

Institution: King's College London		
Unit of Assessment: 10 Mathematical Sciences		
Title of case study: Research on information filtering leads to successful Silicon Valley start-up with impact on the finance and education sectors		
Period when the underpinning research was undertaken: 2010 - 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Tiziana Di Matteo	Role(s) (e.g. job title): Professor of Econophysics	Period(s) employed by submitting HEI: From 09/01/2009
Period when the claimed impact occurred: 2015 - 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words) Professor Tiziana Di Matteo's research in complex networks at King's College London (KCL) has led to the discovery of a new method to filter information out of complex datasets. Di Matteo's approaches can be used not only to extract relevant and significant information but more importantly to extract knowledge from an overwhelming quantity of unstructured and structured data. Through the use of this research, Di Matteo's former PhD student founded Yewno, a successful Silicon Valley start-up which provides software products across sectors including educational technology, finance, government and life sciences. The key idea underlying Yewno's products is the concept of the Knowledge Graph, a framework based on Di Matteo's research, whose goal is to uncover relations between various networks and concepts from a timely evolving corpus of data. Yewno has around 35 FTE staff, with offices in Silicon Valley, New York, London and Sarajevo, and has contracts with a total value of USD10,000,000 in the period 2018 to 2020. Its customer base spans 10 countries across the US, Europe, and Asia, and includes more than 30 universities, around 100 libraries and 15 leading financial institutions, such as <i>Nasdaq</i>, <i>Citi Group</i>, <i>Credit Suisse</i> and <i>Moody's Analytics</i>. The speed of the Yewno systems and their ability to make new and unexpected connections has brought significant benefits to university students and staff, library users, financial institutions and investment clients, including: more effective knowledge discovery, greater exploitation of library resources, improved investment products and lower costs to Yewno's customers.		
2. Underpinning research (indicative maximum 500 words) Di Matteo's main research area is complex networks. Since the start of her time at KCL in 2009 she has been focusing on this stream of research and produced several important contributions in the field. She was the first scientist to propose analysing complex financial datasets (correlation and autocorrelation matrices of interest rates and stock market indices) from the perspective of geometrical and topological properties of metric graphs, embedded in spaces of appropriate dimensions and curvature. Di Matteo and collaborators have introduced network-theoretic tools to filter information in large-scale datasets. They have shown that such filtered graphs are powerful tools to study complex datasets, valuable for risk management and portfolio optimization [R1, R2], and enable the construction of sparse probabilistic models of financial systems that can be used for forecasting, stress testing and risk allocation [R3]. These tools can be used to analyse information while it is generated and provide ways to reduce complexity and dimensionality while keeping the integrity of the dataset [R5]. Moreover, Di Matteo's research has shown that these tools can be used to extract clusters and hierarchies from high-dimensional complex data sets in an unsupervised and deterministic manner, without the use of any prior information [R4]. This method is scalable to very large datasets and it can take advantage of parallel and GPU computing. In particular a new algorithm, the Triangulated Maximally Filtered Graph (TMFG) that optimally extracts a planar subgraph was then introduced. The method is adaptable to online updating and learning		

with continuous insertion and deletion of new data as well as changes in the strength of a given similarity measure [R5].

Di Matteo's network-based approaches to information filtering have opened new ways to study financial systems and several other fields. The common principle is to use developments in computational linguistics and graph theory to build a graph representation of knowledge [R6], which can be automatically analysed to discover hidden relations between components in many different complex systems. This Knowledge Graph based framework and inference engine has a wide range of applications in finance, economics, biotechnology, law, education, marketing and general research.

3. References to the research (indicative maximum of six references)

[R1] Spread of risk across financial markets: better to invest in the peripheries; Pozzi F., Di Matteo T. and Aste T., 16 Apr 2013, In: Scientific Reports 3 (2013), 1665; DOI:10.1038/srep01665.

[R2] The Multiplex Dependency Structure of Financial Markets; Musmeci, N., Nicosia, V., Aste, T., Di Matteo, T. & Latora, V., 20 Sep 2017, In: COMPLEXITY; DOI:10.1155/2017/9586064.

[R3] Parsimonious Modelling with Information Filtering Networks; Wolfram, B., Previde Massara, G., Di Matteo, T. & Aste, T., 13 Dec 2016, In: PHYSICAL REVIEW E. 94; DOI 10.1103/PhysRevE.94.062306.

[R4] Hierarchical information clustering by means of topologically embedded graphs; Song, W-M., Di Matteo, T. & Aste, T., 9 Mar 2012, In: PLoS One. 7, 3, e31929; DOI 10.1371/journal.pone.0031929

[R5] Network Filtering for Big Data: Triangulated Maximally Filtered Graph; Previde Massara, G., Di Matteo, T. & Aste, T., 7 Jun 2016, In: Journal of complex Networks. 5, 2, p. 161-178; DOI 10.1093/comnet/cnw015

[R6] Graph Theory Enables Drug Repurposing – How a Mathematical Model Can Drive the Discovery of Hidden Mechanisms of Action; Gramatica, R., Di Matteo, T., Giorgetti, S., Barbiani, M., Bevec, D. & Aste, T., 9 Jan 2014, In: PLoS One. 9, 1, e84912; DOI:10.1371/journal.pone.0084912

4. Details of the impact (indicative maximum 750 words)

Yewno is a Silicon Valley start-up, established in 2015, whose business is based on an inference and discovery engine, Yewno's Knowledge Graph, that has applications in a variety of fields such as finance, economics, biotechnology, law, education and general knowledge search.

Di Matteo has had a long-term formal and informal collaboration with Yewno's CEO and founder, Dr. Ruggero Gramatica, who was her PhD student from 2010 to 2015. The research led by Di Matteo in the Econophysics group during the time of this studentship formed the foundation of Yewno and its subsequent development of innovative solutions in a range of fields. The knowledge transfer was also assisted by an advisory consultancy which Di Matteo held with Yewno from 2015-16. [S1]

Among the key Yewno products underpinned by the research led by Di Matteo are:

Yewno Discover, which provides a full dynamic Knowledge Graph to help researchers, students, and educators deeply explore knowledge across interdisciplinary fields.

Yewno Finance, which provides a portfolio of services sold in the Financial Services industry, including Alternative data feeds, Indices, ETFs and an Investment research Platform, leveraging Yewno's proprietary Knowledge Graph to find relationships and investment opportunities.

Yewno Unearth, which provides a semantic snapshot and insights into cross-disciplinary trends, enabling publishers and libraries to better understand and leverage their collections.

Yewno Life Sciences, which uses computational linguistics, neural networks, machine learning and graph theory to model the behaviour of complex biosystems.

Yewno has around 35 FTE staff, with offices in Silicon Valley, New York, London and Sarajevo, and has customers in 10 countries.

Currently Yewno has built its business on contracts with a total value of USD10,000,000 in the period 2018 to 2020. The forecast based on the pipeline and business plan for the next 3 years is in the region of USD30,000,000.

Economic impact in the finance sector

Yewno Finance, utilising Yewno's Knowledge Graph, draws from a range of sources relevant to finance and investment, including news, patents, official filings, transcripts, clinical trials, judicial documents, scientific publications and stock prices. This has led to the construction of a portfolio of services sold in the financial services industry. Yewno offers a variety of Artificial Intelligence (AI) augmented products and solutions including Alternative Data, Index strategies, Exchange traded funds (ETFs) constructions and an Investment Research platform suitable to users from quantitative analysts to fundamental portfolio managers to research analytics and investment advisors, with a range of benefits as set out below.

The customer base for these services spans across the US and Europe, and includes the following clients: Nasdaq, Deutsche Boerse Group, WorldQuant, Stoxx, BNP Paribas, Amundi Asset Bank, Citi Group, Credit Suisse, Coin Capital, Yahoo Finance, Factset, Solactive, Morningstar, DWS Investments and Moody's Analytics. [S2]

Citi Global Data insights (CGDI) is a Citi Group business unit which develops data and analytics products for its clients.

"Using Yewno's patented Knowledge Graph, CGDI is expanding its range of investment themes using AI rather than an analyst-driven approach. [...] Yewno is able to detect hidden relationships, extract concepts and links across varied data sources, and provide valuable insights that would have otherwise gone undetected. The amount of data available to institutions and their analysts at any given moment in time is impossible to ingest, associate and process. Add to this the dynamic nature of market data and news, and essentially we as humans just can't keep up. Yewno's AI provides [us] a way to remove the bottleneck and tedium of those functions so that analysts can spend their time pursuing the ideas, themes and strategies that excite them and deliver superior returns." – Head of Citi Global Data Insights [S3]

Moody's Analytics, a subsidiary of Moody's Corporation which provides economic research regarding risk, performance and financial modelling, partnered with Yewno in 2020 to improve the Moody's Analytics CreditEdge platform by providing an integrated newsfeed. CreditEdge delivers a probability-of-default model and advanced analytics for managing credit risk. By integrating Yewno's Knowledge Graph, the CreditEdge platform now offers an AI-enabled newsfeed feature as an addition to its core capabilities.

"Yewno's technology goes far beyond keyword search, and beyond news articles' titles and headings, by finding indirect news connections such as company relationships and geopolitical events. It ingests and reads full-text news from thousands of items on an intra-day basis. Yewno's Intelligent Newsfeed uses AI capabilities to give our users the news stories that matter for the companies they monitor." – Director, Moody's Analytics [S3]

STOXX is a Swiss index provider, covering world markets across all asset classes. Through partnership with Yewno, STOXX created the world's first ever Artificial Intelligence Index which launched in 2018, and captured the performance of 200 companies from a wide range of industries that invest heavily in the development of new AI technologies [S3]. Partnering with Yewno, and through the use of Yewno's Knowledge Graph, STOXX has found that they saved quite a bit of time and resources – creating indices and testing strategies that would have previously taken a team member days now takes minutes. This benefits their clients too, as the indices are less expensive with lower fees, and because they have access to new and creative strategies with faster setup. [S4]

“Yewno’s AI both speeds up our processes and eliminates both human bias and error, so there are many increased efficiencies and capabilities that we could not have offered previously. [...] Being that speed to market, innovation and purity of an investment theme are of paramount importance to our clients, leveraging Yewno’s services puts us in an advantage in providing all of those advantages to our clients. [...] In an industry where being first to market is the main indicator of your product’s success, speed is of utmost importance. Also of great importance is transparency, robust methodology, and pure data, all of which Yewno offers. We partner only with the best in class and Yewno is of that designation” – Managing Director, STOXX [S3, S4]

Nasdaq, the US stock exchange which ranks second after the New York Stock Exchange, also found that the speed of creating indices was of great benefit to themselves and to their clients.

“Where traditional research for index creation involves thousands of man hours and a large research staff, using the Yewno Knowledge Graph allowed us to accelerate the building, calculation and periodic rebalancing of the indexes we created together. Because Yewno’s knowledge graph is dynamic, the indexes can be updated daily. New ideas and themes can be built and tested in minutes. The result is that by using Yewno’s technology, Nasdaq can create low-cost, low maintenance indexes that result in lower-fee end products.” - VP, Head of Americas, Nasdaq [S3]

In 2020, Yewno received Frost & Sullivan’s Global Technology Innovation Award for predictive analytics in financial services industry. [S5]

Impact on teaching and learning through education technology

Based on the research led by Di Matteo, Yewno built an intelligence framework capable of reading the structure of data sources and understanding meaning, identifying concepts, definitions and distinguishing the differences, and mapping them in a structure similar to the brain. This unsupervised intelligence framework extracts inferences fed by more than 200 million sources, including:

- Academic publishers (such as Springer Nature, Taylor and Francis Group, Wiley, PLOS ONE)
- University presses (such as Cambridge University Press, Oxford University Press, MIT Press, Stanford University Press)
- Online archives (such as Arxiv, bioRxiv, JSTOR)

Based on this approach, in 2017 Yewno launched Yewno Discover, a fully dynamic Knowledge Graph for the education technology industry. [S2] The amount of literature available through traditional keyword-based search engines can prove overwhelming: the concept-based discovery offered by Yewno Discover enables more efficient, fruitful and creative discovery of knowledge. Students and academics are thus enabled to learn more effectively and discover hidden relationships across the vast corpus of literature.

“Yewno Discover is paving the way to what we are calling “assisted serendipity”, the opportunity to explore a topic from a truly personal perspective, unbiased by the usual results list. [...] Because of their Knowledge Graph framework, it was possible for Yewno to ingest our content corpus and map the millions of concepts therein alongside their own. We have benefited immensely from their sophisticated technology.” – University Librarian, Università Cattolica del Sacro Cuore [S3]

The customer base for Yewno Discover comprises more than 30 Universities and around 100 libraries. Clients include Stanford University, University of Cambridge, Università Cattolica del Sacro Cuore, Bavarian State Library, Stonehill College, Roger Williams University and the University of Denver.

Stanford University has been using Yewno Discover and Yewno Unearth since 2017 and have found that Yewno saves significant time on the discovery process itself. Further, the visualisation helps their users to understand and find concepts and connections that they might not have thought to look for in the first place. Their reference librarians and subject specialists train

students and academics on the best use of Yewno Discover through lectures and tutoring. They find that Yewno helps their staff and students to make better use of library resources: they can quickly determine what is of interest to them, evaluate if there is any further or deeper discovery to pursue, and if not, quickly pivot topics and hypotheses. [S7]

“Using Yewno Discover, not only has our library been able to facilitate online and remote research, but we have been able to capitalize on the use of our digital collections. It’s a benefit to our research community to be able to offer an online tool and we can also see increased usage in our content collections. The relatively minor investment in Yewno, a low 5 figure annual expense, yields considerable benefits in making more accessible by concepts and swift linking to relevant articles and books that we have purchased or licenses for annual costs in the millions, even tens of millions of US dollars.” – Vice Provost and University Librarian, Stanford University

The Bavarian State Library has been using Yewno Discover and Yewno Unearth since 2017. They have found that the AI capabilities and Knowledge Graph visualisation enables them to offer a new way to explore content through concepts and connections, both to in-person and remote users. [S6]

“The benefits are wide ranging; the visualisation is very beneficial to learning and understanding and helping people who are not sure how to start their search. The ability to hypothesise is a great advantage to more senior researchers. One of the frustrations of research today is that traditional search engines produce ever increasingly long lists of results that no researcher or patron can possibly explore. Yewno’s engine helps people find what they are looking for much quicker and makes the research process more enjoyable.” – Director General, Bavarian State Library.

The Università Cattolica del Sacro Cuore, a private university based in Milan, has been using Yewno Discover to optimize their library content and support student research since 2017. In response to the Covid pandemic, they partnered with Yewno to offer Yewno Discover free of charge through their website to all of Italy until the end of 2020.

“At UCSC we believe that knowledge is a common asset and sharing our documental resources has always been part of our mission. The past few months have been challenging across the globe, particularly here in Italy. [...] Yewno Discover is an important asset to share because it inspires learning, and that’s really important right now. The fact that it’s a web-based tool is also convenient for those who are continuing to stay home and maintain social distance.” – University Librarian, Università Cattolica del Sacro Cuore. [S3]

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] Testimonial from CEO and Founder of Yewno

[S2] Testimonial from COO of Yewno

[S3] Yewno Customer Testimonials

[S4] Testimonial from Managing Director, Head of North America - Indices, at Qontigo (STOXX is now part of Qontigo)

[S5] [Frost & Sullivan 2020 Global Predictive Analytics for Financial Services Technology Innovation Award](#)

[S6] Testimonial from Director General, Bavarian State Library

[S7] Testimonial from Vice Provost and University Librarian, Stanford University