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THOUGHT LEADERSHIP BRIEF

Eye in the Sky: Private Satellites and Government Macro Data

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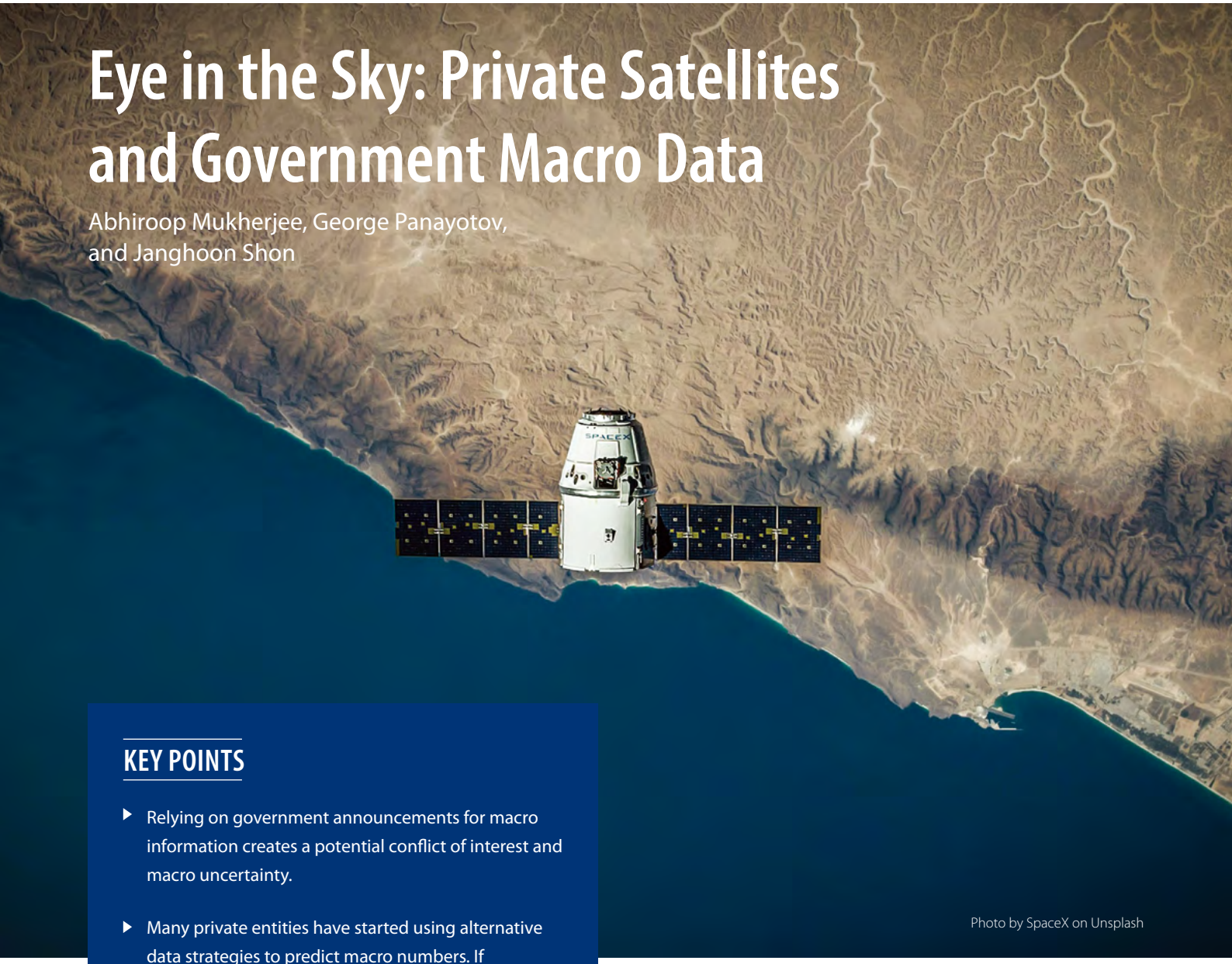


Photo by SpaceX on Unsplash

KEY POINTS

- Relying on government announcements for macro information creates a potential conflict of interest and macro uncertainty.
- Many private entities have started using alternative data strategies to predict macro numbers. If alternative data strategies can work for macro predictions, we can get a sense of what is happening in the economy without having to rely on the government to inform us.
- We find a reduction in implied volatility and in price jumps in the U.S. crude oil market as a result of satellite-based inventory estimates.
- These findings point to a future in which the resolution of macro uncertainty is smoother, and governments have less control over macro information.

ISSUE

Since the very beginning of economic measurement, markets have relied on government announcements for macro information. However, this raises two main issues. First, since such macro information is also used to measure the government's economic performance, this reliance creates a potential conflict of interest. Second, government announcements are intermittent and often come with delays. This leads to uncertainty about macroeconomic conditions in periods without announcements, and implies that decision-makers typically do not have access to the latest information before they act.

Many private entities, such as hedge funds, have started using alternative data strategies to predict macro numbers. Satellite imagery has seen a sharp increase in popularity as a source of economic estimates. Companies such as Planet Labs, Spire Global, and SpaceKnow track planes, ships, roads, buildings, and containers worldwide, Tellus Labs tracks global crops, and Orbital Insight and Ursa Space Systems focus on the real-time estimation of the amount of oil stored in various facilities around the world. Many of these providers estimate macroeconomic variables, which is of particular interest to traders in financial markets.

While the motivation for market participants to estimate macroeconomic numbers is clear, it is not known whether such estimates are effective. We develop an approach to measure whether estimates of macroeconomic variables derived from satellite images are effective in resolving macro uncertainty before government announcements in the U.S. crude oil market. The oil market provides a unique advantage for our study as crude oil is the only traded asset for which there is a weekly official U.S. government announcement.

ASSESSMENT

In this case, the main issue stems from the scale of the information-gathering activity, which is typically beyond the reach of even large private entities. However, we find it may not be necessary to monitor entire economies to estimate macro quantities. This is due to the fact that measuring economic activity at a few select locations, such as production hubs or bottlenecks in the supply chain, is often critically important for a macro estimate provider. We exploit this concentration in our test design, and focus on a series of natural experiments that randomize the availability of satellite data over a select few hubs. The second insight underlying our identification strategy is that satellites cannot "see" if clouds obscure their view. So satellite-based estimates of oil inventories are likely to be noisier when clouds cover key supply hubs.

Essential for our study is the choice of oil storage hubs over which to measure cloud cover. On one hand, the locations should sufficiently represent overall oil inventories, so that a measure based on them can be meaningfully related to aggregate oil market quantities, and hence to the price of oil. On the other hand, these locations should be limited in number to avoid the possibility that local cloud cover at these locations is somehow directly related to the overall demand or supply for oil in the U.S.

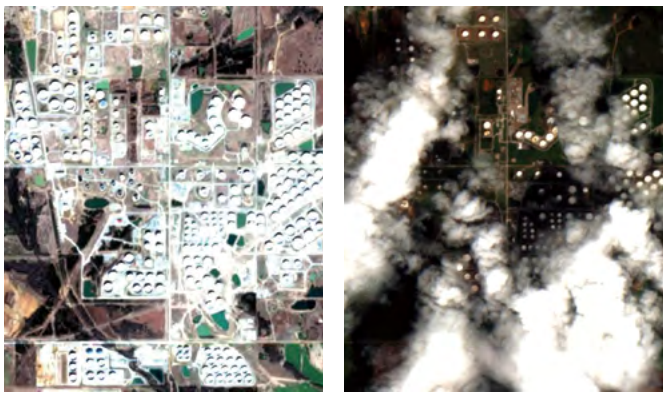
Figure 1 plots the five U.S. PADDs (Petroleum Administration for Defense Districts), which date back to World War II, and are relevant mostly for data collection purposes. The figure also shows the amounts stored in each PADD at the end of 2016. PADDs 2 and 3 account for over 80% of the total storage. Within PADDs 2 and 3, there are a few key points where multiple pipelines intersect, creating centralized storage hubs. The most conspicuous of these junctions is at Cushing, Oklahoma which accounts for 14% of the total U.S. oil inventories. We focus on ten specific locations, shown in red circles, that we use to construct a weekly cloudiness measure. Storage facilities in these ten locations account for up to a third of the entire U.S. inventory.

Figure 1. U.S. PADDs and main oil storage locations

Because oil is often stored in tanks with floating roofs, satellites are able to observe the differences in the shadows cast inside each tank; this makes it possible to estimate the level of oil. However, shadows cannot be observed if clouds cover the storage location. Even scattered clouds can significantly affect the measurement of shadows that are critical for an accurate reading.

Energy trading in large part revolves around weekly crude inventory surveys taken every Friday by the EIA (the U.S. government's Energy Information Administration). After aggregating the responses, the EIA announces the results at 10:30 a.m. the following Wednesday in its Petroleum Status Report. The price impact of the EIA announcement depends on whether the EIA brings in any new information about the latest inventory situation. In the presence of alternative estimates, the Friday inventory number announced by the EIA on Wednesday may not necessarily be the latest information available to the market at that time. This is especially likely to be true in clear weeks, when satellites can provide a better inventory estimate before the announcement.

Figure 2. Satellite images of oil inventory fields in Cushing, Oklahoma

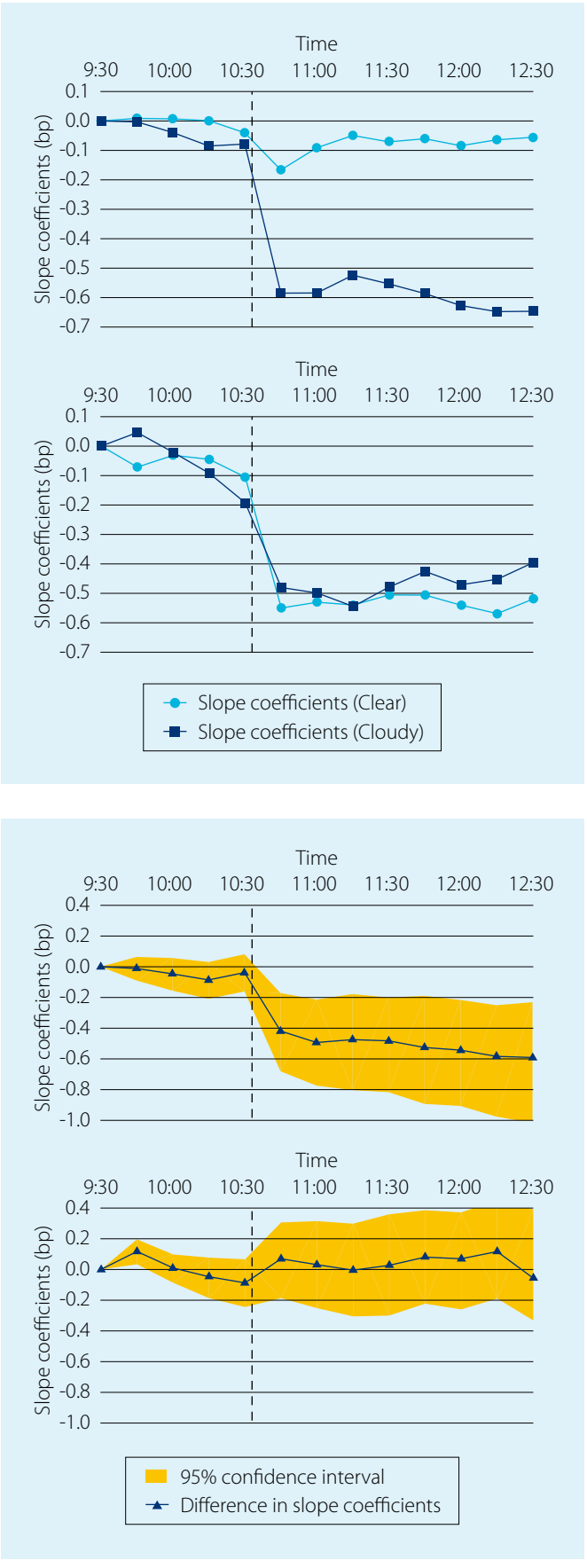


To construct our measure of cloudiness, we collect cloud cover data from the ISD (Integrated Surface Database) via Climate Data Online, provided by NOAA (National Oceanic and Atmospheric Administration). We average the cloud cover measure over all daylight hours to define a cloudy week as one when none of the days between the measurement day and the announcement day is clear.

We find that in cloudy weeks, satellite-based inventory estimates are indeed less accurate, and the oil price responds significantly to the EIA announcement. Completely cloudy skies increased the sampling error by 72.9% relative to completely clear days, indicating an economically non-trivial relation between our cloudiness measure and the observability of oil storage tanks. However, in weeks with clear skies – when satellites can accurately monitor changes in storage, and inform the market of inventory levels before the EIA – prices do not respond to the same announcement. Placebo checks find no such difference between the price impacts of the same announcement in cloudy and clear weeks in an earlier period ("pre-period"), when few commercial satellite-based predictions were available. This is exactly what one would expect if cloudiness affected the oil price impact of government announcements only through its effect on satellite-based estimates.

We also find that the average size of an oil price jump is 25% higher in cloudy weeks relative to clear weeks. This evidence is consistent with a causal link between price jumps and the availability of more frequent sources of information in financial markets. Overall, our evidence points to cloudiness affecting the resolution of uncertainty in the oil market through its impact on the accuracy of satellite-based estimates.

Figure 3. Oil inventory announcements and oil prices: baseline vs. pre-period



Investors have long shown interest in verifying official macroeconomic numbers with independent estimates for various high-growth markets, including China and India. In this spirit, we apply our approach to Chinese manufacturing. Here, our interest is in satellite-based estimates of Chinese PMI (Purchasing Manager Index), which is an important barometer of manufacturing activity. We use local cloud cover over eight hub cities, two in each of four key provinces (Guangdong, Jiangsu, Shandong, and Zhejiang). These provinces together account for 35-40% of the manufacturing activity in China. We find that satellite-based PMI estimates are significantly less accurate in months when it is predominantly cloudy over these cities, and government announcements of the PMI move a broad Chinese stock market index (CSI300) significantly. The impact of such announcements is substantially smaller in clear months. As with U.S. crude oil, we find larger price jumps in cloudy months.

RECOMMENDATIONS

Our evidence on the reduction in implied volatility and in price jumps in the U.S. crude oil market as a result of satellite-based inventory estimates suggests a shift in the way macroeconomic uncertainty is resolved in markets. Our evidence on Chinese manufacturing suggests a shift in the way markets get macro information in emerging markets. Besides these, there are many other possible consequences of effective alternative macro estimates that are beyond the scope of our paper. For example, effective estimates based on alternative data can help reduce noise in macroeconomic measurement, which has always been an important issue faced by governments. Finally, it is important to clarify that our goal is to suggest an approach towards understanding the effectiveness of satellite-based estimates, rather than to claim that our evidence in some particular case is conclusive. We recognize that it may take some time before alternative data sources can provide a viable alternative to a wide range of government-produced macro data, if ever. Yet, given the growing interest in such new data sources, it might be timely to develop a rigorous framework to study these developments.

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