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A System Dynamics Study of Uranium and the Nuclear Fuel Cycle

EPRG Working Paper 1311

Cambridge Working Paper in Economics 1319

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Abstract To advance current knowledge of the uranium market, a system dynamics model of the nuclear fuel cycle for the time period 1988 to 2048 has been developed. The proposed framework of analysis illustrates some of the key features of the market for this commodity, including the role that time lags play in the formation of price volatility. Various demand reduction and substitution strategies and technologies are explored, and potential external shocks are simulated to investigate how price and the associated industry respond. Sensitivity analysis performed by considering key model parameters indicates that the time constant related to the formation of traders' expectations of future market prices embedded in the proposed price discovery mechanism has a strong influence on both the amplitude and frequency of price peaks. One particularly interesting and timely scenario simulated is the possibility of the ending of the "Megatons to Megawatts" program, in which the USA agreed to buy down-blended uranium from former Soviet nuclear warheads for use in power production. This agreement has not been formally renewed and we find that in the absence of new substitute sources this could cause a significant rise in uranium prices. Finally, our analysis leads us to believe that uranium resource scarcity will not pose any significant challenges until the second half of the twenty first century at the earliest, even if high uranium demand projections are realized.

Keywords System dynamics, uranium mining, nuclear fuel cycle, uranium market dynamics, sensitivity analysis.

JEL Classification

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Publication May 2013
Financial Support MPhil and PhD funding for Matthew Rooney by AREVA.