Risk Regulation Seminar

Tuesday, April 21, 2009
"Risks and Opportunities of Manned and Unmanned Space Flight"
4:30-6:00 p.m.
G 50, Jon Huntsman Hall, The Wharton School
MOLLY K. MACAULEY
Senior Fellow and Director of Academic Programs, Resources for the Future, Washington, DC

Since the dawn of the space age in 1957, the use of space has led to an accumulating amount of debris orbiting the earth, including defunct satellites and rocket bodies; mission-related debris like discarded camera lens caps, stray nuts and bolts, paint chips, and frozen particulates from propellant fuel, along with fragmentation debris as orbiting debris collides with itself and breaks into smaller projectiles. Most of the debris is located at altitudes where space activities currently take place, and the accumulations are largely irreversible.

If present trends continue, some analysts believe that many low-altitude orbits will become unusable within two decades. Others argue that the problem is manageable through various, albeit costly, strategies to mitigate debris generation and/or adapt to collision risk. One strategy is to incorporate orbital maneuvering capability into spacecraft (e.g., through additional fuel reserves) which can help them to avoid observable projectiles (but not small projectiles). Space vehicles can also be designed to contain debris generation, for example by using thicker or stronger craft materials (which also reduces own-damage risk), tethering of disposable parts that would otherwise escape during rocket separation, and incorporating the capability to combust residual rocket fuel.

Nonetheless, space vehicle producers and operators currently under-invest in these strategies, to the extent they would yield spillover benefits to other operators through reduced collision risk. This suggests the Pigouvian prescription of pricing both launch rockets and spacecraft to account for their impact on elevating collision risks for (current and future) space fleets. In fact, a system of launch taxes, with various rebates, can be designed to mimic outcomes under first-best pricing. This paper provides a first attempt to model and quantify the magnitude of space debris externalities, the optimal tax system for addressing them, and whether there are quantitatively important differences in efficiency between the first-best and a range of alternative second-best tax structures. To do this, we derive intuitive and empirically useful formulas for the optimal tax structure using an analytical model of externalities of large (observable) and small (unobservable) debris generation that encompasses all the mitigation/adaptation strategies just described as well as debris cascading. This involves an extensive estimation of parameter values obtained from synthesizing projections from debris generation models, projections of spacecraft fleets, engineering analyses of mitigation/adaptation technologies, and of productivity losses from debris collisions.

Molly K. Macauley is a Senior Fellow with Resources for the Future (RFF) and Director of RFF's First Wednesday seminar series and academic fellowship programs. Her research interests include space economics and policy, the economics of new technologies, climate policy, and the use of economic incentives in environmental regulation. She has testified before Congress on numerous occasions and serves on many national level committees and panels including the National Research Council's Space Studies Board, the Climate Working Group of the National Oceanic and Atmospheric Administration, and the Earth Science Applications Analysis Group of the National Aeronautics and Space Administration (NASA). In 1994, she was selected as one of the National Space Society's "Rising Stars," and in 2001 she was voted into the International Academy of Astronautics. She has received awards from NASA and the Federal Aviation Administration for her research. Macauley is also a visiting professor in the Department of Economics at Johns Hopkins University.