Application for NBER Digital Economics and AI Tutorial

Stephanie Hutson
University of California San Diego, Department of Economics
703-965-3602, shutson@ucsd.edu
https://smhutson.github.io/

Background and Graduate Education

I am a 3rd year Economics PhD student at the University of California San Diego, where my fields of interest are Industrial Organization and Environmental Economics. Before coming to UCSD, I spent a year at the University of North Carolina, Chapel Hill, transferring after first year to solve a two-body problem. Prior to going to graduate school I was a senior software engineer, first in a startup, where I was primarily a backend engineer, and spent about 20% of my time working with the data science team, then at a defense contractor working closely with the US Navy on in flight communication software.

I completed the core Microeconomic, Macroeconomic and Econometric sequences. At UCSD we take two years of Econometrics. To fulfill the Environmental Economic field requirements, I took Economics of Natural Resources, Energy Economics, Public Goods and Externalities, and Topics in Environmental Economics. To dig into Industrial Organization I took Contract Theory and as a campus exchange with UCLA, I took Industrial Organization with John Asker. I also took classes in Firm Dynamics and Trade.

The classes which had the greatest impact on my research are Energy Economics, Firm Dynamics and Industrial Organization. The first two classes I took during my first year at UCSD because I was able to test out of the microeconomics sequence from my time at UNC. I have always been interested in energy as a main driver of climate change and behind the scenes a major driver of economic activity. The class in firm dynamics, introduced me to quantitative macroeconomics, and understanding the equilibrium dynamics of firm behavior. The two classes together gave me tools to think critically about how firm behavior interacts with policy and market conditions. Finally, the Industrial Organization class not only enhanced my understanding of the bread-and-butter IO models but also helped to establish an understanding of how IO economists think about problems, data and industry. Since taking the class at UCLA, I have been able to join the UCLA IO group's student and invited seminars which has been a great opportunity to continue grow as an IO economist.

In service to the UCSD Economics department, I have organized a weekly "Green Teatime", an hour-long tea and coffee break for the environmental students and faculty to meet and discuss their current research projects, share ideas and gain feedback. Because UCSD does not have an official IO group or IO faculty, I also lead a summer Industrial Organization reading group for a group of students who intend on using IO techniques in their dissertation.

Research Interests

My research interests are at the intersection of firm behavior during uncertain or unusual times and the relationship with energy usage and production. I have two main projects that have been developed so far. The first of which explores the dynamics of firm entry and demand queueing during a period of subsidy removal. The second, and clearly more relevant to the AI tutorial, explores how energy prices – especially focusing on energy capital – impact the intensity of innovation of AI chips, algorithms, and other data center related energy efficiency innovation technologies.

The first paper, titled "Queueing for Subsidies: Evidence from rooftop solar during a transient demand shock", exploits the California NEM 2.0 to Net Billing subsidy change impacting the rooftop solar industry which occurred in the first half of 2023 to understand how, in an industry with relatively low barriers to entry, firms optimally set pricing and allow their demand for goods to queue up to be delivered later. A key feature of the policy around the policy change was that consumers could receive the higher subsidy if they signed a contract with a firm prior to a set deadline, and then had up to 3 years for the installation to be fulfilled. This allowed firms to queue up demand for later delivery. The main findings of the paper include an observation that firms are following a first-in-first-out queuing policy, there is a spike in entry leading up to the deadline, where new firms are able to charge higher rates due to high demand and not having a queue, and I observe a decrease in price with delivery time that is not present during the pre-period, which is consistent with a discount factor of about 15%. Future versions of this work will consider the counterfactual where firms must deliver by the deadline, and observing what happens to pricing and firm composition after a new equilibrium has been reached. This has been presented internally at UCSD, at the *American Environmental Resource Economics summer conference* in May 2025 and will be presented at the *Manchester Workshop on the Economics of Energy Transition* in December of this year.

The second project, "Necessity the Mother of Invention? Energy efficiency in the AI Race", which is still in the works, explores not what impact AI energy demand has on energy prices, which has received quite a lot of press and attention from economists, but instead on how energy capital prices and delays impact the levels of innovation in energy efficiency within the AI space. If we consider the frontier of innovation to expand along a vector of types of innovation (eg, FLOPS and FLOPS/W), then are we innovating along the optimal vector? Sources of inefficiency include the unpriced social cost of carbon, constrained supply of energy through long interconnection queues and monopoly power of the manufacturers of combined cycle gas turbines. I argue that firms are behaving in a winner-take-most fashion which encourages over-entry, and excessive investment. In doing so, I consider a modification of Reinganum (1981)[1] to understand the elasticity of innovation across input costs where the left-

[1] Reinganum, J. F. (1981) Dynamic games of innovation, Journal of Economic theory, 25, 21–41

hand-side of the production function, rather than human capital as in Reinganum, is model quality. With each improved level of model quality, firms have a higher probability of "winning".

I then develop a 3-stage empirical model to understand first, the intensity of innovation, then how that innovation translates into frontier levels in capital goods, finally how this translates into quality of the outcome model. For data, I will use US patent data over the last 7 years, leveraging the technical knowledge of the frontier large language models to categorize and rank the degree to which each patent pertains to one type of technological improvement versus another. This is used to estimate an intensity of innovation. I then use pricing data of GPUs and gas turbines – because AI firms are increasingly deciding to install their own turbines over direct grid connection, I argue this is optimal behavior for them at the time, therefore the marginal price of electricity from the IOUs is not currently necessary to consider. I will then use model benchmark achievement records to see the impact of these innovations. Once I have completed the estimation, I can consider counterfactuals, such as a first best where the social cost of carbon is accounted for and a competitive market for combined-cycle turbines.

Beyond these two projects, I am more generally interested in firm decision and investment during policy uncertainty, and during times of urgency. Policy uncertainty and firm investment has been studied from many angles, however the main innovations have been in defining uncertainty. I believe that this can be broken down further into the types of investment, for instance in the durability of the investment. For instance, if a regulation has been put into place, but there is uncertainty about the future of the regulation, it may be advantageous for a firm to choose a low fixed cost, high marginal cost technology over a high fixed cost, low marginal cost technology. Similarly, as we have seen in the AI race, firms (notably, xAI) building hyperscale data centers have chosen to avoid the expanding wait times for combined cycle turbines and opt for simple cycle turbines which are vastly less efficient, more emitting, and smaller. This nuance in the *types* of investments that firms are making I believe has been under explored and impacts not only the growth of, in this case, AI development but also energy prices and global emissions.

Conclusion

I believe is not a stretch to say that the relationship between energy and AI infrastructure will be a major topic within economics over the coming years. The tutorial I hope will give me the opportunity to interact with research leaders, provide insight into the industry mechanics, and enable me to develop valuable and insightful economic research on the topic.

Committee Members:

Mark Jacobsen (Chair, UCSD), m3jacobsen@ucsd.edu

Judd Boomhower (UCSD), jboomhower@ucsd.edu