SPRING 2017 SEMESTER: ME 794-001

A Principal-Agent Problem with Heterogeneous Demand Distributions for a Carbon Capture and Storage System

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Wednesday, March 1, 2017
MEC 224 1:00 – 2:25PM

Abstract:
Carbon capture and storage (CCS) is a process of capturing carbon dioxide from major point sources, like fossil fuel plants and factories with major carbon dioxide emissions, before it is released to the atmosphere. The captured gas can then be compressed and transported to special storage sites where it is injected deep underground and stored indefinitely. CCS is projected to be a significant player of a multi-faceted approach to reducing carbon dioxide emissions. For CCS to achieve its potential in mitigating greenhouse gas emissions while allowing the continued use of low-cost fossil fuels, it needs to be deployed on a commercial scale. This requires market-based incentives that encourage the participation of both the emitters and a CCS storage operator, who provides the service of transporting and storing captured carbon dioxide. In this work, we study the effect of market-based implementation of CCS technology through the theoretical extension of mechanism design and simulation optimization. Specifically, we consider the principal-agent framework with the setting where emitters have heterogeneous emissions profiles and the CCS storage operator offers a menu of contracts stipulating quantities and transfer payments for each demand distribution. Two types of hidden information are considered: information asymmetry between the CCS operator and the emitters, and agents' actual demands are not observed until the implementation stage. We present analytical solutions for the special case when there are two distributions each taking two discrete values, as well as a method for deriving analytical solutions from numerical solutions. We classify optimal solutions into three categories: separating contracts, contracts with pooling options, and contracts with non-participating options, and conclude that the optimal solution not only depends on the demand distribution but also the ordering of the demand levels across distributions.

Biography:
Selina Wenbo Cai is an Assistant Professor at the Mechanical and Industrial Engineering Department at NJIT. She received her Ph.D. in June 2012 from the department of Industrial Engineering & Operations Research at University of California, Berkeley. Prior to that, she worked in the consumer credit risk industry for two years. Dr. Cai's Operations Management Lab conducts research on sustainable supply chain, with a particular focus on incentives in carbon capture and storage systems, e-commerce returns and inventory policies, integrating additive manufacturing in supply chains, and primary care planning and scheduling. In 2015, Dr. Cai received an NSF award on optimizing incentives for carbon capture and storage systems.

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