Growth of growth economics

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1 Synopsis

The theme of this Gruter meeting is growth economics. The theme of this paper is the growth of growth economics. The problem is I don't know anything about growth economics. So, the goal was to learn something about growth economics, fast, and without reading any papers. How old is the field? Is it still growing? How is it related to the fields I do know? What are the key papers I need to read? And how is it divided into further subdisciplines? I wasn't able to answer all of these questions with this small study, but I was able to construct a mental map of the field so that when I do start reading papers, I won't waste any time.

2 Ranking and mapping large networks

My colleagues and I have spent the last several years thinking a lot about ranking and mapping [1, 7, 3]. Ranking by itself is useless; ranking with

context can be incredibly powerful, especially when dealing with large, complicated systems. We have developed an algorithmic toolset for extracting higher information from social and biological networks. Our favorite model system for developing network theory is a citation network: where a node is a paper and the links are the millions of citations purposefully laid down across the generations of scholars. There is a wealth of information just in how these papers and ideas are connected. In fact, I contend that the links themselves are as important as the words written in the paper. See Google [2]. In this paper, I employ a few of these tools to answer the questions above. I find that growth economics is continuing to grow; it is broken into ten, well-defined subdisciplines and the core theory papers are not isolated to one decade.

3 Mapping JSTOR

I extracted 1,787,351 scholarly papers from the digital archive, JSTOR. The time span goes from 1545 to the present time, and the papers are from a wide range of disciplines from the life sciences, social sciences and humanities. Each of these 1.8 million papers cited or received at least one citation from one of the other 1.8 million papers. This was necessary for building the citation network. Using the mapequation [3], the network was clustered. This map can be found in Figure 1. Each node consists of thousands of papers (or journals). The size of the node represents the proportion of time that a random walker, following citations, spends in each cluster. The thickness of the edges (links) represent the per step probability that researchers

move between disciplines. It is from this clustering that growth economics papers could be located.

From the clustering 13,678 research articles were identified with 49,328 citations among these papers. The oldest paper in the field is from 1830. The title is "On the Progressive Improvements Made in the Efficiency of Steam Engines in Cornwall, with Investigations of the Methods Best Adapted for Imparting Great Angular Velocities". It was written by Davies Gilbert and published in *Philosophical Transactions of the Royal Society of London.* Although JSTOR has a reasonably good economics representation, it is still just a sample. As more data becomes available, the better these algorithms perform.

4 Ranking growth economics

The growth economics articles were ranked using an approach similar to journal-level Eigenfactor scores (Eigenfactor.org). The Eigenfactor score is a network centrality score similar to Google's PageRank algorithm [7]. The top 25 papers are shown in Table 1. According to the papers and citations analyzed, the Eigenfactor algorithm ranks Robert Solow's paper on "A Contribution to the Theory of Economic Growth" as the most influential paper in this area. Interestingly, not all of the top 25 articles came from the same decade. In fact, Paolo Mauro's paper on "Corruption and Growth" comes as early as 1995. The full distribution of all articles over all time periods is shown in Figure 2. There is not stagnation in growth economics as there are in other fields, despite the overall growth of the scientific literature.

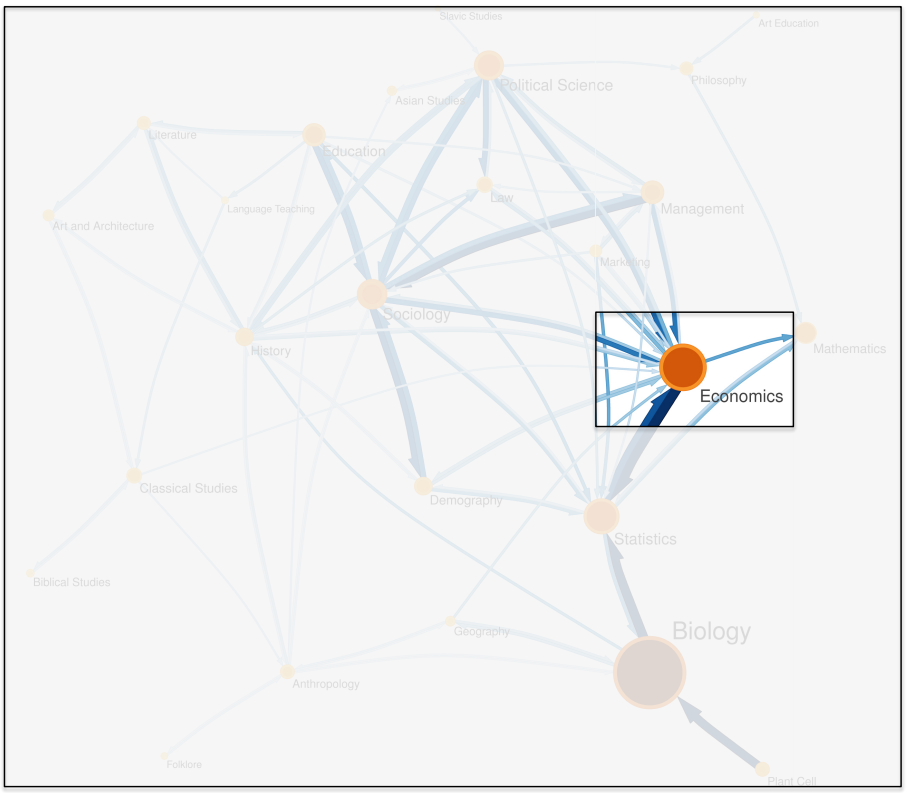

Figure 1: Map of science. There were 1.8 million papers and 8.2 million citations pulled from the JSTOR corpus. The nodes in this map represent groups of papers (or journals) and the links represent the the movement of ideas between fields. It is possible to zoom further into this maps. It is from economics that I pulled all papers associated with subdiscipline, growth economics.

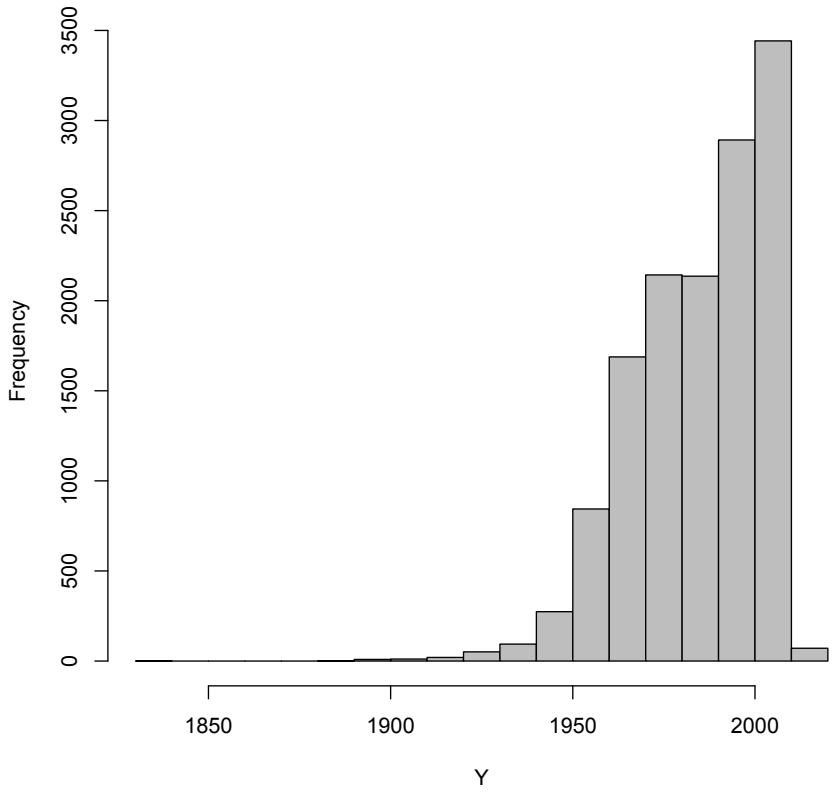

Figure 2: Time window for growth economics. The histogram shows the number of papers published in each time period since 1830. It also shows a growing number of papers in the field.

Table 1: The top 25 articles in growth economics. There were 13,678 articles from 1830 to 2011 classified as growth economics. EF is the article-level Eigenfactor score multiplied by 10^5. CT is the number of incoming citations for each article.

	Article Title	Year	FirstAuthor	EF	CT
1	A Contribution to the Theory of Economic Growth..	1956	Robert Solow	11.1452	657
2	Increasing Returns and Long-Run Growth..	1986	Paul Romer	9.92242	725
3	Technical Change and the Aggregate Production Func..	1957	Robert Solow	8.6973	520
4	International Investment and International Trade i..	1966	Raymond Vernon	7.41606	487
5	Economic Growth in a Cross Section of Countries..	1991	Robert Barro	7.20873	531
6	The Economic Implications of Learning by Doing..	1962	Kenneth Arrow	7.14795	423
7	Endogenous Technological Change..	1990	Paul Romer	7.05925	588
8	Capital-Labor Substitution and Economic Efficiency..	1961	Kenneth Arrow	6.94939	315
9	The Penn World Table (Mark 5): An Expanded Set of ..	1991	Robert Summers	6.88795	474
10	Migration, Unemployment and Development: A Two-Sec..	1970	John Harris	5.88026	380
11	A Contribution to the Empirics of Economic Growth..	1992	Gregory Mankiw	5.2458	454
12	The Political Economy of the Rent-Seeking Society..	1974	Anne Krueger	5.01729	412
13	International Corporations: The Industrial Economi..	1971	Richard Caves	4.86879	286
14	A Model of Labor Migration and Urban Unemployment ..	1969	Michael Todaro	4.50855	262
15	Non-Linear Estimates of the Engel Curves..	1952	Sig Prais	3.84227	18
16	The Internationalization Process of the Firm-A Mod..	1977	Jan Johanson	3.72441	305
17	A Sensitivity Analysis of Cross-Country Growth Reg..	1992	Ross Levine	3.67346	303
18	Protection and Real Wages..	1941	Wolfgang Stolper	3.63529	201
19	Optimum Growth in an Aggregative Model of Capital ..	1965	David Cass	3.40873	137
20	Corruption and Growth..	1995	Paolo Mauro	3.21313	240
21	A Model of Growth Through Creative Destruction..	1992	Philippe Aghion	2.91128	266
22	Prices of Factors and Good in General Equilibrium..	1953	Paul Samuelson	2.86392	161
23	Factor Endowment and Relative Commodity Prices..	1955	Tadeusz Rybczynski	2.84286	129
24	Convergence..	1992	Robert Barro	2.80739	228
25	The Incidence of the Corporation Income Tax..	1962	Arnold Harberger	2.79109	194

The Eigenfactor score (EF) and total incoming citations (CT) in Table 1 are related. However, the two measures provide different information [6]. For example, Figure 3 compares the two rankings for all articles with more than ten citations. The red line is the least squares estimate of the slope. Those journals above the red line do better when taking into account the full network (Eigenfactor) and those below do relatively worse. The outliers are worth examining. For example, the outlier with the pointing arrow does significantly better under a network-based measure. The title of this outlier is called "Non-Linear Estimates of the Engel Curves" (citation). It was written in 1952 by Sig Prais and published in *The Review of Economic Studies*. It has only received 18 citations over the past half century. This number of citations would put it in the top 900 of all articles in growth

economics. However, when ranked by Eigenfactor, this article is in the top 15! I don't know anything about Engel Curves, but according to Eigenfactor, this paper has had an important influence on the development of growth economics. It would be fun to verify this ranking shift with a field expert.

5 Mapping growth economics

The 13,678 growth economics articles extracted from JSTOR were isolated from the rest of JSTOR and then clustered. Ten subdisciplines were found. Growth Theory is the subfield that sees the most traffic. It includes 328 research articles and is strongly connected to Cross Country Growth. Commodity Structure and Empirics have central positions in the network and many of the other fields get their ideas from these two fields. The arrows in this map are weighted and directed so asysmetries like this between different fields can be detected.

This mapping can also be done hierarchically [5] and over time [4]. In this way, we can see the formation of growth economics, the combining of growth economics with other fields and the splitting apart of growth economics in multiple disciplines. This extended analysis was not done for this paper, but there are plans to analyze temporal networks in growth economics.

6 Conclusion

This is a small study with small conclusions; there is still much to be done to fully understand the development of growth economics from a network perspective. The temporal analysis needs to be done, and, ideally, it would

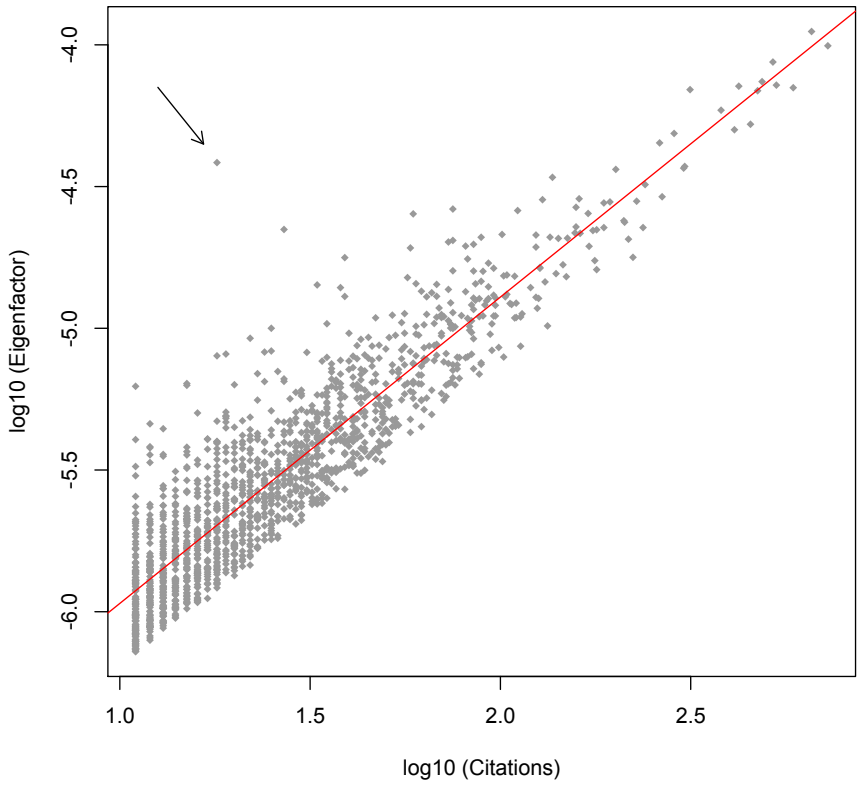

Figure 3: Eigenfactor versus citation counts. There are 1,521 articles shown. Only articles with greater than 10 citations are plotted. The x-axis is the number of incoming citations since publication (log, base 10). The y-axis is the article-level Eigenfactor score (log, base 10). The red line is the least squares estimate of the slope of a linear model. The arrow indicates an outlier article. This article – "Non-Linear Estimates of the Engel Curves" – has received a relatively small number of citations since its publication. However, the citations it has received have come from important journals within growth economics.

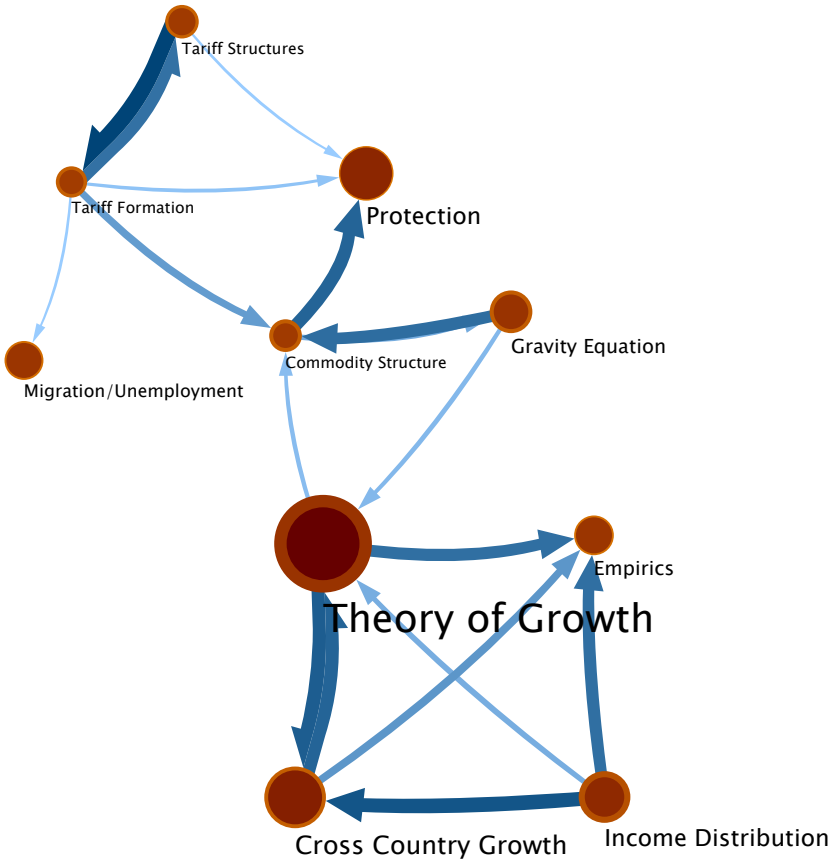

Figure 4: Map of growth economics. This includes 13,678 research articles with 49,328 citations among these articles. As describe in Figure 1, the nodes represent a group of papers and the size of nodes represent the random walker traffic. The weighted, directed links represent the traffic between subfields. The large and darker the link, the more traffic moving from one field to another. The clustering finds 10 subdisciplines within growth economics. The papers within each field are available upon request.

be useful to verify with an expert whether the rankings in Table 1, outliers in Figure 3 and the mapping in Figure 4 make any sense[1]. Once these steps are completed, I think I'd be ready to start reading some words.

References

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