them. Network formation depends on the strategic decision-making by its participants – by strategically deciding who to form relationships with participants can improve their future chances of landing a new job.

While the "networking" advice is omnipresent, it is difficult to study how such stable networks form and how they operate due to the difficulty of collecting detailed data on the exact structure of such networks. This paper takes a first step to bridge the

gap between the advice many receive and a study of a network where relationships are established and influence labor market outcomes. We do so by studying the labor market for academic economists. Due to their particular nature, a high skilled labor market like the academic labor market is conducive for studying network aspects. Unlike other labor markets, particularly those involving private corporations, where it is very difficult to easily observe employees and collect information on them as well as their social relations, academic labor markets are much more transparent. Given their public character, universities provide plenty of information on their employees, particularly the academic staff. Universities publish various information on faculty in their catalogs or on university web pages. In addition, faculty themselves typically post their own resumes on their web pages. Given the wealth of readily available information, academic labor markets are good candidates to help assess the importance of networking in labor markets.

The social networks perspective treats actors and their actions as being interdependent instead of being autonomous units. Such models view the network structure as providing opportunities for or constraints on individual actions. Links between nodes define information flows and affect outcomes. This implies that the labor market can be expressed through patterns or regularities among the interacting agents. This paper examines the structure of the academic labor market in economics using an empirical approach. Universities form the interacting agents in such a market with the hiring decision acting as the link between agents. In the absence of a significant employment history, a worker's type is often not known. As a consequence the reputation of the university is often used as a proxy for quality in this market for high skills. This

suggests that the academic market can be quite hierarchical and mobility across ranks may be difficult leading to possible inequality in the hiring process.

In this paper we use publicly available data on the top two hundred economics departments in the world. We collect data on tenure or tenure track faculty collecting information on their current employer, the university where they obtained their degree, and their rank. We first look at the global production and absorption of Ph.D. students in economics describing the structure of the network. This global structure involves only a very small set of countries with no African or South American country either hiring from or placing any student in the 200 economics departments. Next we examine the nature and size of departments to investigate the relationship between rankings, faculty size and hiring decisions. This also throws light on the pattern of self-hiring at different levels. We then divide universities into groups of 25 and examine hiring and placement within groups above and below as well as one's own group. In general one would expect that a hierarchical network would not be a small world – instead it would be composed of several components. However, we find that the top 200 schools in the world as well as the schools in our North American sample satisfy all properties of a small world network.

2. Data

In order to investigate the economics labor market, the information on the top two hundred departments and their faculty was collected. Tom Coupe's (2003) ranking of departments was used to select the departments to be studied. Coupe's (2003) ranking is used as it was the most recent available worldwide ranking when data collection began. Coupe (2003) arrived at his ranking by using several different measures of research

output, while most other rankings use a single measure. While we do not claim Coupe's (2003) ranking is the ultimate one and do not wish to engage in a debate about rankings, we point out that rankings developed by various authors are very similar. This can be observed in Table 1, which presents correlations of Coupe's ranks with other recent rankings. Correlation across rankings is particularly high for the top 100 departments and somewhat weaker for the bottom 100. Terms department, university, and institution are used interchangeably and all refer to departments of economics located at these universities. The top two hundred universities ranked by Coupe (2003) are referred to as the ranked universities. Since the list of ranked universities is by no means complete and it is possible those universities hire graduates of universities which are not ranked, those universities are collectively referred to as unranked.

Data were collected during the 2005-2006 academic year from information published on university websites. Data include tenured and tenure-track faculty (assistant, associate, and full professors) for each department. It includes only faculty with a terminal degree in economics. Information on economists in other parts of the university, such as business schools, agricultural economics departments, public policy departments, and others were omitted. While this resulted in some prominent business schools with many economists (University of Chicago, Northwestern University, University of Pennsylvania, Harvard University) being omitted from the study, collecting data on all economists employed by a single university would be much more difficult. It would entail combing the rosters of every unit within a university which could potentially hire an economist and examining the terminal degree of every faculty member. While in certain cases such information is somewhat easily available (some business schools do

provide faculty breakdown based on fields of specialization), in others it is more difficult to obtain it. In addition, since the main goal is to evaluate the labor market for academic economists, studying both production and placement, most units outside economics departments produce few economics Ph.D. Thus, their omission should result in a small bias.

Information on each individual includes the university which granted the terminal degree, the current employer, and professorial rank. These three pieces of information are the minimum required for the analysis.[4] The department which employed the individual when data were collected is referred to as 'employer,' while the department which the individual graduated with the terminal degree to as the 'grantor' or 'producer.'

The sample consists of two hundred employer universities, of which 126 are located in North America, 57 in Europe, 7 in Asia, and 4 in Australia. The total number of individuals in these departments is 5,530, of which the minimum required information (employer, grantor, and rank) is available for 5,081 individuals (92%), which is the size of the sample analyzed. The 449 economists for whom the required information is not available are all employed by universities in Europe, Australia, and Asia. Complete information is available for every academic economist employed in North America. A total of 321 universities granted terminal degrees to economists in the sample. Almost 98% of faculty with the minimum required information are Ph.D. degree holders in economics. The remaining 109 individuals do not have a Ph.D. as their terminal degree. With this in mind, we will generally refer to Ph.D. as the terminal degree for all individuals.

[4] For future use, where available the year of graduation, year of employment by current university, first employer and year, as well as fields of specialization were collected as well.

3. Network Structure

Table 2 presents the number of degrees granted and individuals hired by the countries in which the employer and grantor universities are located. The United States produces and hires by far the largest number of academic economists, producing a total of 3,395 economists in the sample (67%) and hiring 2,794 (55%). The UK is a far second with 529 economists produced and 521 hired. Canada is a close third. Figure 1 presents links between employer and grantor countries. Employers are located in 20 and grantors in 30 countries. Each employer and each grantor is represented by a node. If a country both hired and produced economists it is represented by two nodes. Hiring countries are concentrated in the middle of the figure, while grantors are on the edges. The direction of the arrow points in the direction of the placement of produced economists. An arrow pointing from France to Germany means that a French Ph.D. was hired in Germany. There is no arrow in the opposite direction, meaning no German trained scholar was hired in France.

Figure 2 shows interactions between continents, as both employers and grantors. The thicker line between North America and Europe indicates more interactions between these two continents compared to others. Information illustrated in Figure 2 is shown in Tables 3 and 4. Rows show the total number of degrees granted on each continent, while columns show the total number of economists employed on each continent. In both tables, 'N' indicates the actual number of economists. The only difference between the two tables is that Table 3 shows row percentages indicating the placement distribution across continents, while Table 4 shows the column percentages indicating the hiring

distribution across continent. North America produces a total of 3,635 economists, of whom 3,052 (84%) are hired by North American universities, 310 (9%) are hired by European universities, 77 (2%) are hired by Australian universities, and 196 (5%) by Asian universities. The 3,052 North American trained economists hired by North American universities represent 93% of all economists hired by North American universities. North America hired 204 economists educated in Europe who amount to 6% of all economists hired by North American Universities. Asia and Australia jointly account for less than one percent of academic economists in North America.

We should state we are more confident in results pertaining to the North American network for several reasons. First, there is complete coverage of North America. This is due to the tendency of departments outside of North America providing less information on their faculty members or providing less information in English (though there is only a small number of faculty outside North America for whom we were unable to collect the necessary information). Second, departments outside of North America have a much higher tendency to hire their own graduates than do the North American departments (though exceptions exist on both sides). This may be a result of smaller labor markets in which departments operate and may not truly reflect the networking aspects we aim to study. Third, the academic labor market in North America is very centralized, facilitated primarily through the efforts of the American Economic Association. While universities and graduates outside of North America participate in the North American market, their participation is limited relative to their numbers (both employment and number of economists produced). Labor markets on other continents are not as centralized (this is particularly true of Europe). In addition, geographic distance

and borders between countries outside of North America are likely to create fragmented markets and result in different institutional settings. However, to give a broader context and to assist further research, results for both the worldwide and North American networks will be presented.

In addition to these two samples, the worldwide and the North American networks, two more networks must be created. Since the goal is to analyze the labor market from a network point of view, it is necessary to create 'square' networks, where each department functions as both the employer and the grantor. Due to this requirement, the square samples will consist only of ranked departments. For the few universities which do not grant Ph.D. degrees, such as Dartmouth College, granting activity is set to zero (i.e., they only employ economists, but do not produce any).

Summary statistics for the various samples are provided in Table 5. The first column provides information for the worldwide network of all ranked universities. Faculty in the top two hundred departments received their degrees from 321 departments. The second column provides information on the square version of the full network – keeping only ranked departments whose graduates were employed by ranked departments. Out of two hundred top departments 179 have granted degrees to 4,783 faculty members currently employed by the top 200 universities. They form 94% of all hires.

The average, the median, and the standard deviation of Ph.D. hires (rows 4-6) from all grantors are not significantly different than hires from ranked grantors only (column 2 of Table 5). The average department size is 25.41 faculty members, with 23.92 hired from ranked departments. On average, ranked departments employed only 1.5

faculty members trained by a non-ranked department. The median number of faculty per employer does not differ much from the mean. However, the average, the median, and the standard deviation of the number of placements per granting department (rows 7-9) in the full network is much different than those in the square network. While the average number of placements per grantor in the full network is 15.83, the average number of placements per grantor in the square network is 26.72 individuals. Such differences are due to the few economists trained by the many unranked departments (298 economists received their terminal degree from 121 unranked departments). This indicates there is an unequal output of Ph.D. graduates. Higher ranked universities have the ability to produce more Ph.D. holders. By the same token, differences in program capacity may help explain why the standard deviation in the square network is higher than that in the full network. Placement of graduates in ranked universities is difficult and is very unevenly distributed (and at least to some extent correlated with total capacity which is unobservable in this study since we do not observe graduates who find jobs outside the academia). Only Massachusetts Institute of Technology, Harvard University, University of Chicago, and University of California at Berkeley have successfully placed more than 200 graduates each in other ranked university. Only nine additional universities have placed more than 100 of their graduates in ranked universities. These top thirteen producers are responsible for training a full 45% of all economists hired by ranked universities in the worldwide square network (or 42% in the full network).

The third and fourth columns of Table 5 present the statistics of the North American sample. The number of all grantors whose graduates have been hired at ranked North American universities is 197, but only 108 of them are located in North America.

The number of faculty members in ranked North American universities holding degrees from ranked North American universities, referred to as the *North American square network*, is 3,026, while the total number of faculty members in North America is 3,279. While the average size of a ranked department in North America is 26.02, an average of 24.02 faculty were trained by ranked North American universities. Within North American universities, the employment capacity varies less than in the full network, leading to smaller standard deviations in. As with all ranked universities, average and median number of faculty in North America are not very different. The median faculty size is 25, while the median number of faculty hired from ranked North American universities is 22.

Since most faculty in North American universities received their degrees from other ranked North American universities, the average number of placed graduates per grantor is 16.99 for all (worldwide) grantors and 28.02 for North American ranked grantors. The standard deviation of placement by North American universities is as high as among all ranked universities because North American universities are the majority of all granting universities and their placement and production capacity varies greatly. Not surprisingly, a large department can produce a large share of Ph.D. graduates. As an example, Harvard University has placed 196 Ph.D. graduates in top-ranking North American universities, while Louisiana State University has placed only 3.

North American universities employ few Ph.D. graduates from non-ranked Ph.D. grantors (71 faculty members). Only 182 of their faculty members received their degree from a ranked department outside of North America. Faculty hiring from North American grantors amounts to 92% of total faculty hiring (Table 5). Moreover, compared to all

ranked universities, institutional self-hiring in North American ranked universities is much lower. Only 5% of faculty members in a North American university received their degree from their current employer as compared to 12% for all universities.

3.1 Group Analysis

In order to capture the interactions between universities in different layers of the top 200, they have been divided into 8 tiers, each with 25 members as shown in Table 6. The 25 top-ranked universities form Group 1, those ranked 26 to 50 form Group 2, 51 to 75 form Group 3, etc. It may be said that moving from the top to the bottom tier reflects a decline in quality, since the ranking order is based on faculty publications. North American universities are divided into 5 groups as shown in Table 7. Each of the first four groups contains 25 universities, while the fifth has 26 members. Interactions and links between different tiers in both samples are presented in Figures 3 and 4. Links between nodes are valued in terms of the number of faculty hired or placed between the nodes or groups. Thus, the thickness of lines, or edges, between groups reflects tie strength. The patterns of interactions between groups in both networks are quite similar. Although each group connects directly to each other, the strength of ties varies. Every group connects to Group 1, the highest-rated group, with strong ties. The strongest (thickest) tie is between Group 1 and Group 2. The ties between other groups, except their ties with Group 1, are moderate to weak. The weakest ties are connections between low-level groups. For example, the tie between Group 5 and Group 8 in the worldwide network (Figure 3), and the tie between Group 4 and Group 5 in the North American network (Figure 4), are both weak.

Tables 8 and 9 present the summary information for each group in both networks. These tables provide information on total and average faculty size as well as the distribution of hiring and placement of graduates relative to the rank of the group. 'Hiring (Placement) within' refers to hiring (placement) within the same group, while 'Hiring (Placement) within Self' refers to hiring own graduates. Several patterns are clear. The rank of a group is inversely proportional to faculty size. The highest ranked group (Group 1) has the most faculty. This tendency is clearest in the North American network. The high-level groups are much larger in terms of faculty than lower-level groups. The size ratio between the highest and lowest groups in both samples is 2-to-1.

Other patterns of hiring and granting are also clearer in the North American network (Table 9). Percentage of 'hiring above' indicates that every group hires intensively from groups ranked above it. As should be expected, the lower the group the more it hires from groups above it since departments try to hire the best faculty possible. This translates in hiring graduates from higher ranked departments. The same reasoning applies to patterns in 'hiring within' and 'hiring below.' The lower the group, the lower the percentage of faculty hired within the group and below the group. That Group 1 has the highest percentage of hires within the group is not surprising since it has no universities above itself to hire from. This pattern is not as clear-cut across the eight groups of all ranked universities. This is mainly because of the higher tendency of universities outside of North America to hire their own graduates (see Groups 5, 7 and 3 in Table 8). As is seen in Table 8, universities in Group 5 hire by far the highest percentage of their faculty from their own graduates. Almost 23% of their faculty are

their own graduates. While Group 4 in the North American sample also breaks the trend for self hires, it does so by a much smaller margin.

Certain patterns are present in the distribution of placement of graduates. As the rank of the group decreases, the percentage of graduates placed to higher groups increases, while that of graduates placed to lower decreases. This is to a large extent due to the nature of the sample used. As the rank of the group decreases, the number of lower ranked universities observed where graduates can be placed decreases, while the number of higher ranked universities where graduates can be placed increases. In addition, especially for the lowest groups, few graduates are placed to begin with, implying that the relative distribution can be somewhat misleading. Given that all possible academic placements are not observed, the limits imposed by what is possibly observed in the sample results in the observed patterns.

Percentages of 'placement below' indicate that higher groups place faculty in lower groups more than lower groups place faculty in higher ones. Group 4 hires 90% of its faculty from higher-ranked universities, while it is able to place 22% of its graduates to universities in Group 5. Comparing placements above and below, most universities place the majority of their graduates in lower ranked universities. This pattern is somewhat reduced in the lower half of ranked universities, but it is still the case that they place more graduates at their own level or below than in universities ranked above them. These findings are in line with Moore and Newman (1977)'s "downstream pattern," that most new Ph.D. graduates are likely to find a job at a lower-level university than the university from which they graduated.

Table 9 provides two more interesting facts. One is that lower groups place more graduates to other universities within the same group than higher groups do. For example, Group 5 in the North American network places 45% of its graduates within its own group, while Groups 1 and 2 place only 37% and 20% within their own groups. What is more, universities in lower groups more frequently place their graduates to themselves than the universities in higher-level groups. Group 5 in Table 9 has the highest percentage of placement to self. The percentage of self-hiring to total Ph.D. granting of group 5 is 28% compared 4% in group 1. Both of these results are due to the low production capacity of the lowest ranked universities. Given their low rank and the few graduates they are able to place to ranked universities, they are much more likely to be able to place them within their own group, or to hire them themselves, than to place them in higher ranked departments. This could be a consequence of not observing lower ranked universities which might be the main employers of Group 5 graduates.

3.2 Trivial Pursuits

Here we provide an idiosyncratic collection of facts culled from those tables.

In our sample MIT has placed the largest number of graduates, 255, followed by Harvard at 233 placements. The first non-North American institution is London School of Economics with 115 placements. They are followed by Oxford with a 106. In the top 10 programs Michigan (9^{th}) and Columbia (10^{th}) have each placed less than a 100 students while the other 8 have all placed over 100 students. Focusing on continental Europe institutions with highest placements are Paris I (51), Louvain (35), Toulouse (32), Copenhagen (31), European University Institute (27), Tilburg (26) and Bonn (23). In Australia, Australian National University has the highest number of placements with 24.

In Asia, Tokyo University with 32 placements is the placement leader. Typically the number of placements decreases with the rank, but occasionally there are some exceptions like Queen Mary in London which despite its rank of 198 has placed 5 students in top ranked programs. Similarly, SUNY Stony Brook and CUNY are exceptions with 13 and 9 placements respectively. Explanations for these differences can range from the size of the program to locations and reputation of the institutions themselves.

Our data on university faculty sizes is based on roster data available from the department's webpage. Note that this number can be misleading since in many universities economists may be spread over different departments. The single largest department in our sample is University of Bologna with faculty size of 64 followed closely by Toronto with 61. In North America the smallest departments are University of Colorado at Denver (194^{th}) and University of Rhode Island (200^{th}) having 10 faculty members each.

In terms of hires from non-ranked universities, we can see the likely effect of the segmented labor market outside of North America. University of Bologna has 11 members from non-ranked universities followed closely by Universidad Carlos III de Madrid and Paris I with 10 members each and University of Nottingham with 9. North American universities hire much less frequently from outside the ranked universities. Toronto (25^{th}) has 4 of its 61 members hired from universities that are not ranked. Cornell (14^{th}), Purdue (62^{nd}), Florida State (78^{th}), Temple (178^{th}) and Concordia (196^{th}) each have 3 faculty members who obtained their doctoral degree from a non-ranked university. Among the top 10 schools only UC Berkley has a hire from a non-ranked

university - Université Libre de Bruxelles. Princeton's (11th) one non-ranked hire is from the University of St. Gallen, while Cornell's non-ranked hires are from Heidelberg (2) and University of Aarhus (1).

In the North American sample we also examine how often universities hire from ranked schools outside of North America. In terms of having an "international flavor" Canadian universities seem to be doing better than their US counterparts. Of the US Universities, USC has 26% and Virginia Tech has 23% of their hires from ranked universities outside North America. Six Canadian schools have more than twenty percent of their faculty members from ranked universities outside North America – McGill (24%), York (77%), Laval (78%), Montreal (79%), Quebec (79%) and Guelph (79%).

Self-hiring is quite predominant in the top 10 universities with MIT having 29% of its own doctoral students on its faculty. Harvard comes next with 26% while Michigan (2%) and Columbia (2%) have the lowest percentages. Among the other American schools Carnegie-Mellon has the highest number of self-hires at 14%, closely followed by Syracuse with 11%. Other universities with high self-hires are American University and Georgia State at 10% each. Among Canadian universities Waterloo has the largest number of self-hires (14%) followed by Queen's at 13% and UBC at 12%. In universities outside the US self-hires can be very high ranging from 42% at Oxford and 50% at Cambridge to over 90% in a few institutions. Paris I, among the leading continental Europe universities in placement, placed 30 of its 51 graduates with itself, resulting in 75% of its faculty being self-hires. These differences with North America can be attributed to language barriers, reputation of institutions as well as to institutional factors such as segmented nature of academic labor markets outside North America.

4. Small Worlds

In recent years there has been an explosion in research on the small-world phenomenon. However, the literature in economics on this topic consists of a single paper. Goyal et al. (2005) investigated what they perceived to be an emerging small-world network of increasing collaboration and distant co-authorships among economists. They constructed distinct networks of collaboration among world economists who published in journals during three periods: 1970-1979, 1980-1989 and 1990-1999. Results indicated the presence of a small-world phenomenon in the collaboration network. Giant components not only existed, but had grown substantially from fifteen percent in the first period to forty percent in the third period. All networks were connected. The number of authors was very large, while average degrees of connection overall, and in the giant component, were low, although they had increased over time.

4.1 A Small World Model

For the purpose of investigating the small-world phenomenon in the economics academic labor market network, the model proposed by Watts and Strogatz (1998) and Watts (1999a, b) and used by Goyal et al. (2005) is adopted. This section tests whether the academic labor market network in economics satisfies the following small-world properties:

1. The number of vertices needs to be far greater than the average degree. For the $n >> k >> \ln(n) >> 1,$ condition of sparseness to be met and $k>>1$ to guarantee that the network is connected.

2. The network must be connected or have a largest component for the characteristic path length to be measured.
3. The characteristic path length must be almost as small as the characteristic path length in a corresponding random network, $L \approx L_{random} \sim \frac{\ln(n)}{\ln(k)}$.
4. The clustering coefficient must be much greater than that in a corresponding random network: $C >> C_{random} \sim \frac{k}{n}$.

4.2 Empirical Results

The economics academic network is described by the grantor-employment matrix A, where A_{ij} is the number of faculty graduating from university *i* and employed by university *j*. The square version of the worldwide network is depicted in Figure 5, while that of the North American network is shown in Figure 6. The arrow lines show the source and target of exchange (self-hires are not shown). The arrows indicate placement from the grantor to the employer. The thickness of each line indicates tie strength. The figure shows all universities in the network are connected. There is a single component in the network and no isolated universities. Figure 7 shows Harvard University's neighborhood, its so-called *ego network*, which reveals a number of important features of the square network. For instance, Harvard has placed eight Ph.D. graduates in MIT and four in Oxford. It employs thirteen Ph.D. graduates from MIT and one from Oxford. Although Harvard has bilateral relationships with both MIT and Oxford, the relationship with MIT is stronger. Single-direction relationships are exemplified by the fact that Harvard has placed twelve graduates at Columbia, seven at Boston University, and one at UC Riverside, but does not employ a single graduate of any of these institutions.

Harvard, then, has stronger ties with Columbia than with Boston University, which is a stronger tie than that with UC Riverside.

Figure 8 presents Oxford University's ego network. It provides an example of a European institution which hires its own products at a much higher rate. Oxford hires about 42% of its faculty from within the square network. Although it interacts with universities inside and outside Europe, there is a sense of stronger ties within Europe. For example, Oxford University has placed five graduates at University of College London (UCL), five at London School of Economics (LSE), and nine at Bologna, while placing only two at MIT, one at Harvard, and two at UC Berkeley. On the other hand, Oxford has hired five graduates of Cambridge, four of LSE, and four of UC Berkeley.

In order to analyze and test for small-world properties in the academic network, its matrix was transformed to represent as an unweighted-directed-unlooped network. The transformed matrix Y consists of element Y_{ij}=1, if A_{ij}>1, $i \neq j$, Y_{ij}=0 if A_{ij}=0, $i \neq j$ and Y_{ii}=0. This representation helps distinguish between in- and out-degree. Out-degree captures placement of graduates. In-degree captures employment of graduates from one institution by another. The total number of faculty in the network is 4,783 individuals in the worldwide network and 3,026 individuals in the North American network (see Table 10 and 11). After transforming networks from valued into unweighted networks, the total in-degree and out-degree connections are 2,646 and 1,739 in the worldwide network and the North American network, respectively.

In the valued or weighted network the row summation is the number of graduates placed by a university, in the unweighted network it is the number of universities where one university was able to place its graduates – the number of degrees is less than the

number of faculty in the networks. For example, Harvard placed 239 graduates in the worldwide square network, representing a total of 90 universities (excluding Harvard itself). Harvard's out-degree in the valued network is 239 and only 90 in the unweighted network. Harvard's in-degree in the valued network is 53 (faculty size), but only 15 in the unweighted network (total number of different universities able to place graduates at Harvard). Even though the number of in-degree and out-degree for each university are different, in the square matrix the summation of these parameters are the same.

The small-world properties will be examined in the order they were introduced earlier. Tables 10 and 11 show the characteristics of the square worldwide and North American networks, respectively. There are 200 total vertices in the square network and 126 vertices in the North American square network. The average in-degree and out-degree is 13.23 in the former and 13.80 in the latter. The average degree in the worldwide network is greater than 2.30, which is the logarithmic value of the number of vertices in the network ($ln(200) \approx 2.30$). The average degree in the North American network is also greater than the logarithmic value of the number of vertices in the network ($\ln(126) \approx 2.00$). Both connected networks have a number of vertices far greater than the average degree. This number is also greater than their logarithmic values ($n>>k>>ln(n)>>1$). Thus, the first condition for a small world network is satisfied in both the worldwide and the North American networks.

Due to the fact that both the worldwide and the North American networks have only one single component, the characteristic path length pertains to each graph as a whole. The characteristic path length, which is the average of the shortest distance from one university to any other, is 2.80 in the North American network, a little shorter than

the 2.93 for the overall worldwide network. In other words, an economics department in one North American university can reach any other on the same continent with a slightly shorter chain than in the global network. Most top 10 ranked universities connect directly to each other. The maximum shortest path length between them, in both networks, is only 2. For example, the distance between Harvard and Chicago, University of Pennsylvania, and MIT is one. The distance between Chicago and MIT to Harvard is also one; from University of Pennsylvania to Harvard is two.

The distance between lower ranked universities to the higher ones or within their same group of quality is longer. For example, the distance from University of Southern California, located in Group 2, to Harvard is five, which is higher than distance to any other university in Group 2 but University of North Carolina and Vanderbilt. Since some universities are unable to place graduates at ranked universities, some distances in the network cannot be computed. Those universities, then, are considered to be somewhat disconnected. The distance weighted fragmentation, shown in Tables 10 and 11, calculates the distance weighted by the number of connected vertices. The distance weighted fragmentation in the North American network is 0.67, quite a bit smaller than 0.96 in the worldwide network. The distance weighted fragmentation of these real networks is quite close to random networks. Hence, in both networks the second condition for small-worlds is satisfied.

Unsurprisingly, the density value in the North American network (0.11) is greater than the value in the worldwide network (0.07), of which it is a subset. Within the North American network, the chance of sharing information or exchanging Ph.D. graduates is

higher than in the worldwide network. The standard deviation values of density in both networks differ only slightly.

The clustering coefficient in either network is higher than its density. This is because the clustering coefficient is measured with the local neighborhood, which is of much higher density than that of the overall network. However, the clustering coefficient of the worldwide network is 0.24, which is slightly smaller than 0.27 of the North American network. In other words, the neighborhood of one university in the worldwide network relates more to other nodes less than in the North American network. This fact might indicate that universities in North America rely on connections in the network more than universities outside of that continent. The North American network has a size weighted clustering coefficient to of 0.20, compared with 0.17 for the worldwide network.

The characteristic path length and clustering coefficients of the respective Erdos and Renyi random networks are also given in Tables 10 and 11. The characteristic path length calculated for a random network with the same number of vertices and average degree as the worldwide network is 2.05 and 1.84 for the equivalent North American network. The characteristic path length in both real-world networks is not much greater than that in the simulated random networks (2.93 and 2.80). Thus, it can be concluded that the third condition for a small-world phenomenon is satisfied by both networks.

The clustering coefficient of an Erdos and Renyi random network equivalent to the worldwide network is 0.07 and 0.11 for the North American equivalent random network. Both clustering coefficients in the real-world networks are much higher than

those of their random counterparts. Thus, the last condition for a small-world network is also satisfied.

In order to make these above comparisons more reliable, one hundred Erdos and Renyi random networks with the same number of vertices and density values were. Average characteristics of these random networks are presented in Tables 10 and 11. In Table 10, the average value of the characteristic path length and clustering coefficient of random networks are 2.32 and 0.07, respectively. In Table 11, the average value of the characteristic path length and clustering coefficient of random networks are 2.09 and 0.11, respectively. The third and fourth conditions are confirmed by comparisons with multiple random networks. Since they satisfy all conditions, both real-world networks can be said to exhibit properties of the small-world phenomenon.

5. Conclusion

This paper represents one of the first attempts to examine empirically a labor market from the social network perspective. This is achieved by studying the academic labor market for economists, which, due to its transparency and public nature, makes for a fairly easily observable market. The main difficulty in studying the role of networks in labor markets is collecting information on market participants and their links. Given universities publish information on their faculty, the academic labor market can overcome this hurdle. We collect data on economics professors employed by the top 200 universities in the world and examine the network formed by their graduate school training and subsequent employment in a university.

We describe the structure of the university network created by education and employment decisions. The network is fully connected, with no isolated universities. In other words, every university is connected with at least one other university in the network. This network is shown to be fairly hierarchical in the sense that higher ranked universities employ more economists, produce more graduates, and are able to place more of their graduates in academic employment with other universities. Lower ranked universities are smaller in both size and output and placement of graduates. This largely conforms with well known (though rarely described) characteristics of the labor market for academic economists. However, this network is not hierarchical in its nature. Rather, it is best described as a small world.

References

Coupe, Tom. (2003): "Revealed Performances: Worldwide Rankings of Economists and Economics Departments, 1999-2000," *Journal of the European Economic Association,* 1(6), pp. 1309-1345.

Dusansky, Richard, and Clayton J. Vernon. (1998): "Rankings of U.S. Economics Departments," *Journal of Economics Perspectives,* 12(1), pp. 157-170. 10 Jan. 2007 <http://www.jstor.org>.

Goyal, Sanjeev, Macro van der Leij, and Jose Luis Moraga-Gonzalez. (2005): "Economics: An Emerging Small World," *Journal of Political Economy*, 114(2), pp. 403-412.

Granovetter, Mark S. (1973): "The Strength of Weak Ties," *American Journal of Sociology*, 78(6), pp. 1360-1380.

Heck, Jean L., Peter A. Zaleski, and Scott J. Dressler. (2006): "Economic Departments and Their Contributions to the Elite Economic Journals," *Journal of the Academy of Business Education*, 7. 20 Mar. 2007 <www.abe.sju.edu/proc2006/heck.pdf>.

Kalaitzidakis, Pantelis, Thanasis Stengos, and Theofanis P. Mamuneas. (2003): "Rankings of Academic Journals and Institution in Economics," *Journal of the European Economic Association,* 1(6), pp. 1346-1366.

Montgomery, J. D. (1991): "Social Networks and Labor-Market Outcomes: Toward an Economic Analysis," *American Economic Review*, 81(5), pp. 1408-1418.

Moore, William J., and Robert J. Newman. (1977): "Academic Placement of Econommists 1960-74," *Job Openings for Economists,* American Economic Association.

Roessler, Christian. (2004): "Rankings," 20 Feb. 2007 <http://www.econphd.net/rankings.htm>.

Scott, Loren C., and Peter M. Mitias. (1996): "Trends in Rankings of Economics Departments in the U.S.: An Update," *Economic Inquiry*, 34, pp. 378-400.

Watts, Duncan J., and Steven H. Strogatz. (1998): "Collective Dynamics of Small-World Network," *Nature,* 393, pp. 440-442.

Watts, Duncan J. (1999a): *Small World: The Dynamics of Networks between Order and Randomness,* Princeton: Princeton University Press.

Watts, Duncan J. (1999b): "Networks, Dynamics, and the Small-World Phenomenon," *The American Journal of Sociology*, 105(2), pp. 493-527.

Table 1: Correlation between Coupe (2003) and Other Rankings

		Correlation Coefficient with Coupe (2003)
Christian Roesster (2004) Network Rankings	Worldwide (200)	0.75
	100 upper rank	0.75
	100 bottom rank	0.29
	North America	0.85
	100 upper rank	0.82
	100 bottom rank	0.25
Christian Roesster (2004) Average Productivity Rankings	Worldwide (196)	0.80
	100 upper rank	0.76
	100 bottom rank	0.43
	North America	0.87
	100 upper rank	0.82
	100 bottom rank	0.66
Kalaitzidakis, Stengos, and Mamuneas (2003)	Worldwide (200)	0.78
	100 upper rank	0.73
	100 bottom rank	0.26
	North America	0.85
	100 upper rank	0.82
	100 bottom rank	0.49
Heck, Zaleski, and Dressler (2006)	Worldwide (186)	0.80
	100 upper rank	0.80
	100 bottom rank	0.31
	North America	0.87
	100 upper rank	0.85
	100 bottom rank	0.37
Scottand Mitias (1996) Wide 36 Journals (concentrate)	100 US Departments	0.87
Scottand Mitias (1996) Core 5 Journal (Stock)	80 US Departments	0.17
Dusansky and Vernon (1995)	50 US Departments	0.65
NRC Faculty Survey in 1993	50 US Departments	0.83
USNWR Overall Survey in 1996	50 US Departments	0.81

Table 2: Grantor and Employer Countries

Grantor Country	Number of Graduates	Percentage
Australia	78	1.54
Austria	19	0.37
Belgium	76	1.50
Canada	240	4.72
China	1	0.02
Czech Rep.	2	0.04
Denmark	38	0.75
Finland	1	0.02
France	141	2.78
Germany	98	1.93
India	8	0.16
Ireland	4	0.08
Israel	27	0.53
Italy	63	1.24
Japan	64	1.26
Kazakhstan	1	0.02
Netherlands	102	2.01
NewZealand	2	0.04
Norway	25	0.49
Poland	1	0.02
Russia	4	0.08
Scotland	3	0.06
Serbia	1	0.02
Singapore	5	0.10
Spain	74	1.46
Sweden	57	1.12
Switzerland	21	0.41
Taiwan	1	0.02
UK	529	10.41
USA	3395	66.82
Total	5081	100.00

Employer Country	Number of Hires	Percentage
Australia	166	3.27
Austria	20	0.39
Belgium	52	1.02
Canada	485	9.55
China	94	1.85
Denmark	42	0.83
France	120	2.36
Germany	79	1.55
Ireland	3	0.06
Israel	56	1.10
Italy	125	2.46
Japan	109	2.15
Netherlands	114	2.24
Norway	31	0.61
Singapore	42	0.83
Spain	146	2.87
Sweden	49	0.96
Switzerland	33	0.65
UK	521	10.25
USA	2794	54.99
Total	5081	100.00

Table 3: Distribution of Economists in Ranked Universities (Row Distribution)

			Employer				Total Granting
			Asia	Australia	Europe	North America	
Grantor	Asia	N =	88	1	4	13	106
		Row %	83.02	0.94	3.77	12.26	
	Australia	N =	4	60	6	10	80
		Row %	5.00	75.00	7.50	12.50	
	Europe	N =	13	28	1,015	204	1,260
		Row %	1.03	2.22	80.56	16.19	
	North America	N =	196	77	310	3,052	3,635
		Row %	5.39	2.12	8.53	83.96	
	Total	N =	301	166	1,335	3,279	5,081
		Row %	5.92	3.27	26.27	64.53	

Table 4: Distribution of Economists in Ranked Universities (Column Distribution)

			Employer				Total
			Asia	Australia	Europe	North America	
Grantor	Asia	N =	88	1	4	13	106
		Column %	29.24	0.60	0.30	0.40	2.09
	Australia	N =	4	60	6	10	80
		Column %	1.33	36.14	0.45	0.30	1.57
	Europe	N =	13	28	1,015	204	1,260
		Column %	4.32	16.87	76.03	6.22	24.80
	North America	N =	196	77	310	3,052	3,635
		Column %	65.12	46.39	23.22	93.08	71.54
	Total Employment	N =	301	166	1,335	3,279	5,081

Table 5: Summary Statistics for Ph.D. Graduate Employment in Economics Departments

		Worldwide Full Network Ranked Employers, All Grantors	Worldwide Square Network Ranked Employers and Grantors	North American Full Network Ranked Employers, All Grantors	North American Square Network Ranked Employers and Grantors
1	Number of Employing Universities	200	200	126	126
2	Number of Ph.D. Granting Universities	321	179	193	108
3	Total Number of Faculty	5,081	4,783	3,279	3,026
4	Average Faculty per Employer	25.41	23.92	26.02	24.02
5	Median of Ph.D. Faculty per Employer	24	22	25	22
6	Standard Deviation of Faculty per Employer	12.05	11.42	10.63	9.81
7	Average Number of Placements per Grantor	15.83	26.72	16.99	28.02
8	Median Number of Placements per Grantor	3	12	3	9
9	Standard Deviation of Number of Placements per Ph.D. Grantor	35.48	44.61	36.50	45.66
10	Number Hired from Non-Ranked Grantors	298		71	
11	Number Hired from Non-North American Ranked Grantors			182	
12	Percentage Hired from Ranked Universities	94.14		92.28	

Table 6: Eight Groups in Worldwide Square Network

Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**	**Group 8**
Harvard	Oxford	WOntario	UCSB	Oregon	Rice	Clemson	Kansas
Chicago	UBC	JHU	LBS	GMU	Tennessee	Birmingham	NHH
Penn	UCSD	ANU	FLSt	Birkbeck	Emory	Guelph	Temple
Stanford	USC	Vanderbilt	UNSW	VUAmsterdam	NUSingapore	Hitots	Glasgow
MIT	BU	Queen's	Alberta	UMass	Laval	Tufts	SIUC
UCBerkeley	PennSt	WUSTL	McMaster	SCarolina	C3MU	BYU	KanSt
Northwestern	CMU	Montreal	Houston	ParisI	Waterloo	Tokyo	CUNY
Yale	Cambridge	GTown	Syracuse	Bristol	WayneSt	CULon	Oklahoma
Michigan	Florida	COBoulder	UAB	Melbourne	WiscMil	Zurich	CWM
Columbia	MichSt	UGA	Nottingham	UIC	Missouri	StonyBrook	Strathclyde
Princeton	Rutgers	VATech	HKUST	Copenhagen	UCRiverside	Carleton	Edinburgh
UCLA	UWash	Purdue	Bonn	McGill	Alabama	Reading	UHK
NYU	UNC	UCIrvine	YorkU	Groningen	Quebec	AcademiaS	WashSt
Cornell	TAMU	BC	CalTech	ChUHK	Albany	KUL	Uppsala
LSE	Indiana	IowaSt	LSU	ULB	Oslo	Bar-Ilan	Osaka
WiscMad	Iowa	Amsterdam	Southampton	NewcastleuT	MiamiFL	EUI	Tsukuba
Duke	TelAviv	NCSt	UConn	Tulane	Maastricht	Bocconi	UNM
OhioSt	UVA	Erasmus	GASt	American	Delaware	Utah	UCDublin
Maryland	UCL	Dartmouth	UKY	Mannheim	Sydney	Brandeis	CODenver
Rochester	Hebrew	Louvain	GWU	Auburn	EHESS	IUPUI	RomeLS
UTAustin	Brown	UYork	INSEE	UPF	Vienna	Exeter	Concordia
Minnesota	Tilburg	ASU	SMU	Buffalo	Munich	Bologna	SCU
UIUC	Pitt	Toulouse	NotreDame	Manchester	EAnglia	Wyoming	QMUL
UCDavis	Warwick	Essex	SSE	UCSC	Geneva	Nebraska	MontSt
Toronto	Arizona	Stockholm	SFU	Monash	INSEAD	WVA	URI

Table 7: Five Groups in North American Square Network

Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
Harvard	UCSD	UGA	Oregon	Clemson
Chicago	USC	VATech	GMU	Guelph
Penn	BU	Purdue	UMass	Tufts
Stanford	PennSt	UCIrvine	SCarolina	BYU
MIT	CMU	BC	UIC	StonyBrook
UCBerkeley	Florida	IowaSt	McGill	Carleton
Northwestern	MichSt	NCSt	Tulane	Utah
Yale	Rutgers	Dartmouth	American	Brandeis
Michigan	UWash	ASU	Auburn	IUPUI
Columbia	UNC	UCSB	Buffalo	Wyoming
Princeton	TAMU	FLSt	UCSC	Nebraska
UCLA	Indiana	Alberta	Rice	WVA
NYU	Iowa	McMaster	Tennessee	Kansas
Cornell	UVA	Houston	Emory	Temple
WiscMad	Brown	Syracuse	Laval	SIUC
Duke	Pitt	YorkU	Waterloo	KanSt
OhioSt	Arizona	CalTech	WayneSt	CUNY
Maryland	WOntario	LSU	WiscMil	Oklahoma
Rochester	JHU	UConn	Missouri	CWM
UTAustin	Vanderbilt	GASt	UCRiverside	WashSt
Minnesota	Queen's	UKY	Alabama	UNM
UIUC	WUSTL	GWU	Quebec	CODenver
UCDavis	Montreal	SMU	Albany	Concordia
Toronto	GTown	NotreDame	MiamiFL	SCU
UBC	COBoulder	SFU	Delaware	MontSt
				URI

Table 8: Worldwide Universities by Group

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Faculty size	995	706	648	610	579	532	593	418
Average size	39.8	28.24	25.92	24.4	23.16	21.28	23.72	16.72
% Hiring above		65.99	67.92	78.03	66.22	85.22	79.04	86.23
% Hiring within	86.34	22.97	19.80	11.60	27.03	11.29	20.04	13.77
% Self-hiring	7.75	9.45	11.46	7.73	22.97	9.86	18.01	10.65
% Hiring below	13.66	11.05	12.27	10.37	6.76	3.49	0.92	
% Placed above		10.14	14.88	21.94	23.85	44.53	31.64	39.08
% Placed within	31.50	20.55	25.37	33.67	53.85	42.97	61.58	60.92
% Placed within Self	2.83	8.45	14.68	22.45	45.77	37.50	55.37	47.13
% Granting below	68.50	69.31	59.75	44.39	22.31	12.50	6.78	

Table 9: North American Universities by Group

	Group 1	Group 2	Group 3	Group 4	Group 5
Faculty size	978	688	616	506	481
Average size	39.12	27.52	24.64	20.24	18.5
% Hiring above		77.25	85.04	90.77	95.40
% Hiring within	91.13	16.90	10.39	7.51	4.60
% Hiring within Self (Self-hiring)	8.65	2.69	2.46	3.65	2.91
% Hiring below	8.87	5.85	4.58	1.72	
% Placed above		12.38	19.41	33.33	55.32
% Placed within	37.40	20.08	34.71	44.87	44.68
% Placed within Self	3.55	3.19	8.24	21.79	27.66
% Placed below	62.60	67.54	45.88	21.79	

Table 10: Real-World and Random Network of Ranked Universities Compared

	Real-World Network	Random Network	
	Square Network	Erdos and Renyi's model	Average of 100 Random Graphs
Total Universities	200	200	200
Total Number of Faculty	4783		
Total In-Degree	2646		2667
Average In-Degree	13.23	13.23	13.34
Standard Deviation of In-Degree	5.4		3.53
Total Out-Degree	2646		2667
Average Out-Degree	13.23		13.34
Standard Deviation of Out-Degree	21.13		4.14
Density	0.07		0.07
Standard Deviation of Density	0.24		
Characteristic Path Length	2.93	2.05	2.32
Distance-Weighted Fragmentation	0.69		0.53
Clustering Coefficient	0.24	0.07	0.07
Weighted Clustering Coefficient	0.17		0.07

Note: The square network was transformed into an unweighted directed un-looped network. 100 Random graphs were generated, with the same density and size as the ranked university network. In-Degree for random network is the average employment value calculated from the set. Out-Degree value is average placement.

Table 11: Real-World and Random Network in North America Compared

	Real-World Network	Random Network	
	North American Square Network	Erdos and Renyi's Model	Average of 100 Random Graphs
Total Universities	126	126	126
Total Number of Faculty	3026		
Total In-Degree	1739		1732
Average In-Degree	13.80	13.80	13.80
Standard Deviation of In-Degree	3.6		3.45
Total Out-degree	1739		1732
Average Out-degree	13.80		13.80
Standard Deviation of Out-Degree	19.76		4.05
Density	0.11		0.11
Standard Deviation of Density	0.31		
Characteristic Path Length	2.80	1.84	2.09
Distance-Weighted Fragmentation	0.67		0.48
Clustering Coefficient	0.27	0.11	0.11
Weighted Clustering Coefficient	0.20		0.11

Note : The North America square valued network was transformed into an unweighted directed un-looped network. 100 Random graphs were generated with the same density and size. In-Degree value for random network is the calculated average employment across all 100 random graphs. Out-Degree is average placement.

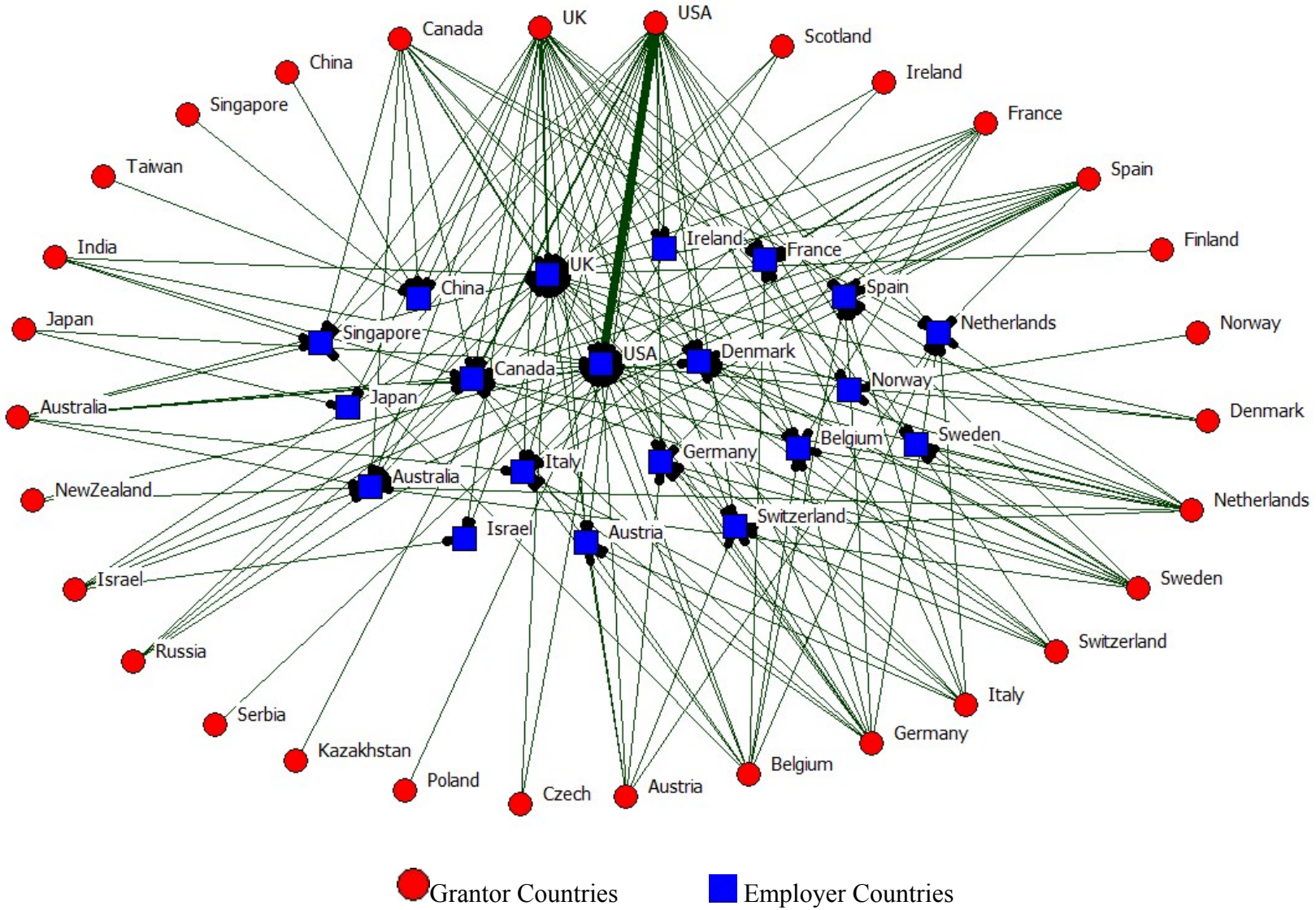

Figure 1: Interactions between Countries as Employers and Grantors

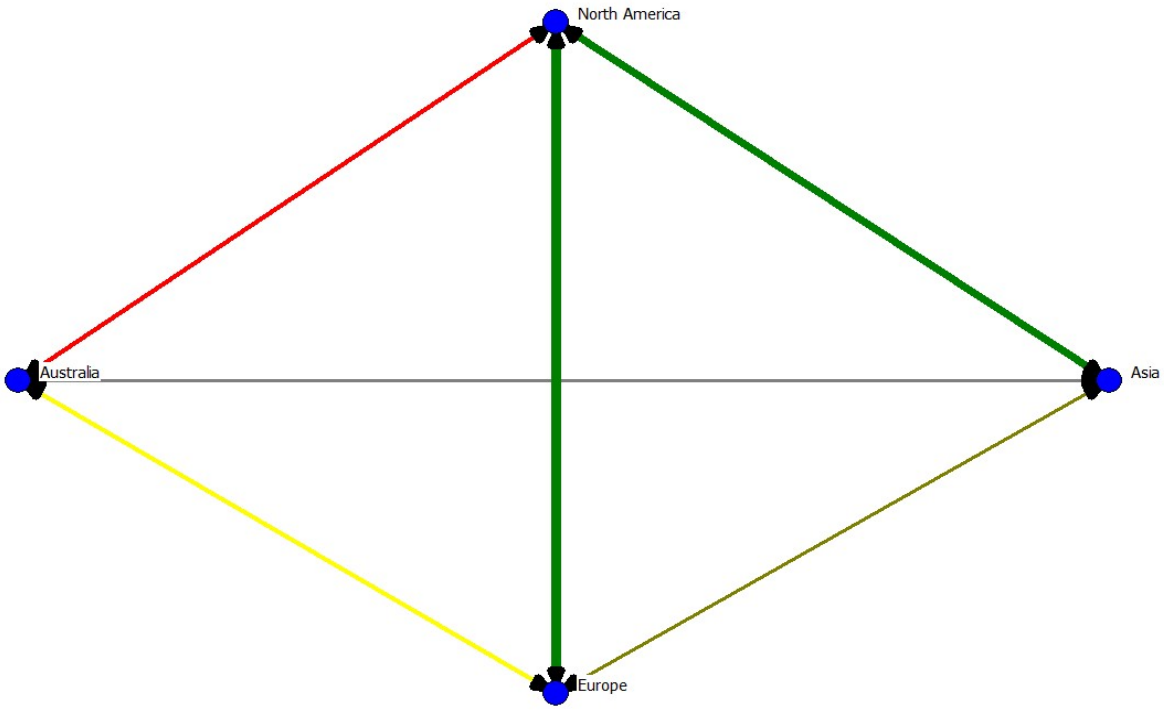

Figure 2: Interactions between Continents as Employers and Grantors

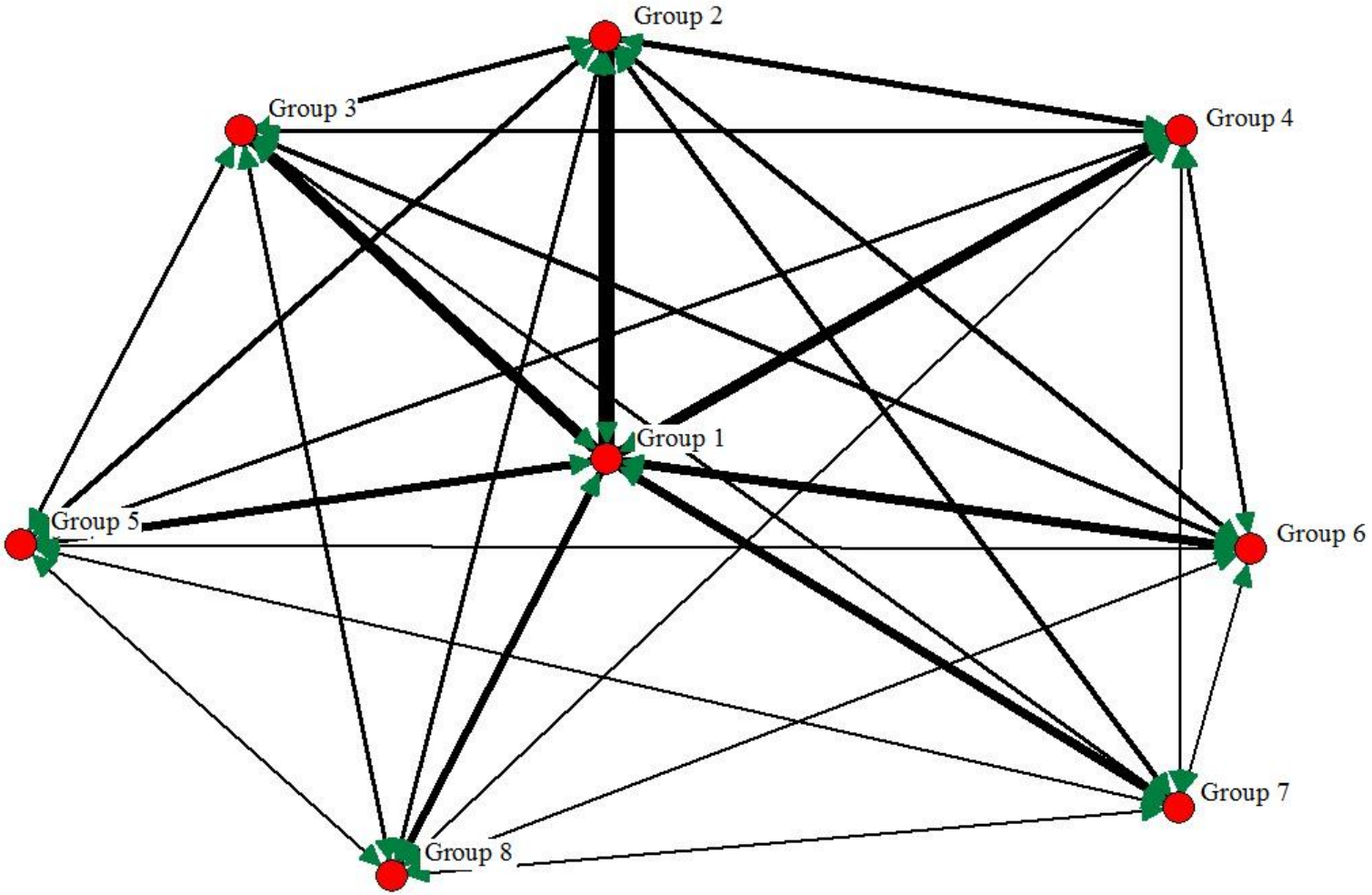

Figure 3: Group Interactions in the Worldwide Square Network

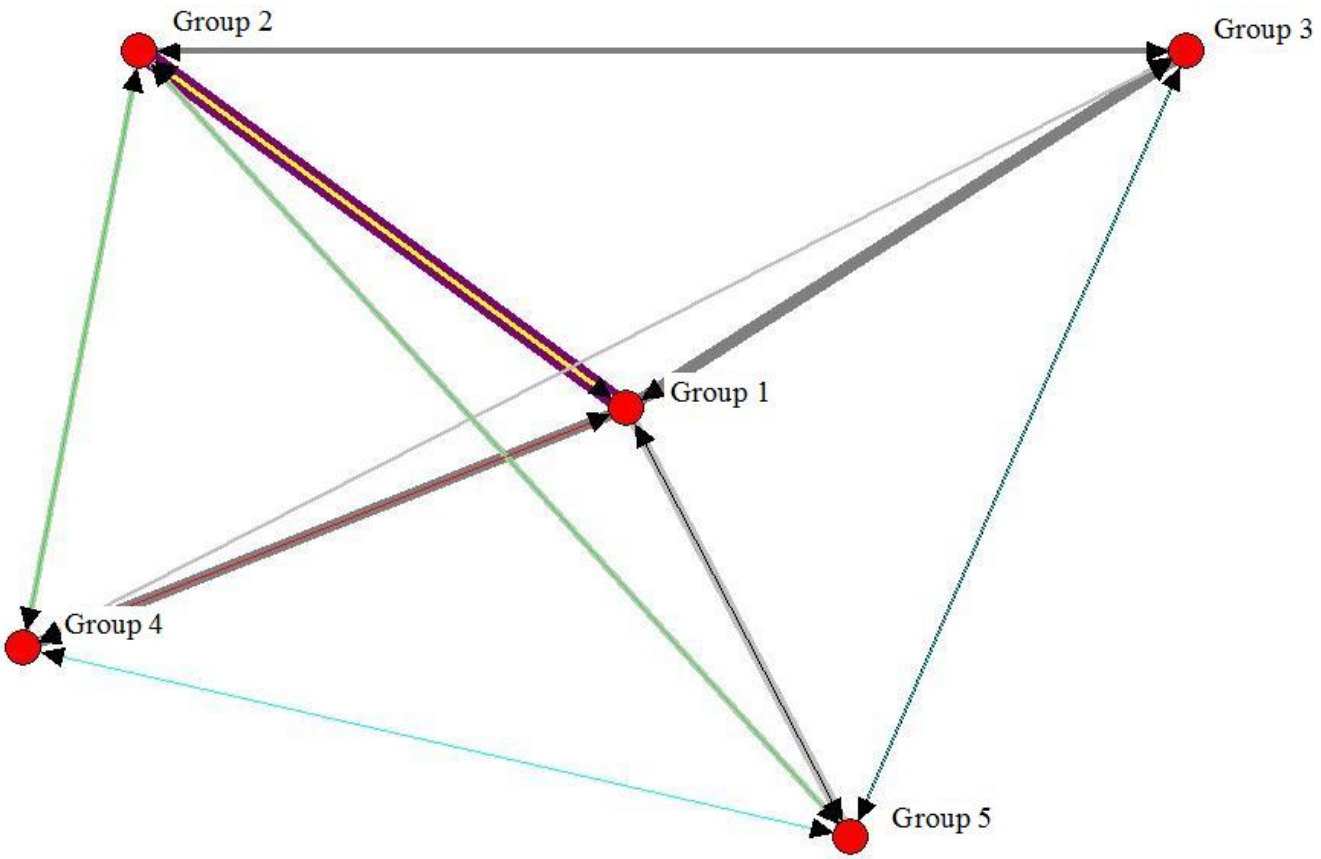

Figure 4: Group Interactions in the North American Square Network

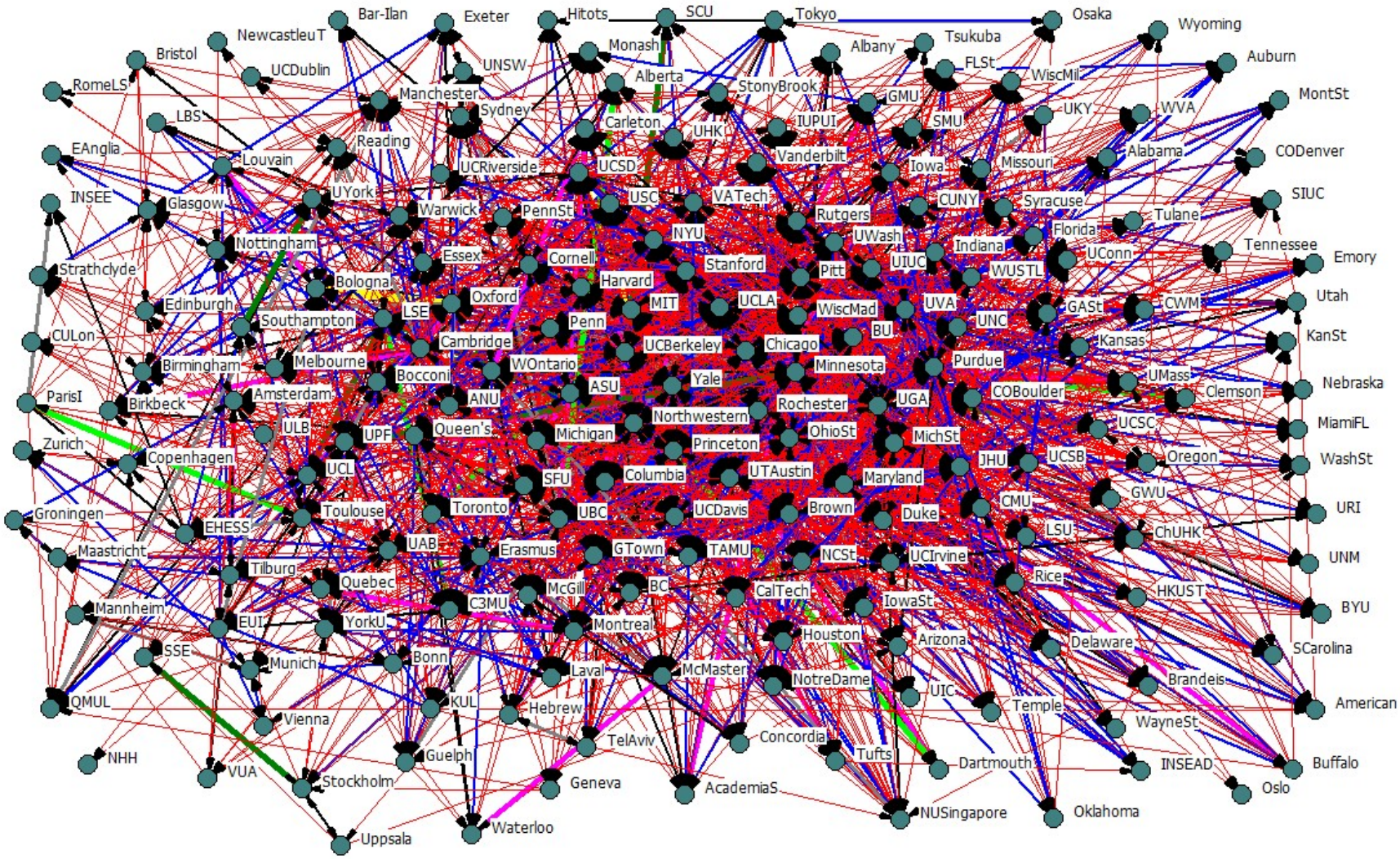

Figure 5: Connections between Universities in the Worldwide Square Network

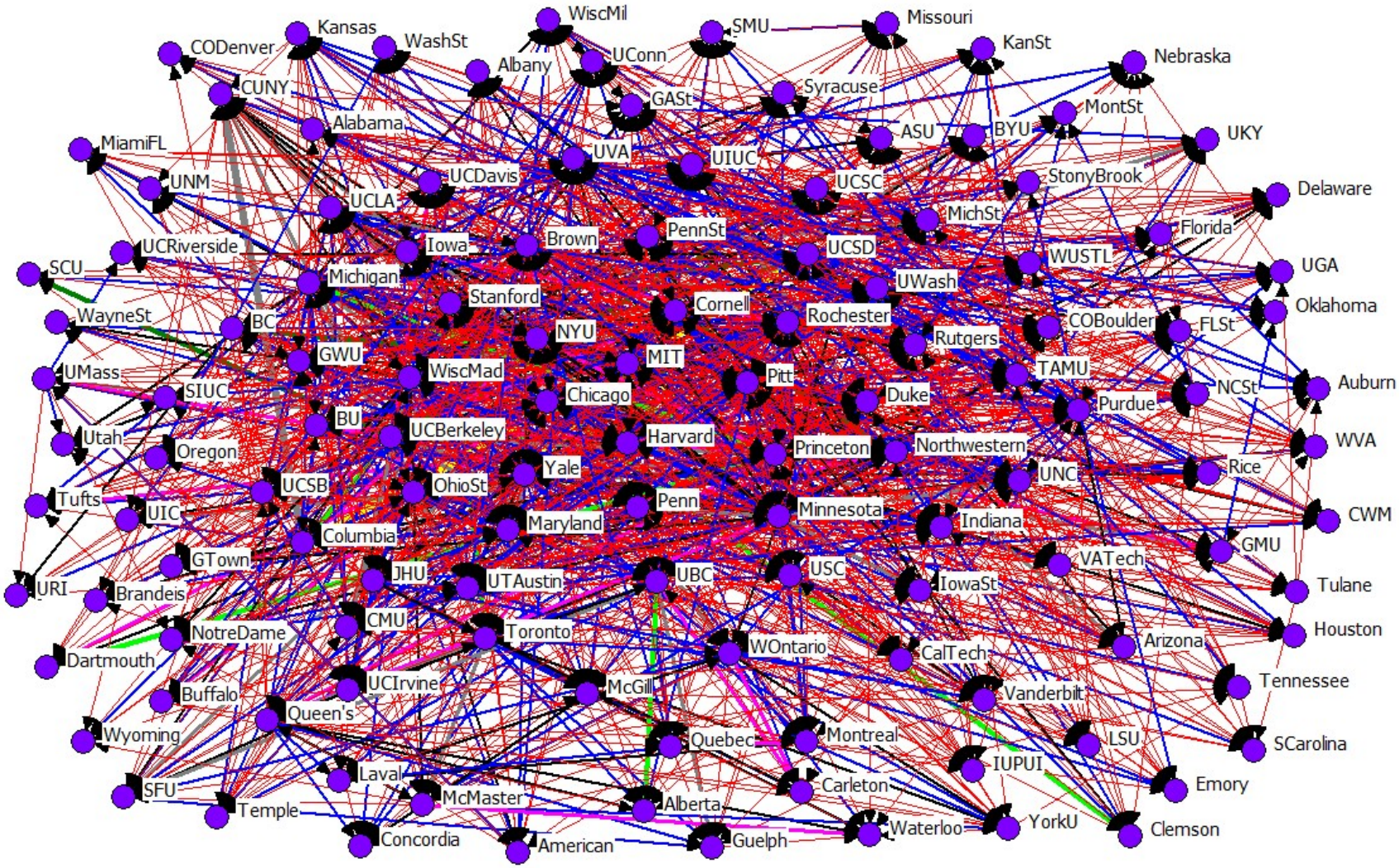

Figure 6: Linkages between Universities in the North American Square Network

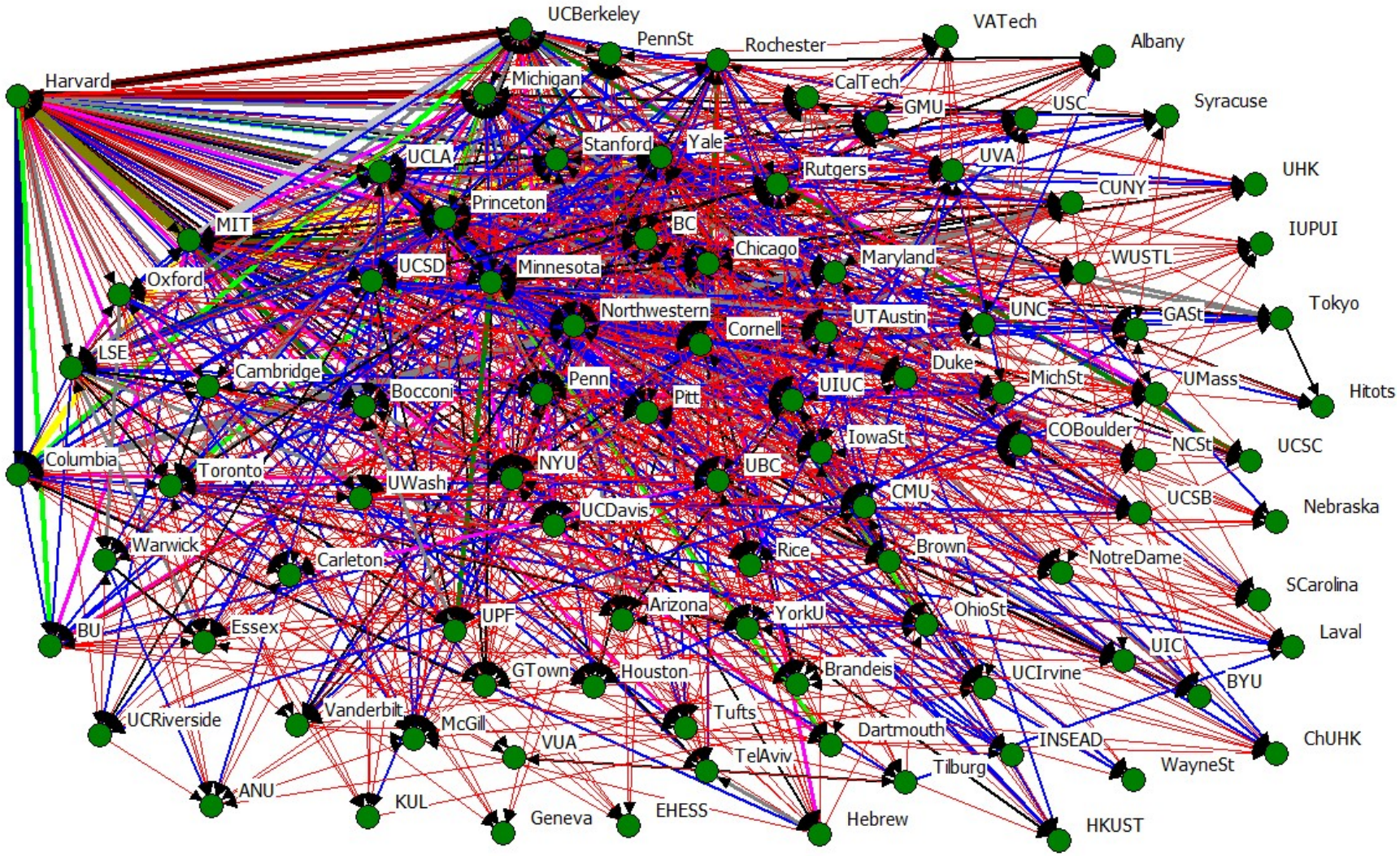

Figure 7: Harvard's Ego Network within the Worldwide Square Network

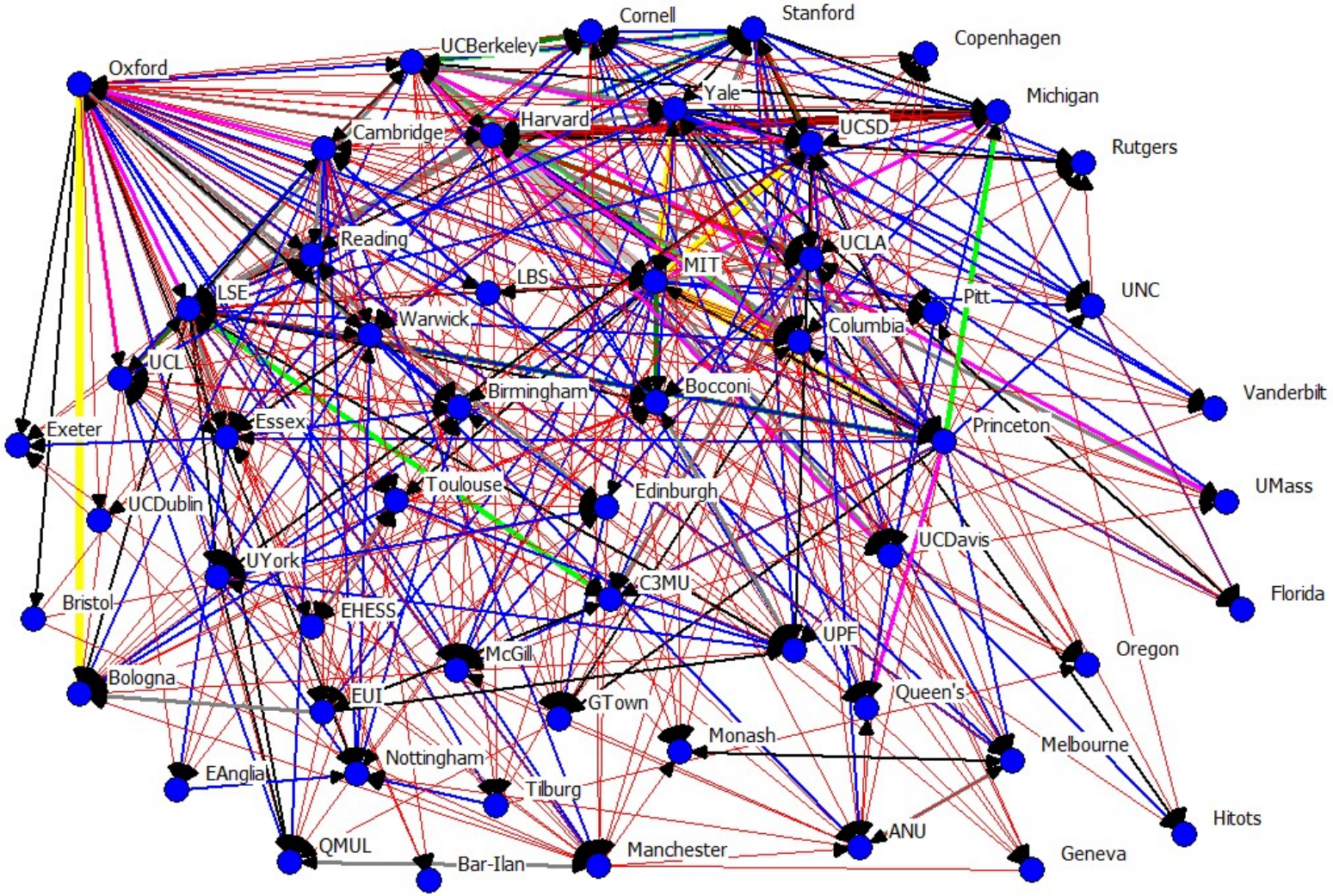

Figure 8: Oxford's Ego Network within the Worldwide Square Network