

FUNDAMENTAL NETWORKS

January 2018

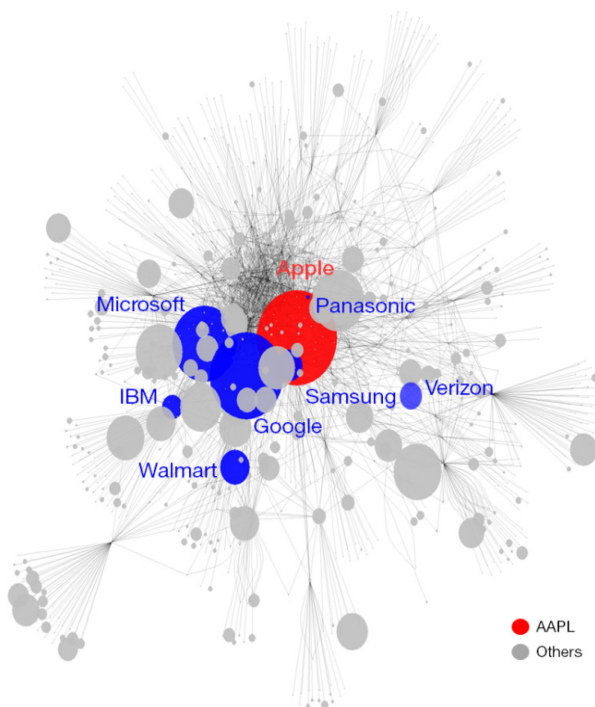
For institutional investor, qualified investor and investment professionals only. Not for retail public distribution.

Charles Liu, Quantitative Researcher
Ed Fang, Deputy Director of Research

It's no secret that today's companies exist in an increasingly complex, interconnected 'ecosystem'. A single organization has multiple relationships across geographical regions: other companies along the supply chain, competitors, and partners. This evolving web of connections poses challenges for traditional investors who have finite capacity and speed to process information, resulting in potentially exploitable mispricing opportunities. These types of relationships are intuitive, and we believe that 'fundamental networks' in markets can help uncover opportunities.

At Man Numeric, our team has developed systematic techniques aiming to extract under-utilized, stock-specific information using fundamental relationship data. Figure 1 gives an example of a fundamental network around a particular company, Apple Inc, where circles (or 'nodes') represent the companies connected to each other and their market cap. This is just one way of illustrating such a network – others include more granular analysis of individual business segment revenues or market cap.

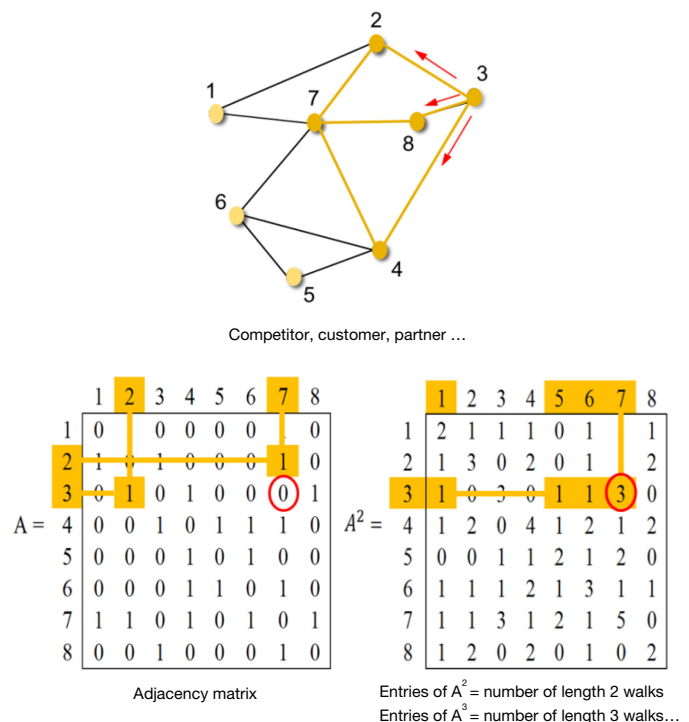
Figure 1: Example of fundamental networks – Apple Inc



Source: Man Numeric. For illustrative purposes only. The content of this material is not intended to constitute, and should not be construed as, a recommendation or solicitation to transact in the securities of the companies named. The organisations and/or financial instruments mentioned are for reference purposes only. This information is solely used to demonstrate Man Numeric's internal research capabilities.

How do we use this type of information to understand a company's ecosystem? There are three key considerations in using network analysis: record network information, information propagation and node centrality. First, recording network information involves describing precisely how companies interact with each other – for example, the direction of information flow between them, or the properties of each node in a network. Second, information propagation is about the way we observe information from one company impacting another company. For example, two nodes in a network are strongly connected if they are linked by multiple paths. Figure 2 gives an example of both these dynamics, illustrating a simplified undirected global network, comprised of competitors, customers and partners. At top is a representation of a simplified network of companies (1 to 8), connected in various ways. The adjacency matrix in the left shows whether the companies are directly connected ('1' indicates they are, '0' indicates they are not), and the matrix on the right plots the number of two-step routes between companies. We have highlighted the links between companies 3 and 7 on each matrix – not connected directly (hence the 0 in the first matrix) but accessible via three different two-walk paths (via nodes 2, 8 or 4, hence the 3 in the second matrix).

Figure 2: Information propagation in a simplified global network



Source: Man Numeric. For illustrative purposes only.

We believe these first two steps are important for quantifying the connectivity of companies in a network. But the third area of focus is the importance of individual nodes – which is not always the same as the number of links it has to others. Indeed, equal weighting of nodes in a network may fail to capture the real dynamics at play between companies, where a node is ‘central’ if it has many connections to others, and where its status can depend on the status of its neighbours. There are multiple ways of quantifying the importance of a company in a network, and the choice between them depends on the specific applications and types of network. For investors, the key question here is about whether they generally look to take positions in more or less

‘central’ companies – which again depends on the investment strategy to which this analysis is being applied.

Ultimately, fundamental networks are built on intuitive observations about the way companies interact. Their basis is nothing new, but we believe that this systematic approach to quantifying relationships across markets can help investors understand the equity market universe using a more consistent framework. As interconnectivity between companies continues to increase, advanced network data analysis can be used to complement existing quantitative equity research, and we believe that if used intelligently, it can potentially provide further opportunities to add value.



Charles Liu

Quantitative Researcher

Charles joined Man Numeric ('Numeric') in 2016 as a quantitative researcher and a member of the Strategic Alpha Research team. Prior to joining Numeric, Charles was a doctoral student at New York University, Stern School of Business. During his graduate studies, he interned at Goldman Sachs (Asia) as an equity research analyst. Charles received a doctorate degree in quantitative marketing from New York University and a master's degree in system engineering from the University of Pennsylvania.



Ed Fang, PhD, CFA

Deputy Director of Research

Ed joined Man Numeric ('Numeric') in the summer of 2005 after he completed his doctorate degree in economics from Duke University. He has been actively engaged in a broad spectrum of research ranging from bottom-up alpha models to top-down dynamic asset allocation and alternative investment products. Ed has also been responsible for developing and managing several innovation portfolios within the Numeric Absolute Return and Alternative Beta strategies. He obtained his Bachelor of Science in Economics and Management Information Science with honors from Fudan University in China. Ed is also a CFA charterholder.

IMPORTANT INFORMATION

This information is communicated and/or distributed by the relevant Numeric or Man entity identified below (collectively the "Company") subject to the following conditions and restriction in their respective jurisdictions.

Opinions expressed are those of the author and may not be shared by all personnel of Man Group plc ('Man'). These opinions are subject to change without notice, are for information purposes only and do not constitute an offer or invitation to make an investment in any financial instrument or in any product to which the Company and/or its affiliates provides investment advisory or any other financial services. Any organizations, financial instrument or products described in this material are mentioned for reference purposes only which should not be considered a recommendation for their purchase or sale. Neither the Company nor the authors shall be liable to any person for any action taken on the basis of the information provided. Some statements contained in this material concerning goals, strategies, outlook or other non-historical matters may be forward-looking statements and are based on current indicators and expectations. These forward-looking statements speak only as of the date on which they are made, and the Company undertakes no obligation to update or revise any forward-looking statements. These forward-looking statements are subject to risks and uncertainties that may cause actual results to differ materially from those contained in the statements. The Company and/or its affiliates may or may not have a position in any financial instrument mentioned and may or may not be actively trading in any such securities. This material is proprietary information of the Company and its affiliates and may not be reproduced or otherwise disseminated in whole or in part without prior written consent from the Company. The Company believes the content to be accurate. However accuracy is not warranted or guaranteed. The Company does not assume any liability in the case of incorrectly reported or incomplete information. Unless stated otherwise all information is provided by the Company. Past performance is not indicative of future results.

The information in this material is for illustration and discussion purposes only. It is not intended to be, nor should it be construed or used as, investment, tax or legal advice, any recommendation or opinion regarding the appropriateness or suitability of any investment(s) or strategy/strategies, or an offer to sell, or a solicitation of an offer to buy, an interest in any security, including an interest in any private funds or pools, or any other investment product(s), managed account(s) or other investment vehicle(s) (each, an "Investment Product") advised by Numeric or any of its affiliates..

All investments involve risks including the potential for loss of principal. Alternative investment strategies involve magnified risks, are speculative, are not suitable for all clients, and intended for experienced and sophisticated investors who are willing to bear the high economic risks of the investment. There is no guarantee that any of the investment strategies discussed herein will be successful.

This material was prepared by Numeric Investors LLC ("Numeric"). Numeric is registered as an investment advisor with the US Securities and Exchange Commission ("SEC"). Numeric is also registered as a commodity pool with the U.S. Commodity Futures Trading Commission ("CFTC") and a member of the National Futures Association ("NFA"). The registrations and memberships in no way implies a certain level of skill or training, or that the SEC, CFTC or NFA have endorsed Numeric

Australia: To the extent this material is distributed in Australia it is communicated by Man Investments Australia Limited ABN 47 002 747 480 AFSL 240581, which is regulated by the Australian Securities & Investments Commission (ASIC). This information has been prepared without taking into account anyone's objectives, financial situation or needs.

European Economic Area: Unless indicated otherwise this website is communicated in the European Economic Area by Man Solutions Limited which is an investment company as defined in section 833 of the Companies Act 2006 and is authorised and regulated by the UK Financial Conduct Authority (the "FCA"). Man Solutions Limited is registered in England and Wales under number 3385362 and has its registered office at Riverbank House, 2 Swan Lane, London, EC4R 3AD, England. As an entity which is regulated by the FCA, Man Solutions Limited is subject to regulatory requirements, which can be found at <http://register.fca.org.uk>.

Germany: To the extent this material is used in Germany, the communicating entity is Man (Europe) AG, which is authorised and regulated by the Liechtenstein Financial Market Authority (FMA). Man (Europe) AG is registered in the Principality of Liechtenstein no. FL-0002.420.371-2. Man (Europe) AG is an associated participant in the investor compensation scheme, which is operated by the Deposit Guarantee and Investor Compensation Foundation PCC (FL-0002.039.614-1) and corresponds with EU law. Further information is available on the Foundation's website under www.eas-liechtenstein.li. This material is of a promotional nature.

Hong Kong: To the extent this material is distributed in Hong Kong, this material is communicated by Man Investments (Hong Kong) Limited and has not been reviewed by the Securities and Futures Commission in Hong Kong. This material can only be communicated to intermediaries, and professional clients who are within one of the professional investor exemptions contained in the Securities and Futures Ordinance and must not be relied upon by any other person(s).

Liechtenstein: To the extent the material is used in Liechtenstein, the communicating entity is Man (Europe) AG, which is regulated by the Financial Market Authority Liechtenstein (FMA). Man (Europe) AG is registered in the Principality of Liechtenstein no. FL-0002.420.371-2. Man (Europe) AG is an associated participant in the investor compensation scheme, which is operated by the Deposit Guarantee and Investor Compensation Foundation PCC (FL-0002.039.614-1) and corresponds with EU law. Further information is available on the Foundation's website under www.eas-liechtenstein.li.

Switzerland: To the extent this material is distributed in Switzerland, this material is communicated by Man Investments AG, which is regulated by the Swiss Financial Market Authority FINMA.

This material is proprietary information and may not be reproduced or otherwise disseminated in whole or in part without prior written consent. Any data services and information available from public sources used in the creation of this material are believed to be reliable. However accuracy is not warranted or guaranteed. © Man 2017

US/GL/IW