Christiane Baumeister

On measuring the effects of oil shocks, changes in global energy markets, and forecasting tail risks

At an age when most children would be looking at storybooks, Christiane Baumeister was drawn to supply and demand graphs. "My father was a high school economics teacher, and I loved to spend time in his office browsing through his books," she says. "When I had to pick my field of study in high school, I picked economics, and I never looked back."

The selection of her research specialty was similarly serendipitous. When she entered her Ph.D. program in economics at Ghent University in 2005, oil markets were about to experience a remarkable run-up in prices. Between the start of that year and the summer of 2008, the global price for a barrel of Brent crude more than tripled. But, to the puzzlement of many economists at the time, this historic price surge was not immediately accompanied by the slowdown in economic activity and the rise in inflation witnessed during past oil price shocks. That piqued Baumeister's interest, and she decided to focus her research on "understanding and quantifying the drivers of oil price fluctuations as well as their time-varying effects on the macro economy." This task was complemented by her other interest: exploring new econometric modeling methods.

After completing her Ph.D. in 2010, she joined the Bank of Canada as an analyst and researcher until 2015. That summer, she began teaching at the University of Notre Dame, where she is currently the Lambert Family Professor of Economics. She has published numerous papers in academic journals such as *Econometrica, American Economic Review,* and the *Journal of Monetary Economics* about modeling and forecasting oil price fluctuations, an area of research that has left her with no shortage of work.

"Oil markets are never dull," she says. "One thing I've learned is that even when things are calm, the next price shock is just around the corner."

Tim Sablik interviewed Baumeister in June.

IMAGE: COURTESY OF LEAH INGLE, UNIVERSITY OF NOTRE DAME

EF: How does an oil shock move through the economy? What is the timing of that process?

Baumeister: From a macro perspective, we tend to focus on the effects of oil supply disruptions on consumer prices and real economic activity. When thinking about the passthrough of oil prices to consumer prices, you can divide that into a direct and an indirect mechanism. Given that households do not directly consume crude oil, the first stage of passthrough really happens in oil-related products. The price passthrough is reflected in energy goods and services that form part of the consumer basket, and price developments in these oil-related products then are summarized by the energy component of consumer prices. These effects tend to show up very quickly, typically within the same month of the shock, and they also drive up headline inflation, roughly one-for-one with the share of the energy component.

Indirect inflationary pressures are the result of higher energy prices increasing the cost of inputs for firms. As a result, the oil shock can also have an effect on the production of non-energy goods and services. If firms decide to pass those costs on to consumers, that will show up in core inflation. This component follows a more staggered process, since not all firms raise their prices at the same time. Historically, it can take about three to six months to reach the peak response.

Another important channel is inflation expectations. Given that oil price changes are so highly visible — they're covered in the media all the time, and households witness the effects at the pump right away — means that households might disproportionately react to changes in oil prices when forming expectations about future inflation. Higher inflation expectations can then set in motion second-round effects via a wage-bargaining mechanism, but the strength and the

persistence of these effects depend very much on the credibility of monetary policy and the ability of the central bank to keep inflation expectations anchored.

Another transmission channel on the real side of the economy is consumer confidence, which is an early indicator for future household spending. A drop in consumer confidence can precede a decline in real GDP, but this typically happens more gradually than the inflation effects. The trough in economic activity is more or less reached between one and two years after the initial shock. So, the timing of the effects on inflation and economic activities is different. Unexpected changes in oil prices show up faster in prices than in the real variables.

EF: Do the effects of an oil price shock differ depending on whether it is the result of a change in supply or a change in demand?

Baumeister: That distinction matters a lot. Broadly speaking, supply shocks tend to be bad news. When oil production gets disrupted, as we're experiencing right now, the economy has less oil available and at a higher price. On the one hand, that's good for oil producers. They can sell more of their product at a higher price and make a higher profit. But other firms face higher production costs, which they might choose to pass on to consumers.

Consumers, then, spend a larger share of their budget on oil-related products — transportation, heating, and all energy-intensive activities. That means that they have less money to spend on other goods and services. Eventually, private consumption will drop and investments get delayed, except possibly in the oil sector, which might have an incentive to expand capacity, but that depends in large part on the duration of the supply disruption. Still, the costs of higher oil prices are pretty widely distributed, whereas the benefits are concentrated among fewer firms.

Crucially, the strength of these effects depends on the elasticity of oil demand, how much households and firms are able to reduce fuel consumption as a result of the oil price increase, and to what extent a country depends on oil imports. If a country depends on oil from abroad, a price increase results in a greater transfer of income abroad.

Demand shocks, on the other hand, are typically a sign that the economy is doing well overall, so oil prices rise because there's more demand for oil, which is induced by strong economic growth. While this will still lead to higher consumer prices, the economic environment in which that happens is usually one where incomes are also rising, so households' real purchasing power is not necessarily diminished.

"What sets the current crisis apart is the sheer size of the supply disruption."

Now, higher demand for oil can also originate from greater uncertainty about the future, which prompts refiners to store more oil in anticipation of future physical shortages. In that case, higher oil prices are still the result of greater demand, but because those oil purchases are being accumulated in inventories instead of fueling economic growth, those higher prices have the potential to depress economic activity.

EF: One point that comes across in your research is that it can be difficult to disentangle whether a change in oil prices is primarily driven by supply or demand. Is the oil price response to the current crisis in the Middle East an example of a straightforward supply shock, or is it more complicated than it might appear on the surface?

Baumeister: Typically, an oil price shock is the result of different drivers, and what matters in a crisis episode is the relative importance of these various determinants. Sometimes supply dominates, sometimes demand, and every historical event is different. But I think what we're experiencing right now is probably the cleanest example of an oil supply shock that we've had in decades. It really follows the blueprint of a classical supply shock: There's a war in an oil-producing country or region where production facilities and energy infrastructure get destroyed, and, in this case, a major waterway gets blocked. That leads to a loss of oil output, which then induces a spike in oil prices.

What sets the current crisis apart is the sheer size of the supply disruption and the fact that it has affected all the countries in a region. Historically, these types of supply shocks have often been the result of conflict between neighboring countries, but the effect of this disruption has spread widely across the most important oil-producing region in the world.

There is also considerable uncertainty about whether we will be able to return to the prewar situation and how long it will take. This uncertainty acts more as an amplification mechanism rather than a separate exogenous shock, and it is likely to exacerbate the real economic consequences of the unexpected loss of oil supplies. This uncertainty puts additional downward pressure on economic activity on a global scale.

EF: When the conflict began, many people compared the disruption in oil supply to the energy supply shocks of the 1970s. How has the U.S. economy's responsiveness to oil shocks changed since the 1970s, and what are some of the factors that have driven those changes?

Baumeister: The current narrative is that the U.S. economy is less vulnerable to oil supply shocks than it was in the 1970s because of reduced reliance on petroleum. Following the oil price

surges of the 1970s, industries gradually switched away from oil to alternative sources of energy. In addition to relying more on renewables, they also developed more energy-efficient technologies and improved energy conservation, all of which then led to a decline in the oil intensity of production, meaning they need less oil to obtain the same output. These efforts were also supported by government policies aimed at reducing oil use in the economy and increasing consumers' energy awareness. The sectoral composition of U.S. economic activity has also changed. There has been a structural shift away from manufacturing toward services, which tend to be less energy intensive.

But as a result, oil consumption is now concentrated in sectors such as transportation, where there are fewer alternatives. In the case of automobiles, electric vehicles are a substitute, but they're still pretty expensive and may not be a viable option for the average household. Depending on the duration of the shock, more households might reach the point where the initial investment in an electric vehicle is attractive, but I think it would take quite a lot to see that kind of shift on a large scale. So, while the overall energy share of consumption has been falling over time, gasoline dependence is still high, particularly among low-income households.

On the supply side, the U.S. has become the world's largest oil producer, which means that higher oil production revenues as a result of higher prices stay in the U.S. instead of flowing abroad. Yet, I think that the U.S. economy would not be fully insulated if we experience a global economic slowdown sparked by lower consumption and investment in other parts of the world. So, to me, it's not so clear that the U.S. economy is as shielded from the effects of an oil supply shock as many people have suggested. I think the macroeconomic consequences for a shock of the current size will still be substantial.

Christiane Baumeister

PRESENT POSITION

Lambert Family Professor of Economics, University of Notre Dame

SELECTED ADDITIONAL AFFILIATIONS

Research Associate, National Bureau of Economic Research; Research Fellow, Center for Economic Policy Research; Fellow, International Association for Applied Econometrics; Research Professor, Deutsche Bundesbank Research Center

EDUCATION

Ph.D. (2010), Ghent University; M.Sc. (2006), Catholic University of Leuven; M.A. (2003), University of Siena; B.A. (1999), University of Bayreuth

EF: What role did monetary policy play during the oil shocks of the 1970s, and have economists' views on how monetary policy should respond to oil shocks changed since then?

Baumeister: There's an old debate among economists about whether oil price shocks themselves or the Fed's contractionary monetary policy response to them trigger a recession. As we discussed, it is important to distinguish between supply- and demand-driven oil price increases, which can generate very different economic environments. The first scenario poses a trade-off between the Fed's dual mandate, while the latter might not necessarily do so.

At the beginning of the 1970s, it was believed that inflation was mostly caused by structural supply side factors that were not really amenable to policy measures, so the central bank could do little about them. That prompted little monetary policy reaction to inflationary pressures, including those generated by the oil shocks of the 1970s. That changed with the Volcker disinflation, but even today, the conventional narrative is that central banks cannot and maybe even should not do anything about temporary supply side shocks, including oil supply shocks. Instead, the central bank should look through them because they're only causing relative price changes.

To me, that view is really outdated. I don't think that's how central banks should behave in the face of a major oil supply shock. Most central banks only have an inflation mandate (the Fed is a special case since it has both an inflation and employment mandate) and in my view, if there are risks that inflation is getting out of hand, central banks should act decisively because there's always the threat that inflation expectations could become unanchored.

EF: What role have oil inventories played in the response to the current oil supply crisis, and what role do you expect them to play over a longer time horizon?

Baumeister: We have seen a very rapid drawdown of oil inventories, both from the strategic petroleum reserves in a coordinated effort by the International Energy Agency member countries, as well as from commercial stocks. To a large extent, this has cushioned the impact of the loss of supply from the Middle East. But oil stocks can only be drawn down once, and then you have to rebuild them down the road. In that sense, inventory drawdowns are buying us some time, but they are no solution to the massive loss of oil supply.

Looking at the longer run, I expect prices to stay elevated for a prolonged period, even after the reopening of the Strait of Hormuz. Not only will it take considerable time to start production and exports up again — think of all the energy infrastructure that has been destroyed, and all the oil tankers that are somewhere else in the world — but oil inventories will have to be refilled. So, there will be delays in getting more oil online, and at the same time there will be sustained demand from two sources: current oil consumption and stock rebuilding. I think those forces will bolster higher oil prices for a considerable period, at least until the end of 2027.

EF: In a recent paper with James Hamilton, you examined how the oil market is shaped by the different responses of individual producers and consumers. One of your findings was that Saudi Arabia has historically played a key role in stabilizing the price of oil by adjusting its supply in response to shocks. How have oil suppliers responded to the most recent crisis?

Baumeister: Saudi Arabia has not really been able to assume its role as a swing producer as it has done historically because it's geographically constrained. A large part of Saudi oil goes through the Strait of Hormuz. That said, Saudi Arabia has been quick to redirect some of its oil flows through the east-west pipeline to the Red Sea port of Yanbu, effectively increasing tanker loadings to around 4 million barrels per day after the outbreak of the war. But the scope for increasing that capacity further is limited, so I don't think that it can really play an important stabilizing role this time around.

Now, there has been some talk that the U.S. is the new swing producer. It has all the earmarks of it. Shale oil provides more flexibility in terms of expanding production quickly, and the U.S. is the largest oil producer in the world right now at 13 million barrels per day. Recently, U.S. oil exports have really ballooned, which would suggest it is increasing supply in response to the shock. But I think that's a little bit deceiving because if you look at some of the underlying indicators of the domestic oil sector, they tell a different story. Both oil production and active drilling rigs have not really increased all that much. In the U.S., we're in the lucky position that we have weekly updates about oil production and drilling rigs, so we can track changes in a very timely fashion. The boost in U.S. oil exports can really be traced to releases from the Strategic Petroleum Reserve (SPR). There has been less domestic demand, but Europe and Asia have been tapping the U.S. SPR.

The reason why I don't believe that the U.S. is in a position right now to act as a swing producer is that the business model for shale oil in the U.S. is very different from the business model for oil producers in Saudi Arabia. Especially since the pandemic, there has been a major shift in priorities from increasing spending on exploring, drilling, and producing oil to generating returns for shareholders, and I don't think that will change anytime soon. There are also concerns about the duration of any shock. Shale oil producers are cautious about expanding drilling because of the volatility in prices and the uncertainty about future demand.

EF: Have different demand responses across countries affected how the current shock has unfolded?

Baumeister: Demand elasticities play a crucial role. A country's ability to reduce its demand for oil in response to a shock depends a lot on its energy mix and its dependence on oil imports. When it comes to the energy mix, I think China has been very forward-looking, in the sense that they have invested a lot in renewables and alternative energy sources. They also have been very strategic in building up oil reserves. They have the largest stockpiles of oil, and it seems they've been very cautious about drawing on them. With China, we don't always have access to hard data, so it can be hard to verify the actual situation on the ground. But we know they have options for fuel switching because of their investments in electric vehicles and alternative energy sources.

EF: A big focus of your research is building models to forecast oil price movements. To many, this might seem like an impossible task. Oil and gas prices are so volatile that they would appear to be inherently unpredictable. How have you gone about developing models for forecasting oil prices?

Baumeister: The conventional view is that the best guess of the price of oil tomorrow is the price today, which implies unpredictability. This stems from the observation that oil prices behave like asset prices, and asset prices are deemed unpredictable in efficient markets. I've challenged that view in my research. What is different for oil compared to financial assets is that oil has an important physical component. That raises the question of whether the forecast performance can be improved when we carefully model the physical market reality. This requires a good understanding of the market structure, the fundamental determinants of oil prices, the role of institutional features, and their development over time. It's these aspects that have guided my selection of suitable predictor variables as well as the choice of the appropriate modeling framework for forecasting success.

When it comes to the variables on the demand side, you want to look at the key determinants. For example, global fuel consumption, so the amount of petroleum products, such as gasoline, diesel, or jet fuel, determines the demand for crude oil by refiners. Another important factor is the profit margin of refiners — how much they can earn by transforming crude oil into petroleum products. Typically, the greater that margin, the more upward pressure on prices. The strength of demand also depends on the state of the global economy. On the supply side, global drilling activity is an important indicator of future production. How much oil we have in storage, so once again inventories, is also important.

So, we have a relatively good understanding of the economic drivers of oil prices, but we also need to be able to accurately measure them and to obtain them in a timely fashion for forecasting. That poses additional challenges because some of these variables, like global petroleum inventories, are only available with considerable delays. For other variables, there's an outright measurement challenge. How do you

approximate the state of the global business cycle, for example? That often requires the construction of suitable indicators from scratch.

Another important aspect that speaks more to the modeling itself is that energy markets have undergone substantial transformations over time, and that can also affect the forecasting ability of models. There are structural changes that can influence the demand for energy: shifts in the energy intensity of production, technological progress, changes in the energy mix, and so on. You need to have a flexible model that accounts for all these changes.

EF: Has it also become more important to consider tail risks when building models to forecast oil price movements? After the oil shocks of the 1970s, there were several decades where oil shocks were rare and relatively short-lived when they did occur. But in the last few years, we've experienced the energy shock from the war in Ukraine and now from the conflict in the Middle East.

Baumeister: Definitely, tail risks have been on the rise in global oil markets. We're experiencing more severe events with greater frequency, which makes it imperative to take tail outcomes into account in our models. Multiple approaches have been proposed in the literature to incorporate these risks in forecasting models, mostly in relation to assessing macroeconomic tail risks. This means looking at risks to growth, inflation, and public debt, for example.

In some of my recent research, we were curious to see whether the takeaways from that literature carry over to oil price risks. We conducted a horse race using three different model classes that are popular for studying tail behavior: quantile regressions, Bayesian VARs with stochastic volatility, and nonparametric machine learning models. We found striking differences between the macro forecasting setting and the oil market. Quantile regressions are widely used in macro forecasting, but they perform abysmally for oil prices, which favor the more flexible machine learning models.

Taking tail risks into account means moving away from focusing on the most likely outcome and factoring in uncertainty by looking at the entire distribution to assess the probability of future extreme oil price realizations. What we propose is to use the predictive distributions to construct early warning indicators to monitor the buildup of oil price risks in real time. We can also assess the likelihood of oil prices exceeding an upper threshold, which is what matters to consumers, or the likelihood of oil prices falling below a lower threshold, which is important for producers. We design what we call consumer and producer distress indices as a way to convey the probability of upside and downside risks of tail events.

"We're experiencing more severe events with greater frequency, which makes it imperative to take tail outcomes into account in our models."

I think it's important to have a device that succinctly communicates these types of risks for the purposes of stress testing and risk management. It's always probabilistic, of course, but I think it's still useful if you have to make decisions under uncertainty that you at least know the probability of a possible tail outcome. Then it's up to the decision-maker to decide how much weight to attach to that risk.

EF: Economists' understanding of oil market dynamics has evolved considerably over the last four decades. What are some ways that your own thinking on this topic has changed over the course of your career?

Baumeister: Let me maybe start by telling you what has not changed. Throughout my entire journey of researching oil markets, the one thing that I came away with is that elasticities are really key. I think a lot of progress has been made to estimate them better, but there's room for more. And this is where my thinking has evolved. It is really important to shift our focus from the aggregate to the disaggregate and study heterogeneity across countries — how oil producers and oil consumers adapt to oil shocks. Understanding the differences in country-specific supply and demand elasticity is very important in the beginning of an oil shock, but also for understanding the transmission to the macro economy. How does an oil shock propagate through the economy at the sectoral level? There's a lot of heterogeneity hidden in the aggregates that we tend to look at, and to really understand the aggregate dynamics, it's important to dig deeper and look under the hood at what's happening at the firm and consumer level.

I'm looking at disaggregated dynamics in various projects right now with the goal of better understanding how macroeconomic shocks impact microeconomic units, such as firms, households, and countries. I'm also taking nonlinearities into account in these models. In order to do that, I'm working with a couple of co-authors to develop a flexible micro-macro modeling framework that integrates multivariate time series models with nonlinear panel models, where the nonlinearities are inferred using machine learning techniques. It brings together a lot of my previous research in terms of techniques.

We want to use this framework to examine how households adjust their inflation expectations in response to oil supply shocks of different sign and size, and also to analyze to what extent households respond heterogeneously to these shocks and whether those different responses are driven by demographic characteristics like gender, age, income, and home country. The ultimate goal is to run a counterfactual scenario of current events to see the differential effects that a large oil shock can have on different types of households. **EF**