Developing portfolios of water supply transfers

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1 Most cities rely on firm water supply capacity to meet demand, but increasing scarcity and supply costs are encouraging greater use of temporary transfers (e.g., spot leases, options). This raises questions regarding how best to coordinate the use of these transfers in meeting cost and reliability objectives. This paper combines a hydrologic–water market simulation with an optimization approach to identify portfolios of permanent rights, options, and leases that minimize the expected costs of meeting a city’s annual demand with a specified reliability. Spot market prices are linked to hydrologic conditions and described by monthly lease price distributions which are used to price options via a risk-neutral approach. Monthly choices regarding when and how much water to acquire through temporary transfers are made on the basis of anticipatory decision rules related to the ratio of expected supply to expected demand. The simulation is linked with an algorithm that uses an implicit filtering search method designed for solution surfaces that exhibit high-frequency, low-amplitude noise. This simulation-optimization approach is applied to a region that currently supports an active water market, with results suggesting that temporary transfers can reduce expected water supply costs substantially, while still maintaining high reliability. Also evaluated are trade-offs between expected costs and cost variability that occur with variation in a portfolio’s distribution of rights, options, and leases.


1. Introduction

2 Rising water demand and concerns over scarcity have driven more regions to explore market-based approaches to water resource management [Anderson and Hill, 1997; Easter et al., 1998; National Research Council, 2001]. Nonetheless, many water markets remain relatively unSophisticated, with transactions revolving primarily around permanent transfers or multiyear leases. While several studies have shown that these types of transfers encourage long-term allocation efficiency [Brookshire et al., 2004; Chang and Griffin, 1992; Colby et al., 1993; Griffin and Bouda, 1992; Hearne and Easter, 1997; Howe et al., 1986; Howe and Goemans, 2003; Nieuwoudt and Armitage, 2004; Saliba, 1987; Young, 1986], such transfers provide a less cost-effective means of managing short-term scarcity. Rising demand in many regions has increased the level of economic and social disruption brought about by seasonal droughts, and consequently some markets are beginning to support a more sophisticated menu of temporary transfers [Howitt, 1998]. This has resulted in an increasing number of researchers investigating the potential efficiency gains associated with “spot market” leases [Characklis et al., 1999; Smith and Marin, 1993; Vaux and Howitt, 1984] and options [Hamilton et al., 1989; Howitt, 1998; Jerchic, 1997; McCarl et al., 1999; Michelsen and Young, 1993; Villinski, 2004; Watters, 1995].

3 Spot market leasing generally involves the immediate transfer of “wet” water, with the lease price subject to considerable variability based on supply and demand conditions. A typical option agreement involves an initial payment that guarantees the purchaser the right to lease water at a later date at an agreed upon “exercise” price. The certainty inherent in the exercise price can make options an attractive hedge against spot market price volatility, while providing the additional advantage of postponing transfer decisions (and full payment) until better information is available. Both leases and options improve market flexibility relative to permanent transfers alone, allowing water users to more rapidly adapt to changing conditions while meeting their reliability goals with a reduced volume of “firm” capacity [Lund and Israel, 1995b]. As leases and options have become more widely available, there has been increased interest in how water users might coordinate the use of these instruments to achieve the dual objectives of maintaining water supply reliability and lowering supply costs.

4 Several previous studies have used either linear or stochastic programming techniques to identify combinations of supply alternatives (e.g., infrastructure, transfers, and conservation) that minimize the expected costs of meeting urban water demand [Jenkins and Lund, 2000; Lund and Israel, 1995a; Watkins and McKinney, 1999; Wilcfort and

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