Seeing Around the Corner: Early Crisis Detection Using Causal Statements

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Are crises happening more frequently in our world today?

It certainly seems that way. And that may be because the interconnection of human activities in the world increases the impact of a crisis when one does happen. That impact is felt on countries, industries and companies in a way it never has been before. That's why the question of *early detection* of such potential crises has become crucial for asset managers, company executives and policy makers.

We describe here a method to leverage in real time the wisdom of crowds of authors, by analyzing the causal statements they express in texts, and track the evolution of these causal statements over time.

We applied that method to two case studies: the 2020 impact of Covid on the airlines industry, and the 2021 semiconductor shortage's impact on the car manufacturing industry.

The results are quite promising: in each case the <u>causal statement method produced an alert a week</u> <u>before</u> an indication can been seen in the analysis of statements about the future of various indicators for the respective industries studied.

We also describe a <u>novel way to present causal graphs</u>, offering a fast understanding of the highlights of a specific company inside its industry. These "causal contrast maps" can be used by investors or managers either as a real-time supervision tool, or to analyze post-mortem the evolution of a crisis and improve detection for future such events.

More information can be obtained at info@causalitylink.com.

Causal Graphs extracted from text

Causal graphs represent the causal relationships between elements of a company or an industry, and Causality Link uses a proprietary natural language processing (NLP) system to extract them from a large corpus of texts (more than 125 million) in 27 languages. These texts are analyzed in real-time at the rate of over 50,000 texts per day.

They abound with obvious causal links such as "Company X increased its profits due to its 10% year over year increase in revenue". From these texts, we derive a very general statement true for almost any industry that "increasing revenue increases profits". Of course, there are also many statements that indicate that "Company X profits declined due to a significant increase in expenses" which enables us to derive that "increasing expenses decreases profit". (Many more complex sentence structures contain causal statements that are detected but we will not describe here.)

The Causality Link system now contains more than 50 million causal links, a rich data set on which various detection methods can be developed and tested.

A crisis detection method leveraging causal statements

Earlier, we developed an alert method to detect novelty in statements about companies, countries and industries that relied on the originality (vs the past 100 days) of the combination of the key performance indicator (KPI) involved, and the specific company/country/industry. Because we can detect about 2,300 KPIs organized as a tree, we used automatic generalization of KPIs to compute originality. This led to great results in the case of the impact of Covid on United Airlines (UAL), for example, as described in the following example.

Fig.1 is the signal curve for UAL where we compare the "demand" KPI signal (in blue) and the stock price (in orange). Our "demand" signal is the percentage of statements about a KPI for a company that correspond to a positive trend for the KPI, over all detections of trends for that KPI. It shows a first drop in early January, then a violent drop on January 28, three weeks before the stock price plunge from \$80/share to \$30/share, which started on February 19, 2020.



Fig.1: Causality Link "Demand" signal for United Airlines in 2020

While this "signal" method leads to great results as described in Fig.1, we have further explored a generalization of this novelty detection method to causal statements in order to compare the faint signal detection capability of statements about KPIs versus statements about causality.

Causal statements indicate that UAL demand had dropped in early January 2020 as a result of reduced demand for its flights to Hong Kong due to the civil unrest in the region (as seen in the few red dots above the label "Jan 2020"). The first strong causal statement linking Covid to a drop in United Airlines demand happened on January 28, when United Airlines announced a suspension of its flights to Shanghai, Beijing and Hong Kong due to "a significant decline in demand".

We tried a new method to refine our earliest possible detection of such a link between Covid and airline demand.

This method proceeds in two steps. The first corresponds to the early detection of a potential cause for a new crisis. The second observes the evolution of the selected potential crisis to increase understanding of its scope and development.

To focus on crisis detection in the context of a specific industry, we query (first step) with a high frequency (daily or weekly) the new causal statements that arrived in the past period and rank them by decreasing novelty.

Novelty is computed by looking at the premise and conclusion of the causal statement and checking how often an equivalent causal link with equivalent premise and conclusion has been found in the past 100 days versus the chosen novelty period (usually a couple of days). Crises usually involve as a premise a rare indicator or event potentially impacting a more standard KPI of a company such as "market", "demand", "production", "revenue" or "risk". The rarity of this combination defines the novelty of the causal link.

For example, if we looked on January 22, 2020 at the most recent causal links impacting the previous KPI of the airlines industry, we would have collected this list of new and novel links:

1 -	<pre>at = laa.link_alerts(source_companies=[],</pre>
2	<pre>source_industries=[],</pre>
3	source_locations=[],
4	source_kpis=[],
5	target companies=[],
6	<pre>target industries=['airlines'],</pre>
7	target locations=[],
8	<pre>target_kpis=['market','demand','production','revenue','risk'],</pre>
9	min novelty=0.75,
10	lastNdays=2,
11	timeMachine='2020-01-22')

		novelty	detections	strength	text
sourcekey	targetkey	3			
thomas_cook_group-revenue	easyjet-revenue	1.00	4 (4)		2020-01-21 17H But in London, shares in EasyJet jumped 4 6 percent after the British no-frills airline said it expected to reduce losses in its first half after revenues grew following the collapse of tourism group Thomas Cook in late 2019. (Source: Agence France Presse)
thomas_cook_group-bankruptcy	easyjet-revenue	1.00	3 (3)	+	2020-01-21 9H It recorded a significant increase in revenue in the first quarter, benefiting from Thomas Cook's bankruptcy, and expects a reduced loss over one year in the first half. (Source: Agence France Presse.)
china-epidemic	lufthansa-demand	1.00	3 (3)		2020-01-22 15H The outbreak of the lung virus in China could significantly reduce demand for services and especially travel offers, according to the market. (Source: ProQuest Information & Learning)
easyjet-operations	easyjet-demand	1.00	2 (2)		2020-01-217H He generally welcomed a 'strong performance this quarter' thanks to 'low capacity levels' among the competition and 'strong customer demand'. (Source: Agence France Presse)
china-epidemic	airlines-risk	1.00	2 (2)	+	22020_122_71! Stocks of state-owned airline companies plurged Monday and estended their declines to Tuesday and concerns on the outbreak of a new concensions that has killed new peoples to give Tolma's Winham of Quarkin Global peopled Tuesday (Source II Newswers) 2020_01_21_11! The spread of the concensions is 'Taising fears of a repeat of the region's experience with SARS 17 years ago," with those concerns contributing to stock losses in Asia on Tuesday, said hava Capital Markets in a note. (Source: III Newswers)
	united_airlines-market	1.00	2 (2)		2020-01-22 BH The financial report came the same day that United shares tumbled on fear that a virus outbreak in China could hurt travel between the U.S. and Asia, a key market for the airline. (Source: San Francisco Chronicle)
eurozone-epidemic	lufthansa-demand	1.00	2 (2)	-	2020-01-21 14H The outbreak of the lung virus could significantly reduce the demand for services and especially for travel services, it was said. (Source: dpa Deutsche Presse-Agentur GmbH)
southwest_airlines-human_rights	southwest_airlines-market	1.00	2 (2)	+	2020-01-22 11H The Orlando market has experienced notable growth in recent years due to its low cost of doing business, high quality of life and warm climate, which also attracts new business to the area and encourages expansion of existing companies. (Source: Information Solutions)
easyjet-revenue	easyjet-outlook	1.00	2 (2)	+	2020-01-21 8H With virtually all share prices of European companies dropping, one bright spot was Easyjet, which jumped 2.2 percent to £14.82 in London after the British no-frills airline reported a better outlook following a solid rise in first-quarter revenue. (Source: Agence France Presse)
world-holiday	easyjet-outlook	1.00	2 (2)		2020-01-21 7H Luton (dpa) - Higher ticket prices in the Christmas quarter have improved the outlook of the British low-cost airline Easyjet. (Source: dpa Deutsche Presse-Agentur GmbH)

Fig.2: Causal statements query and results for the airline industry on 2020-01-22

Out of these 9 new novel links, 4 are related to Easyjet which had just released its results, and gloated at the boost in its revenue produced by the bankruptcy of their competitor Thomas Cook. These are easy to discard as interesting for Easyjet investors but not very wide-ranging. One link is related to Southwest Airlines linking the high quality of life in Orlando to its growing market. And four links (dated Jan. 21 and Jan. 22) are linking the epidemic (in China or Eurozone) to the demand for, or the risk to, Lufthansa, United Airlines or Chinese state-owned airlines.

It takes a few minutes to scan these links and decide to disregard or investigate further. In this case, the potential impact of the epidemic on Lufthansa is clearly expressed as of January 21, 2020. This detection can be used to create a candidate crisis for the second step of our method, which is the setting of a daily causal contrast map dashboard showing the evolution of that potential crisis across all airlines, with a focus on "demand" and "revenue".

Causal Contrast Maps to detect industry-wide patterns: the Covid impact on airline revenue

For our first example, we will look at the evolution of factors on the "revenue" and "demand" of the airline industry, taking United Airlines (UAL) as a focal company.



Here is the Causal Contrast Map on January 28, 2020.

Fig.3: Causal Contrast Map for United Airlines vs Airlines as of 2020-01-28

In this graph, a thicker link indicates more observations. A higher blue intensity indicates a high percentage of mentions of United Airlines for a specific factor. This is how we display the contrast between UAL and all other airlines. The map indicates that UAL contributes to two links: the "financial activity to revenue" link and the "china-epidemic to demand" link.

Hovering over the link between "China-epidemic" and "demand" (meaning United Airlines and its competitors' demand), we get a pop-up menu with the relevant quotes (ranked by oldest first) and additional background information.

Link: china-epidemic->demand

Focal (Oldest first):

2020-01-28 **United Airlines trims service from US to China over virus** United Airlines said Tuesday it will trim its service to China from the United States in light of a big drop in demand amid an outbreak of a SARS-like virus. (Source: Agence France Presse)

Reference (Oldest first):

2020-01-21 (Summary 1815) Dax in Plus despite worries about lung virus in China The outbreak of the lung virus could significantly reduce the demand for services and especially for travel services, it was said. (Source: dpa Deutsche Presse-Agentur GmbH)

Focal link count: 1, Reference link count: 3, Focal ratio: 0.25 First observed: 2020-01-21, Last observed: 2020-01-28 Companies: lufthansa, united_airlines Industries: airlines Locations: china Source KPIs/events: epidemic Target KPIs/events: demand

Fig.4: Example of the pop-up menu on the link China-epidemic -> demand on Jan. 28, 2020

At this point, it is interesting to discover that as early as January 21, 2020, Deutsche Press had published a note potentially linking the "lung virus" to a reduction of demand for airlines. We could have discovered that link in two ways: either because we would have queried that industry for "novel" causal links on the airlines industry on January 22, through the first step of our crisis detection process, as demonstrated in Fig.2, or because we could have looked in a contrast map to all airlines in an attempt to compare their causal links to UAL's and we find this very early signal as we did in Fig.4.

On February 8, the causal contrast map shows that the factor "China-epidemic" becomes prominent, affecting not only the revenue of specific airlines but also the wider industry. IATA compares the epidemic to SARS and Cathay Pacific asks 27,000 employees to take a three-week unpaid leave. By February 19, as shown in Fig.5, it is quite apparent that the issue is having an industry-wide impact.

Fig.5: Causal Contrast Map for United Airlines vs Airlines as of 2020-02-19

This date is interesting as it marks the last day of UAL stock being close to \$80/share, before its plunge below \$30/share over the next month.

This demonstrates that the usage of a "Causal Contrast Map" would have helped investors in UAL assess the seriousness of the situation well ahead of the rest of the market.

Sometimes, it is also interesting to observe the <u>evolution over time of a causal map</u>, in order to understand at a glance the changes in the causal explanations about all the companies in an industry rather than just one. Because we no longer contrast a specific company with its competitors, but we contrast the date at which causal statements are made for each company, we will call this a Causal Time-Contrast Map.

The next figure demonstrates how we can display the detection over time of the impact of the Covid pandemic on the demand for all airlines.

Fig.6: Causal Time-Contrast Map for airlines demand as of 2020-02-15

This time, we positioned the system at the date of 2020-02-15, and looked at the preceding 45 days, highlighting in brown the oldest detections. We note that Lufthansa is the first one to be mentioned as being possibly hit by what is then still called the "lung virus", as of 2020-01-21.

The first usage of such a Causal Time-Contrast Map is for *post-mortem analysis*, either by investors or by managers of the airline industry or its suppliers, as it enables a better understanding of the propagation of the information about such industry-wide issues. The information gathered can then be used to reinforce alert mechanisms. For such a usage, we need to *highlight the oldest texts*, in order to improve our detection of faint signals.

The second usage is more real-time, with a daily or even hourly generation of such Causal Time-Contrast maps to highlight the most recent (versus the oldest) relevant causal links, thus enabling investors and managers to *observe the unfolding of such a crisis* in real-time on all the relevant companies without having to read thousands of documents. In that usage, we highlight *the most recent texts* to maximize the awareness of our users.

This tool can therefore be used to analyze the past, or as a real-time dashboard showing every day the progression of the mentions of the impact of the pandemic on the airline industry. From this information, we can conclude that alerts based on causal links and industry generalization would have provided an alarm on January 21, one full week before the alerts based on the "demand" signal for United Airlines (see Fig.1).

Causal Contrast Maps to detect industry-wide patterns: the semiconductor shortage impact on automotive production

Our second example relates to the impact on the automotive industry of the semiconductor supply shortage that started in December 2020 and propagated to all car manufacturers in Q1 of 2021.

We have taken Tesla as our reference company and asked for the causal graph for "production" for the automotive industry, contrasted with Tesla.

The factors mentioned in the past 30 days as influencing all automotive production as of January 1, 2021 are displayed in the next graph.

Fig.7: Causal Contrast Map for Tesla vs Automobile Manufacturers as of 2021-01-01

In this graph, a thicker link indicates more observations. A higher blue intensity indicates a high percentage of mentions of Tesla for a specific factor. This is how we display the contrast between Tesla and all other car manufacturers. For example, the "taxes" factor is bright blue because, during December 2020, only Tesla mentioned taxes as a factor in their production: they said that higher taxes in California would prevent them from building more plants in that region.

By contrast, the "supply shortage" factor is white because Tesla *was not* mentioned in the context of any supply shortage affecting car manufacturing while other car manufacturers *were* mentioned. In particular, an article from Equities, dated December 4, 2020, is titled "Volkswagen, Continental and Bosch warn of semiconductor supply shortage" and explains that according to Reuters, Volkswagen is facing shortages of electronic stability program components from Continental and Bosch.

This document would have been detected on December 4, 2020, with our first step process, and this detection should have triggered the creation of a causal contrast map dashboard focused on the production of automotive manufacturers in case this map did not already exist to track the lingering impact of Coronavirus in 2020 on that same production.

By January 15, 2021, the cat is out of the bag, and the semiconductor supply issue's impact on car manufacturers' production is prominently featured many companies including Ford, Nissan, Volkswagen, Daimler, and Toyota.

Fig.8: Causal Contrast Map for Tesla vs Automobile Manufacturers as of 2021-01-15

Note that at this point, Tesla is still not mentioned in that context (the white link between "semiconductors-supply shortage" and "production"). It is only on February 25, 2021, that the first mention of Tesla suspending output at its Fremont, CA factory, from February 22 to March 7, due to the semiconductor shortage, would appear in the news.

This example of the usage of a Causal Contrast Map highlights again the power of real-time detection of causal links in the context of an industry, and the value of contrasting one company with its peers.

The information that some members of an industry are experiencing issues (before the focal company) can be used by investors or management of that company, or by its providers or its customers. For example, Michelin sells tires to Tesla but could be interested in early warnings of the

potential disruption of other actors in the car manufacturing industry rather than just its specific customer, Tesla.

The next figure demonstrates how we can display the detection over time of the impact of the chip shortage on the production of all automobile manufacturing companies.

Fig.9: Causal Time-Contrast Map for automobile production as of 2021-06-01

In this case, we have colored the links by the inverse of recency. We have selected 2021-06-01 as the reference date, setting the system to analyze texts produced before that date. We then selected the detections of causal links between the semiconductor shortage and automotive manufacturers' production. The earliest detections color the link in brighter brown, and the intensity decreases with the passing of time. For example, we find that Volkswagen is the first company to have expressed a potential reduction of production due to this shortage of chips, as early as 12-04-2020, while stating it would be limited to China and short-lived.

Hovering over the semiconductors-supply shortage -> Volkswagen_corp-production would create this pop-up:

Link: semiconductors-supply_shortage->volkswagen_corp-production Reference (Oldest first): 2020-12-04 Volkswagen, Continental and Bosch Warn of Semiconductor Component Shortage One senior industry official, who declined to be named, told Reuters that he expects the shortage of chips will continue to impact China's car production for a while and several international and local car companies will face production interruptions in the short-term but at different levels. (Source: Equities.com) 2020-12-07 Automotive chip price set to increase due to supply shortage Volkswagen said on Friday that a global chip supply shortage could lead to interruptions in automobile production in China. (Source: FFC Information Solution) 2020-12-15 Chip shortage expands to car, headphone industries [Global Times] Xu made the comments after an unidentified source at SAIC Volkswagen was quoted in a study report as saying that the company had to stop production due to chip shortages. (Source: SyndiGate Media Inc.) 2020-12-15 VW future, OEM recovery, Passat chop - the week. The report suggested vehicle production could be disrupted in the coming months due to shortages of semiconductors in the automotive supply chain, with high end cars affected particularly due to their high electronic content. (Source: Gale Group) Focal link count: 0, Reference link count: 99, Focal ratio: 0.00 First observed: 2020-12-04, Last observed: 2021-05-24 Companies: volkswagen_corp Industries: automobile_manufacturers, automobiles, luxury_car, passenger_car, retailing, semiconductors

Locations: china, europe, germany, mexico, slovakia, spain, usa Source KPIs/events: supply_shortage

Target KPIs/events: production, plants

Fig.10: Example of the pop-up menu on the link semiconductors-supply_shortage -> Volkswagen_corp-production on 2021-06-01

Hovering over the other links would disclose the first statements about the same link for each company.

Again, the first usage of such a Causal Time-Contrast Map is for post-mortem analysis, either by investors or by managers of the automotive industry or its suppliers, as it enables a better understanding of the propagation of the information about such industry-wide issues. For such a usage, we need to highlight the oldest texts, in order to improve our detection of faint signals.

The second usage is more real-time, with a daily or even hourly generation of such Causal Time-Contrast maps to highlight the most recent (vs the oldest) relevant causal links, thus enabling investors and managers to observe the unfolding of the semiconductors supply shortage crisis in real-time on all the car companies without having to read thousands of documents. In that usage, we highlight the most recent texts, to maximize the awareness of our users.

In the case of the semiconductors supply shortage crisis, we show again that the causal link detection process we highlighted could have warned us as early as December 4, 2020, well ahead of the general awareness of the issue on Wall Street.

Conclusion

These two case studies highlight the potential of the predictive capability of a "wisdom of crowds causal graph" – that is, collective comments made about *explanations about the future evolution of different KPIs* of companies or industries – versus that of a "wisdom of crowds signal" – that is, collective *comments made about the future evolution of the same KPIs*.

This is possibly because causal links about the future can often be expressed by authors with conditional language (such as "the lung virus could reduce demand for airlines"), which is detected as such by our system but does not create a detection on the conclusion ("airlines demand") as it is not identical to an affirmative statement such as "airlines demand will decline". In a sense, when authors want to issue an alert on a potential problem, they feel compelled to express its "why", explaining how conditional causal links could be used as advanced alert signals.

This usage of causality in such statements leverages the predictive power of hundreds of thousands of human authors, with a clear detection timing advantage as compared to statistical causality detection technologies that require a significant amount of data to enable such detection.

Today's unprecedented interconnectivity can compound risks and rapidly increase the potential negative impacts of any crisis. But that same interconnectivity – through causal links detection and filtering – can leverage mankind's collective ability to understand the future and provide early alerts about dangers ahead!

We hope this document has increased your interest in the power of explicit causal links as expressed in documents. If you want to know more, please contact <u>info@causalitylink.com</u>