SAVING FOR TOMORROW: COAL SUPPLY DISTORTIONS, STOCKPILING, AND POWER OUTAGES IN INDIA

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Section 1: (Summary)

Uncertainty in supply of production inputs can change firm incentives and affect output. This paper shows that in case of coal power plants in India, uncertainty in supply of coal causes power outages and inefficient power production. I use a natural experiment driven variation in coal supply uncertainty and employ a difference-in-difference estimation strategy to show that plants faced with uncertain future coal supply respond by decreasing output through effecting partial shutdown of their generating capacity. Affected plants engage in precautionary saving and start stockpiling coal even as the supply of coal remains unaffected. I show that the plant level outages are not actually due to coal shortages as the plants officially claim. The affected plants face lower generation cost and their shutdown decreases total power generation and increases total cost of power generation, resulting in estimated 0.3 to 1.5 billion dollars in welfare loss.

Section 2: (Context and Research Topic)

Access to electricity has been shown to be strongly correlated with economic development across countries (Source: World Bank (2015)). In India, economic development relies upon cheap power generated from vast reserves of inexpensive coal expected to last more than 150 years. Despite the increasing supply of power from renewable sources, coal-based power plants still supply more than 80 % of the total power generated in India (Source: Ministry of Power, India). If energy is the engine of growth, then the importance of coal for the Indian economy cannot be overstated. It is likely the reason that coal and power sectors are tightly regulated by the Government of India (GOI). Both sectors suffer from extremely limited access to markets and from persistent unmet demand. In such heavily regulated sectors with incomplete markets, uncertainty about future supply of factors of production can have a pronounced effect on forward-looking firms' production decisions and output.

In this paper, I describe how a landmark judicial intervention upended the way Indian government allocated coal to power plants leading to a sudden increase in uncertainty in future supply of coal for some of the power plants. Using a difference-in-difference framework, I establish that increased supply chain uncertainty in the coal sector led to an increase in power outages and inefficient power generation. In demonstrating how distortions in coal supply can affect outcomes in the power sector, I highlight the role that supply side inefficiencies play in causing power outages in India.

Section 3: (Policy Background, Identification, Empirical Strategy, And Results)

In 2014, the Supreme Court (SC) of India declared 214 coal block mining contracts illegal due to alleged corruption and ordered that the mining leases be voided at a future date. Specifically, the court ordered the GOI to formulate rules for reallocation of the voided coal mining leases by March 2015. This order led to the beginning of a period of uncertainty about future coal supply that would last until, in theory, a new policy to allocate the cancelled mines came into force in March 2015. This landmark judicial decision led to unprecedented increase in uncertainty for the power plants subject to the ruling—that is, those firms with mining leases that were declared illegal. The rest of the plants had secure long-term fuel supply agreements from the state and were immune to the effects of the SC judgement.

I exploit this quasi-experimental variation in future uncertainty about fuel supply faced by plants, and I use a difference-in-difference empirical strategy to demonstrate how the incentives and constraints that power plants face cause inefficient generation and lead to large economic losses. The empirical results of my paper are derived using a novel dataset that links each coal power plant to the mines it recieves coal from. This, along with other datasets, allows

for a comparison between how much coal plants received, how much of it they rationed, and how much coal they actually used to produce electricty.

The Supreme Court's decision to order a reallocation of mining contracts came in response to the irregularities in the initial awarding of mines, dubbed in popular media as the coal-gate scandal. This judicial intervention in policy making remains the largest of its kind in India's history and was widely unexpected. I show that the affected plants responded to that intervention by declaring generation capacity under outage as a means to engage in precautionary saving of the generation fuel (coal) even before the cancellation of mines became reality. The incentive for plants to engage in precautionary saving comes from fixed charge component of the power purchase contracts (PPA) called capacity payments, which is contingent upon plants having at least 85% of their capacity available for generation on average. In order to be ready to generate power, plants need to have a minimum amount of coal. So, when faced with possibility of supply shocks in the future, they try to smooth their consumption of coal by saving for the uncertain future.

To analyze the effects of the mining contracts reallocation that induced future uncertainty, I use a straightforward two-period model to theorize how uncertainty about future fuel supply might affect power plants' production behavior. I show that if plants believe that future shortages are likely, they engage in precautionary saving and curtail production. Second, using a difference-in-difference framework and rich panel data on plant input and output, I derive empirical estimates of the impact of regulatory uncertainty on power plants' production behavior using a number of different measures of output. The empirical strategy relies on quasi-experimental variation in uncertainty faced by plants as a result of the SC decision and compares the plants affected by the SC decision to the plants that had secure long-term fuel supply from state. The outcome of interest is the output at the plant level, which I measure both indirectly with data on daily capacity under outage (MW), monthly coal delivery, and consumption and stockpiling (Metric Tonnes per month) and directly with data on monthly electricity generation (GWh per month).

The empirical results show that future supply uncertainty has a significant negative impact on firms' output and the direction of the empirical estimates is consistent with the model's predictions. Future uncertainty about coal supply causes plants both to declare their generation capacity to be under outage due to coal shortage and to stockpile coal even as their fuel deliveries see no change. This partial shutdown, induced by precautionary saving motive, resulted in a statistically significant and economically large loss of 7\% of monthly output as measured by monthly electricity generation. The long-term results show that these effects persist over a long period of time (more than 3 years).

The shutting down of power plants not only causes reduction in aggregate output, but also increases the total cost of generation, because, on account of their proximity to the coal mines, the plants affected by the mining cancellation had lower generation cost relative to unaffected firms. To estimate the increased cost of generation, I simulate least-cost dispatch supply curves and show that the change in plants' production decisions led to an increase of approximately 0.3 billion dollars\footnote{290 Million dollars} in the total cost of generation. I estimate the value of lost generation using the results of Alcott, Collard-Wexler and O'Connell (2016) showing the impact of outages on manufacturing plants revenue. The estimated net value of lost generation load is approximately equal to 1.5 billion dollars. These two estimates form the lower and upper bound of the economic cost of regulatory uncertainty. The actual welfare loss is a convex combination of the two estimated bounds.

Section 4: (Conclusion)

The main insight from this paper is that regulatory levers on the supply side play a major role in the persistence of power outages in India. The results of this paper point towards various inefficiencies in the coal allocation policy and how they affect the provision of electricity in India. Policy discussions about addressing power outages in India often revolve around addressing inefficiencies at the generation and distribution of electricity. This paper shows that there is a more fundamental issue of allocation of fuel to power plants that needs to be addressed as part of the solution to power outages and provide continuous access to electricity.