AN INVESTIGATION OF UNINTENDED CONSEQUENCES OF LEGISLATION

A Senior Scholars Thesis

by

SHAUNA RAE YOW

Submitted to the Office of Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

April 2008

Major: Agricultural Economics

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Approved by:

Research Advisor:	M. Edward Rister
Associate Dean for Undergraduate Research:	Robert C. Webb

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ABSTRACT

An Investigation of Unintended Consequences of Legislation (April 2008)

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Texas is experiencing dramatic population growth with an expected doubling by 2050. This growth suggests a substantial increase in the demand for potable water when the state already faces serious water issues. Such dynamics raise concerns regarding both the quantity and quality of future water supplies. One area in which alternative water sources and potable treatment methods are being sought to support a rapid population growth is the Texas Lower Rio Grande Valley. In addition to Rio Grande surface water conventional treatment plants, an emerging and promising approach to expanding potable water supplies is brackish groundwater desalination. Based on recent technology developments in desalination membranes and increasing prices of surface water rights, economics of desalination have become more competitive with traditional treatment methods.

This relationship between conventional and desalination treatments was impacted by 2007 Texas legislation through an amendment to Senate Bill 3 (SB 3). This amendment to SB 3 was an attempt to facilitate meeting increased demand for municipal water and as such, established the price at which irrigation water in the Lower Rio Grande Valley can convert to municipal water, as a result of urban/residential development of agricultural land, at 68 percent of the market price, effective January 1, 2008. Preliminary economic and financial investigations suggest this legislation could introduce an economic bias in the choice between traditional treatment and emerging desalination methods. The institutionally-driven lowering of the costs of conventional treatment methods relative to desalination methods is an example of how legislation can unintentionally impact local decisions and technology adoption. In this case, studies indicate that desalination was less costly, but with the legislation-driven reduction in surface water, conventional treatment becomes the less expensive choice.

The consideration of economic theory and implementation of economic and financial analyses are useful in evaluating the magnitude of possible economic impacts introduced by legislation that impacts this region’s water market. Such effects can negatively impact the adoption of emerging alternative technologies for producing potable water. In addition, unexpected impacts of legislative actions can be identified. The overall objective of this work is to identify the most efficient method and source of providing water to regions where water is scarce and population is rapidly increasing.

DEDICATION

To my parents.

ACKNOWLEDGMENTS

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Finally, I would like to thank all of my family and friends for believing in me and encouraging and supporting all that I do. I would not be where I am today without them.

NOMENCLATURE

AE	Annuity Equivalent
ATC	Average Total Cost
AVC	Average Variable Cost
DMI	Domestic, Municipal, and Industrial
EB	Edgeworth Box
GIS	Graphic Informational Systems
IBC	International Boundary Commission
IBWC	International Boundary and Water Commission
ID	Irrigation District
MC	Marginal Cost
MR	Marginal Revenue
NPV	Net Present Value
P	Price
Q	Quantity
RGWAC	Rio Grande Watermaster Advisory Committee
RO	Reverse Osmosis
TCEQ	Texas Commission on Environmental Quality
WCID	Water Control and Improvement Districts
WID	Water Improvement District

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CHAPTER I

INTRODUCTION

The population of Texas is expected to double from 2000 to 2050 (U.S. Census Bureau 2001). Such extreme population growth will substantially increase the demand for potable water. These dynamics prompt concerns among stakeholders regarding the quantity and quality of future water supplies. The Lower Rio Grande Valley (Valley) of Texas is an area in which alternative sources of water and potable treatment methods are being sought to support a rapid population growth (Rogers 2008; Rogers et al. 2008). One emerging and promising approach to expanding the potable water supplies in the Valley is brackish groundwater[1] desalination (Norris 2006a; Norris 2006b; Sturdivant et al. 2008). Critics of desalination have previously argued that this method is economically inefficient due to high costs of production (e.g., Michaels 2007). However, recent technological developments in Reverse Osmosis[2] (RO) desalination membranes combined with an increasing price of local water rights have resulted in the economics of desalination becoming more competitive with conventional treatment methods (Boyer 2008; Boyer et al. 2008).

This thesis follows the style of the *American Journal of Agricultural Economics*.

[1] Brackish groundwater is underground “water containing more than 1,000 milligrams per liter (mg/L) of total dissolved solids (TDS) and less than 10,000 mg/L TDS” (Texas Water Development Board 2003).

[2] Reverse Osmosis “is the reversal of the natural osmotic process, accomplished by applying pressure in excess of the osmotic pressure to the more concentrated solution. This pressure forces the water through the membrane against the natural osmotic gradient, thereby increasingly concentrating the water on one side (i.e., the feed) of the membrane and increasing the volume of water with a lower concentration of dissolved solids on the opposite side (i.e., the filtrate or permeate). The required operating pressure varies depending on the TDS of the feed water (i.e., osmotic potential), as well as on membrane properties and temperature, and can range from less than 100 psi for some NF [Nanofiltration] applications to more than 1,000 psi for seawater desalting using RO” (Environmental Protection Agency 2005).

In an attempt to help to meet the increasing demands for potable water at an economical cost, the 80th Texas Legislature passed Senate Bill 3. This bill contained a floor amendment that established the price at which irrigation water in the Valley can convert to municipal water in association with the urban/residential development of agricultural land on or after January 1, 2008. The effective price for such rights is 68 percent of the prevailing market price for municipal water rights existing and/or converted prior to January 1, 2008 (Texas Legislature Online 2007b). Preliminary economic and financial investigations suggest that the implementation of this legislation could impact the competitiveness of desalination of brackish groundwater compared to conventional water treatment. The potential effect is a lowering of the costs of production for conventional treatment, resulting in a relatively more favored use of conventional treatment for producing potable water supplies at the detriment of brackish groundwater desalination. This effect suggests the introduction of a disincentive for new technology to be adopted. The institutionally-driven lowering of the costs of conventional treatment methods relative to desalination methods is an example of how legislation can unintentionally impact local decisions and technology adoption.

In an effort to analyze the potential implications of this specific amendment (i.e., Floor Amendment 60) of Texas Senate Bill 3 on the Valley potable water market and its stakeholders, several interviews with experts were conducted. These interviews began in October 2007 and included legal and water experts and irrigation district managers. In addition, intensive on-line and library research was conducted to obtain additional information. Quantitative and qualitative economic analyses of the Valley water market were conducted and evaluated to investigate and illustrate the perceived or possible effects of the legislation on municipalities' choice between alternative water treatment methods. Financial analyses, including capital budgeting and annuity equivalent analyses, were used to compare the financial implications on the life-cycle costs of producing potable water using conventional treatment facilities relative to using brackish groundwater desalination facilities. Conclusions are derived regarding the potential effect of such legislation on the adoption of emerging technologies for producing potable water. The economic gains and losses of consumers and irrigation districts (IDs) in the Valley water market are also examined, allowing for identification of relative potential impacts of the specified legislation.

The ultimate goal of research in progress by Texas AgriLife Research and Texas AgriLife Extension Service scientists is to identify the most cost-efficient source(s) and method(s) of providing potable water to regions where water is scarce and population is rapidly increasing. The immediate objectives of this undergraduate thesis, which is a component of the larger project, are to examine the potential impacts of legislative decisions on the Valley potable water market and illustrate the likely related economic implications for various stakeholders. This information provides insights into the consequential adoption of alternative potable water treatment methods and related impacts on municipalities, consumers, and irrigation districts.

Overview of study area

The area of interest for this project is the southern tip of Texas, also known as the Lower Rio Grande Valley (Valley). This area is comprised of three counties, including Cameron, Hidalgo, and Willacy (Figure 1).[3] The major cities in the Lower Rio Grande Valley are Brownsville, Harlingen, and McAllen. The entire land area of this region is 3,072 square miles, with a total population of 1.1 million in 2007 (Table 1) (The Texas County Information Project 2006).

Major contributing economic sectors for the Lower Rio Grande Valley include agriculture, manufacturing, trade, services, and hydrocarbon production (Texas Water Development Board 2007). In 2006, crop production in the Valley totaled $355.4 million, while livestock production totaled $25.9 million (Table 1) (The Texas County Information Project 2006).

Although the Lower Rio Grande Valley is prospering economically, approximately 30% of the population is living below poverty (see Table 1), which is almost double the 16.2% of Texans living below poverty (U.S. Census Bureau 2006). Currently, the per capita income for people in the Valley is almost half of the per capita income of all

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[3] The careful wording of the legislative amendment to Texas Senate Bill 3 restricted the law to this three-county region (Texas Legislature Online 2007b). Starr County is usually included in the region commonly designated as the Texas Lower Rio Grande Valley (Quinn 2003).

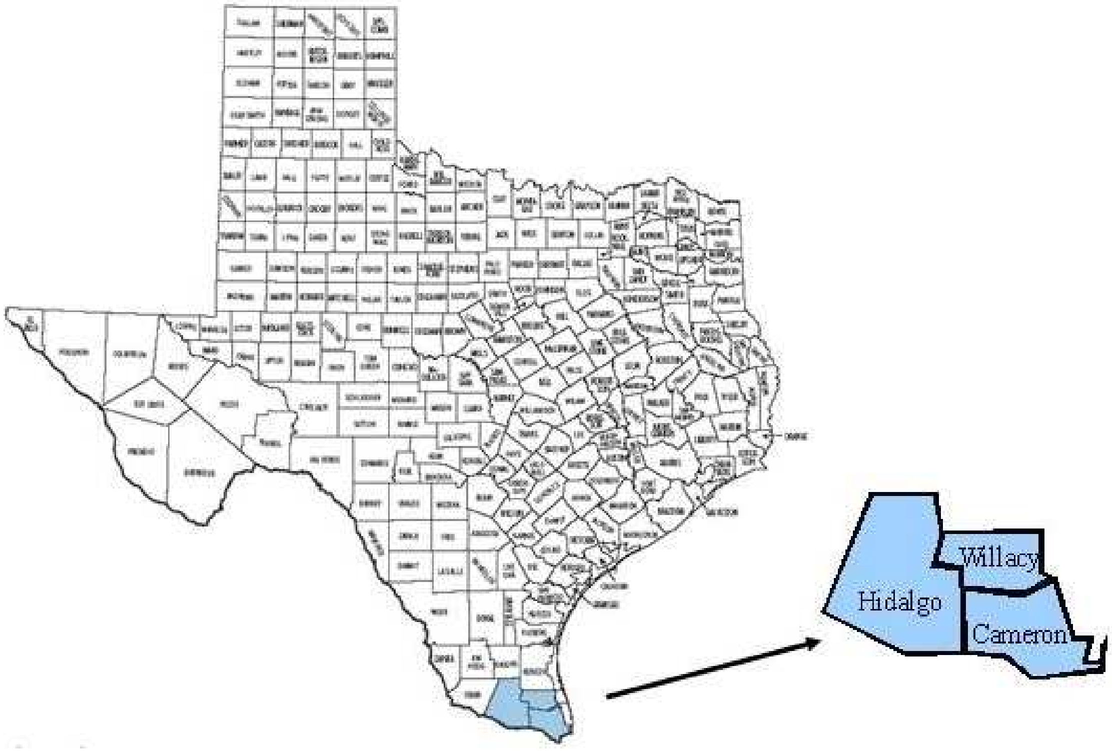

Figure 1. Texas counties affected by Floor Amendment 60 of 2007 Texas Senate Bill 3, 2008

Table 1. Texas Lower Rio Grande Valley Facts for 2006

	County				
Variable	Cameron	Hidalgo	Willacy	Valley Totals	Texas
Total Crop Production ($1,000)[a]	137,531	175,226	42,680	355,437	6,392,626
Total Livestock Production (I$1,000)[a]	1,700	19,690	4,567	25,957	8,720,778
Total Land Area (In Square Miles)[b]	906	1,570	597	3,073	261,797
Population[b]	387,717	700,634	20,645	1,108,996	23,507,783
Persons 18 and Under (%)[b]	34.1%	35.5%	30.6%	34.9%	27.6%
Median Age[c]	28.8	27.1	29.8	28.6	33.1
Persons Per Square Mile[d]	428.06	446.33	34.60	360.98	89.79
Per Capita Money Income, 2005[c]	$ 17,410	$ 16,359	$ 18,417	$ 16,765	$ 32,460
Persons Below Poverty Level, 2004 (%)[b]	29.4%	30.5%	29.6%	30.1%	16.2%
Unemployment Rate (%)[c]	6.6%	7.4%	9.2%	7.2%	4.4%

[a] Source: Texas Cooperative Extension (2006).

[b] Source: U.S. Census Bureau (2006).

[c] Source: The Texas County Information Project (2006).

[d] Calculated by dividing population by total land area.

Texans. In addition, the unemployment rate is roughly 7.2%, which is almost double the total Texas average of 4.4% (Table 1) (The Texas County Information Project 2006).

In response to the rapid increase in industrial growth and international trade, the Valley has become an attractive region for many people (Stubbs et al. 2003). By the year 2060, it is projected that the population in the Valley will be approximately three million, a 138% increase from 2010 (Table 2). The Valley is the fourth-fastest-growing Metropolitan Statistical Area (MSA) in the United States (U.S. Census Bureau 2001). By 2010, it is estimated that six percent of the total population of Texas will reside in the Valley (Texas Water Development Board 2007). The population of the Valley is slightly younger than the population of all of Texas. The median age in the Valley is 27.9, while the median age across all of Texas is 33.1 (Table 1). In addition, over 30% of the population in the Valley is under the age of 18, statistically greater than the related Texas percent as a whole.

Accompanying the rapid growth in population is an increasing demand for potable water. The total demand for water in the Valley will increase by approximately 10% during the next half century, from 1.28 million acre-feet (ac-ft) in 2010 to 1.38 million ac-ft in 2060 (Table 3). Historically, the demand for agricultural irrigation water[4] has been much greater than for all other uses. Due to urbanization in the Valley which

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[4] Hereafter, referred to simply as “irrigation water”.

Table 2. Texas Lower Rio Grande Valley Population Projections and Changes by County for 2000-2060

	Year						
County	2000	2010	2020	2030	2040	2050	2060
Population Level							
Cameron	335,227	415,136	499,618	586,944	673,996	761,073	843,894
Hidalgo	569,463	744,258	948,488	1,177,243	1,424,767	1,695,114	1,972,453
Willacy	20,082	22,519	24,907	27,084	28,835	30,026	30,614
Total	924,772	1,181,913	1,473,013	1,791,271	2,127,598	2,486,213	2,846,961
Change in Population Level							
Cameron	-	79,909	84,482	87,326	87,052	87,077	82,821
Hidalgo	-	174,795	204,230	228,755	247,524	270,347	277,339
Willacy	-	2,437	2,388	2,177	1,751	1,191	588
Total Change	-	257,141	291,100	318,258	336,327	358,615	360,748

Source: Texas Water Development Board (2007).

Table 3. Texas Lower Rio Grande Valley Water Demand Projections by County for 2000-2060 in Acre-Feet, 2008

	Year						
	2000	2010	2020	2030	2040	2050	2060
Cameron							
Irrigation	340,145	367,404	347,771	325,144	325,144	325,144	325,144
Livestock	1,103	1,103	1,103	1,103	1,103	1,103	1,103
Manufacturing	3,430	4,156	4,590	4,983	5,372	5,709	6,165
Mining	8	6	6	6	6	6	6
Municipal	71,792	86,496	102,264	118,321	134,693	151,275	167,665
Steam Electric	1,498	1,616	1,523	1,780	2,094	2,477	2,944
Cameron Total	417,976	460,781	457,257	451,337	468,412	485,714	503,027
Hidalgo							
Irrigation	550,279	583,030	525,971	453,772	453,772	453,772	453,772
Livestock	681	681	681	681	681	681	681
Manufacturing	2,674	3,236	3,559	3,851	4,143	4,403	4,742
Mining	1,196	1,442	1,561	1,633	1,704	1,774	1,836
Municipal	88,037	110,286	135,454	163,992	194,819	229,913	266,564
Steam Electric	3,487	10,355	14,151	16,545	19,462	23,018	27,354
Hidalgo Total	646,354	709,030	681,377	640,474	674,581	713,561	754,949
Willacy							
Irrigation	52,729	59,191	60,203	60,623	60,623	60,623	60,623
Livestock	151	151	151	151	151	151	151
Manufacturing	25	25	25	25	25	25	25
Mining	6	6	6	6	6	6	6
Municipal	3,098	3,287	3,483	3,651	3,779	3,890	3,953
Steam Electric	0	0	0	0	0	0	0
Willacy Total	56,009	62,660	63,868	64,456	64,584	64,695	64,758
Rio Grande Valley Total	1,120,339	1,232,471	1,202,502	1,156,267	1,207,577	1,263,970	1,322,734
Rio Grande Valley Specific Water Use Totals							
Irrigation	943,153	1,009,625	933,945	839,539	839,539	839,539	839,539
Livestock	1,935	1,935	1,935	1,935	1,935	1,935	1,935
Manufacturing	6,129	7,417	8,174	8,859	9,540	10,137	10,932
Mining	1,210	1,454	1,573	1,645	1,716	1,786	1,848
Municipal	162,927	200,069	241,201	285,964	333,291	385,078	438,182
Steam Electric	4,985	11,971	15,674	18,325	21,556	25,495	30,298

Source: Texas Water Development Board (2006).

converts irrigated land to municipalities, irrigation demand is expected to decrease by 20% by 2060, while the demand for municipal water will more than double (Table 3) (Texas Water Development Board 2006).

Defining water

There are two principal types of water currently being used to create potable water in the Valley: surface water and groundwater.[5] The amount of surface water used in Texas accounts for about 40% of the total water used, while groundwater accounts for about 60% (Lesikar et al. 2006). In the Valley, it is important to identify and distinguish between the two types of water while recognizing that surface water sources dominate.

Groundwater is defined as the water below the surface of the earth. This water comes from about 32 aquifers across Texas. Surface water is the water found in above ground lakes, streams, rivers, ponds, and bays. This water comes from rainfall and is stored in reservoirs for later use (Lesikar et al. 2006). In the Valley, the Rio Grande (River) is the principal source of water. The Amistad and Falcon reservoirs serve as storage for later use (Lesikar et al. 2006).

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[5] An additional alternative, seawater desalination, exists, but is not considered in this research because it is currently an economically inefficient method relative to brackish groundwater desalination (Busch and Mickols 2004; Younos 2005).

Alternative water treatment methods

Conventional treatment facilities in the Valley use Rio Grande surface water to produce potable water, while the brackish groundwater desalination facilities use groundwater to produce potable water. For a municipality to increase its current supply of potable water, it must either drill a well or obtain additional surface water.

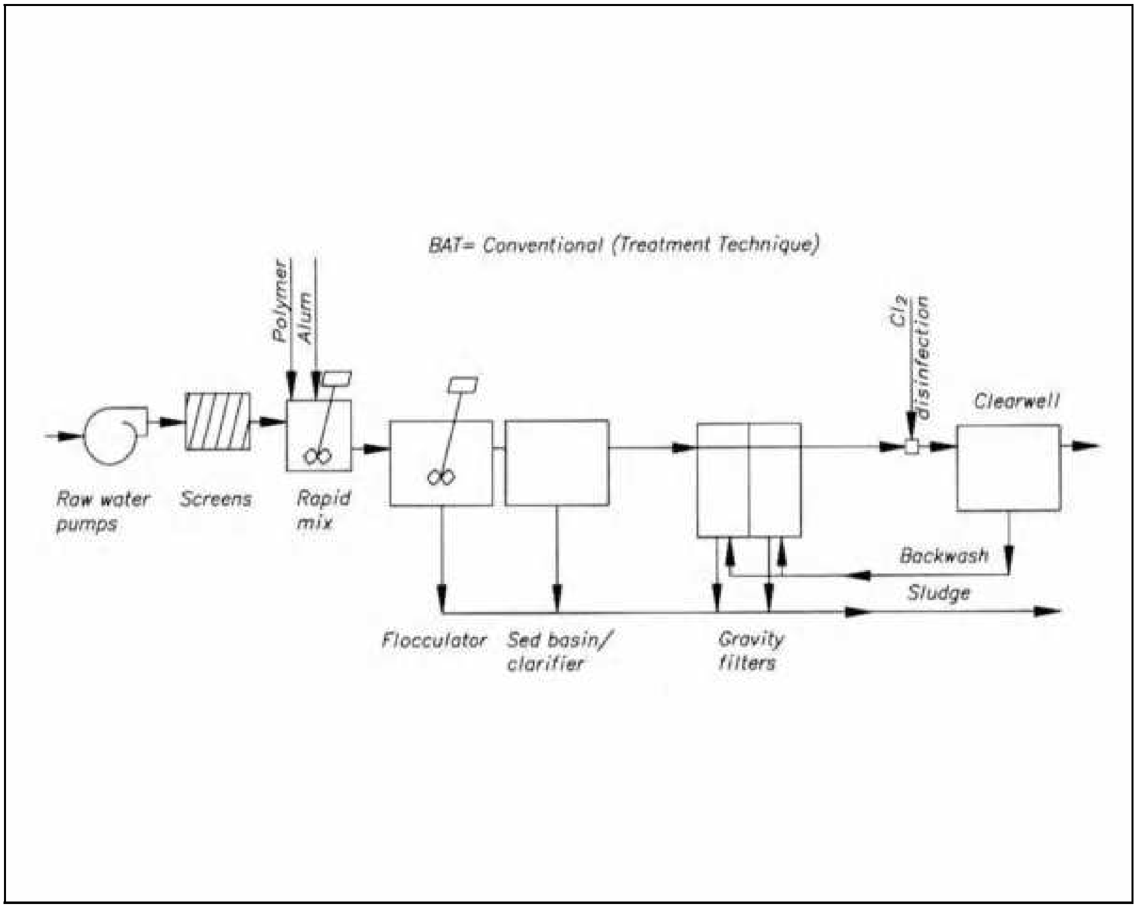
In the Valley, increasing raw source water supplies is often complex and difficult. A municipality can purchase additional municipal rights from irrigation districts or individuals who hold rights to water. With the enactment of Floor Amendment 60 in Texas Senate Bill 3, this process has been affected by an institutional policy, which sets the price for a subset of the market supply of municipal water rights (i.e., those municipal rights converted from irrigation water on or after January 1, 2008 in association with the urban/residential development of agricultural land) at less than the prevailing market price for the municipal water rights supply existing prior to January 1, 2008. Another option municipalities have is to drill a well and obtain groundwater for treatment. Most of the groundwater in the Lower Rio Grande Valley is brackish. The conventional surface water treatment method cannot be used to treat this water. It must instead be treated through a desalination facility (Sturdivant et al. 2008).

Conventional surface water treatment facilities

Approximately 87% of the water used for municipal and industrial sectors in the Valley comes from the Rio Grande (Rogers et al. 2008; Rio Grande Regional Water Planning

Group 2001). The most common practice for producing potable water from the Rio Grande supplies is conventional surface water treatment.

Although each conventional surface-water facility in the Valley is designed differently, each facility utilizes essentially the same process of producing potable water. The water travels several miles from the Rio Grande through a series of surface canals that are operated by one or more irrigation district(s) (ID(s)) or water improvement districts (WID(s)) until it reaches the treatment facility. Irrigation districts are constitutionally obligated by an amendment passed in 1904 (Art. 3, Sect. 52) to provide water services, which include the wholesale and untreated supply of water (Stubbs et al. 2003). At the facility, water is transformed from untreated source water to potable drinking water by removing disease-causing organisms, humus material, grit, and silt, as well as improving the odor, color, and taste of the water. The process includes the use of a series of chemicals, flocculation chambers, sedimentation basins, and filters to remove impurities and disinfect the source water (Rogers et al. 2008). An example of the process used in conventional surface water treatment facilities is illustrated in Figure 2. This schematic overview for a conventional treatment process is similar to that used at the McAllen Northwest Facility in McAllen, Texas (Jurenka et al. 2001 in Rogers et al. 2008).



Source: Jurenka et al. 2001 in Rogers et al. 2008.

Figure 2. Schematic of conventional potable water treatment process

Brackish groundwater desalination

Currently, groundwater accounts for approximately 5.8% of the total municipal water used in the Lower Rio Grande Valley (Sturdivant et al. 2008). A large portion of the total groundwater used is converted to potable water through desalination.

The supply of brackish groundwater is obtained through wells connecting to the Gulf Coast Aquifer (Sturdivant et al. 2008; Boyer et al. 2008). The source water obtained from the aquifer travels through pipelines that extend from the supply wells to the desalination facility. Once at the facility, the water enters a pretreatment process that uses filters to remove solids. The source water then undergoes a reverse osmosis (RO) process to remove the salt. The remainder of the process uses pressure vessels and membranes along with chemicals to further treat and purify the water.[6] An illustration of the desalination process is demonstrated in Figure 3, which is a representation of the Southmost desalination facility near Brownsville, Texas.

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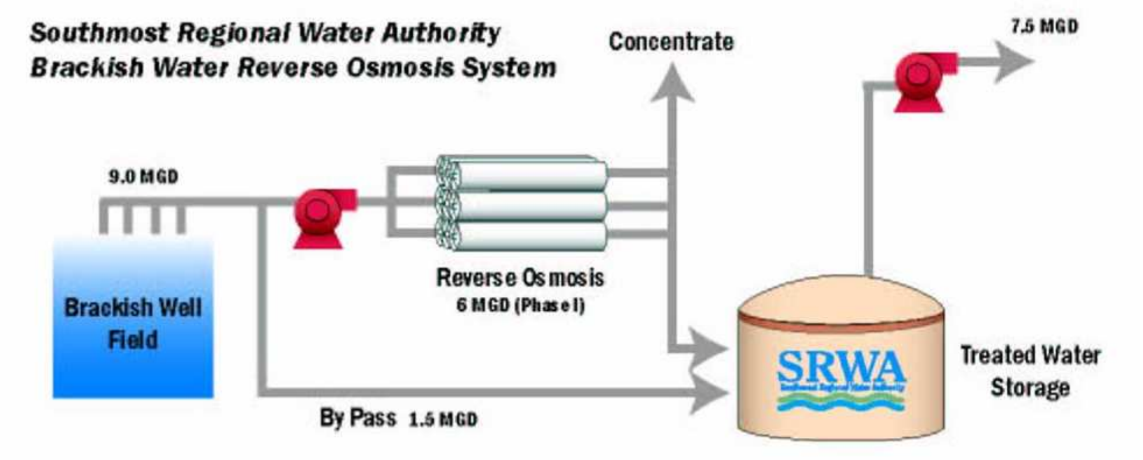
[6] In the desalination process, the majority of water is treated in the RO process and is treated to a level more pure than is required by TCEQ standards. To increase the economic capacity of the plant, a small portion of water that bypasses the RO process, and is subject only to a filtration process, is blended with the treated RO water in the final stage. This creates potable water that is in accordance with TCEQ standards (Boyer et al. 2008).



Source: Southmost Regional Water Authority (2004) in Sturdivant et al. 2008. Approved for use by Norris, 2008.

Figure 3. Southmost desalination facility treatment process, 2007

Chapter summary

The Lower Rio Grande Valley of Texas is an area in which alternative water treatment methods may provide new supplies of potable water and assist in addressing increasing demands. A promising approach is brackish groundwater desalination. The adoption of this technology could be unintentionally affected by recent legislation. The remainder of this undergraduate thesis addresses this issue, by providing a description of the methodology used, a background discourse on relevant economic theory and concepts, discussion of the major stakeholders, review of the evolution of the specific legislation, and an application of economic and financial concepts to identify potential consequences, both intended and unintended, of the legislation.

CHAPTER II

METHODOLOGY

The focus of this research is evaluating unintended consequences of legislation on the Valley water market. This requires an evaluation of secondary effects beyond the obvious benefits and losses to municipalities and IDs. The hypothesis tested in this project (i.e., the null hypothesis) is, "Floor Amendment 60 of Texas Senate Bill 3 does not affect Lower Rio Grande Valley (Valley) municipalities' choices regarding the adoption of technology for producing potable water." The processes for testing this hypothesis are interviews with experts, on-line and library research, legal analysis, financial analyses, and qualitative and quantitative economic analyses. Although no formal statistical tests are employed, the methodology outlined in this chapter in combination with Delphi expert interviews and dialogue with other economists are used as the basis for either failing to reject the null hypothesis or rejecting it and instead, accepting the alternate hypothesis, "Floor Amendment 60 of Texas Senate Bill 3 does affect Lower Rio Grande Valley (Valley) municipalities' choices regarding the adoption of technology for producing potable water."

Interviews

The Delphi process of gathering information through a series of interviews with experts was used to reach a collective conclusion. The Delphi Method implements a structured questionnaire series to collect and analyze knowledge and opinions from a group of experts (Günaydin undated). A modified version of this procedure was used to assimilate information until a solid consensus was reached. The experts that were interviewed include a Valley water lawyer (Jarvis 2007) and an Irrigation District manager (Hinojosa 2007, 2008). The goal of this method was to study the background of the subject policy legislation and understand the process leading up to its passage.

Legal analysis

A close examination of Texas Senate Bill 3 and the Valley Amendment along with the Texas Water Code (1963) helps to determine and interpret the underlying laws. Legal research methods allow for an ethical analysis of statutes, case law, regulations, and policies relevant to the interaction between irrigation districts and municipalities in water markets. A precise examination of the history and establishment of irrigation districts and municipalities and their relationships provides insight for the action taken in the Texas Legislature.

The analytical and methodological approaches used in this study draw from the intersection of three main disciplinary areas – law, economics, and finance. The law, economics, and finance approach allows the researcher to apply the theories and empirical methods of economics to a study of the legal system across the board (Posner 1977). The legal research methods focus on an analysis of the statutes, specifically, the Valley Amendment section of the Texas Senate Bill 3 along with the Texas Water Code (1963). The research also examines the relevant administrative rules, case law, government documents, legal encyclopedias, and other private legal materials. The study explores the interaction between irrigation districts and municipalities in water markets in the Rio Grande Valley. Using the legislative history of Senate Bill 3, the study analyzes the extent of strategic behavior by municipalities and Irrigation Districts in defining contractual options in the water market, and the implications of each option for water-processing technology to augment the potable water supply in the region. Finance tools are used to identify the monetary implications for adoption of alternative water treatment technologies.

Economic analysis

Economic and financial analyses comprise the majority of the research methods used in this undergraduate thesis, establishing the foundation for development of the legal inferences. Development of a conceptual framework for use in investigating the contributing elements of economic theory toward analysis of the aforementioned issue requires integration of several economic theoretical concepts. These concepts are introduced in this section and expanded on in Chapter III in a purely theoretical form, i.e., without application to a specific application. Subsequently, in Chapter V, linkages are established among the theoretical concepts and applied towards developing an understanding of the firm level and aggregate industry Valley potable water supply paradigm. The economic theories and concepts of relevance to this undergraduate thesis include:

- Marginalism
- Utility Curves
- Edgeworth Box
- Game Theory
- Input Substitution
- Firm Cost Curves
- Firm Supply Curves
- Industry Supply Curves
- Individual Demand Curve
- Industry Demand Curve
- Market Equilibrium
- Consumer Surplus
- Producer Surplus

Each of these concepts is discussed in further detail in Chapter III.

Capital budgeting net present value analysis and annuity equivalents

The two water treatment technologies of interest in this study are conventional surface water treatment and brackish groundwater desalination. These technologies are dissimilar in many aspects of equipment and operations. Financial analyses conducted for selected Valley treatment facilities are used to compare the economic implications of these two technologies.

The total cost of providing an acre-foot of potable water by each facility requires careful examination and consideration of the expected life of the facilities, inflation in the overall economy, and the time-value of money. To take all of these factors into consideration, a Net Present Value (NPV) analysis, in conjunction with annuity equivalent calculations, was the method of choice (Rogers et al. 2008). NPV is a type of capital budgeting technique that is often used to determine the economic feasibility of a project. It takes inflation, costs, and returns into account when comparing the value of a dollar today to the value of that same dollar at a future time (Investopedia 2008). Contained within NPV analysis is the use of discount and compound rates. The discount rate is used to find the present value of a dollar at a future time. It contains three components, including a risk premium, an inflation premium, and a risk-free rate for time preference (Rister et al. 2008). The discounting technique was used for dollars and water in this project. Compounding is used to find a nominal value of expected future costs by taking inflation into account (Rogers et al. 2008).

Determining an objective, economic-efficiency based, priority-ranked strategy of alternatives requires a sound and consistent methodology. The goal of such a methodology is to allow for an “apples-to-apples” comparison of alternatives. Each alternative will likely differ in initial and continued costs, quantity and quality of output, useful life, etc. An appropriate approach to determining the most cost-effective alternative is to identify and define each as a capital investment (i.e., project) and apply appropriate financial and economic principles and techniques.

Annuity equivalent analysis provides an extension of NPV calculations by allowing for comparisons across different water treatment facilities (and/or technologies) with different useful lives. As stated in Rogers et al. 2008, an annuity equivalent analysis is conducted by converting the NPV of costs for the useful life of an individual facility "into a per-unit amount which assumes an infinite series of purchasing and operating similar facilities into perpetuity" (Rogers et al. 2008). The annuity equivalent for both units of costs and water are calculated and used to obtain a per unit value ($/ac-ft and $/1,000 gal). Once this value is calculated, a comparison of water treatment facilities and technologies can be conducted.

The appropriate methodology for determining the costs of producing potable water combines standard Capital Budgeting - Net Present Value (NPV) analysis with the calculation of annuity equivalent measures. Refer to Rister et al. (2008) and Rogers et al. (2008) for an expanded version of this methodology discussion. Calculating NPV values for costs and water allows for comparing alternatives with differing cash flows and water production output. The NPV equation for dollars which calculates the total costs in real terms for a given plant is:

$$
\begin{aligned}
EC_{NPV}^{P,Z} = {} & \Sigma_{j=o}^{Y^P} \left\langle \left\{ \left[I_j^{P,Z} * (1+i)^j \right] \right\} \div \left\{ (1+r)^j \right\} \right\rangle \\
& + \Sigma_{t=Y^P+1}^{Y^P+N^P} \left\langle \left\{ \left[(OC_t^{P,Z} + CR_t^{P,Z}) * (1+i)^t \right] \right\} \div \left\{ (1+r)^t \right\} \right\rangle \\
& - \left\langle \left\{ SV^{P,Z} \right\} \div \left\{ (1+r)^Z \right\} \right\rangle .
\end{aligned}
$$

Table 4 is a presentation of definitions for the elements in this and related following financial equations.

Table 4. Definitions for the Elements of Economic and Financial Costs Calculations

Element	Definition
$EC_{NPV}^{P,Z}$	net present value of net economic and financial costs of conventional water treatment plant P over the planning period Z
Z	time (in years) of planning period, consisting of construction period and expected useful life
j	the specific year in the construction period
Y^{P}	length of construction period (years) of conventional water treatment plant P
$I_{j}^{P,Z}$	initial construction cost (which includes the purchase of water rights) occurring during year j of the construction period for conventional water treatment plant P in the planning period Z
i	compounding inflation rate applicable to construction, operation, and maintenance inputs
r	the discount rate (%) used to transform nominal cash flows into a current (i.e., benchmark) dollar standard
N^{P}	length of expected useful life (years following completion of construction period) of conventional water treatment plant P
$OC_{t}^{P,Z}$	operation and maintenance costs during year t of useful life N^P for conventional water treatment plant P over the single economic-planning period Z
$CR_{t}^{P,Z}$	capital replacement costs during year t of useful life N^P for conventional water treatment plant P over the planning period Z
t	the specific year of the expected useful life
G	number of individual facility segments
$SV^{P,Z}$	salvage value for conventional water treatment plant P (including water rights) at the end of year Z
$WP_{NPV}^{P,Z}$	net present value of annual water production of conventional water treatment plant P over the planning period Z
$W_{t}^{P,Z}$	annual water production in year t of conventional water treatment plant P over the planning period Z
$AEEC_{AE}^{P,Z}$	annuity equivalent of economic and financial costs for a series of conventional water treatment plants P, each constructed and operating over a Z planning period, into perpetuity
$AEWP_{AE}^{P,Z}$	annuity equivalent of water production for a series of conventional water treatment plants P, each constructed and operating over a Z time period, into perpetuity
$AAE_{AG}^{P,Z}$	aggregate annuity equivalent of costs per ac-ft for a series of conventional water treatment plants P

Source: Rister et al. (2008) and Rogers et al. (2008) and own modifications.

Similarly, the NPV for water flows (WP) can be calculated:

$$WP_{NPV}^{P,Z} = \sum_{t=Y^P+1}^{Y^P+N^P} \left\langle \left\{ WP_t^{P,Z} \right\} \div \left\{ (1+s) \right\}^t \right\rangle.$$

The use of annuity equivalents facilitates comparisons of projects with different useful lives. An annuity equivalent (or ‘annualized life-cycle cost’) converts the NPV of costs for one plant, over its useful life, into a per-unit amount which assumes an infinite series of purchasing and operating similar plants into perpetuity. The first step in achieving a per unit life-cycle cost is to calculate an annuity equivalent for costs:

$$AEEC_{AE}^{P,Z} = EC_{NPV}^{P,Z} \div \left\langle \left\{ 1-(1+r)^{-Z} \right\} \div \left\{ r \right\} \right\rangle.$$

An annuity equivalent for water production must also be calculated:

$$AEWP_{AE}^{P,Z} = WP_{NPV}^{P,Z} \div \left\langle \left\{ 1-(1+s)^{-Z} \right\} \div \left\{ s \right\} \right\rangle.$$

And finally, a per unit cost annuity equivalent is calculated:

$$AAE_{AG}^{P,Z} = AEEC_{AE}^{P,Z} \div AEWP_{AE}^{P,Z}.$$

The combined approach of NPV-annuity equivalent calculations integrates expected years of useful life with related annual costs and outputs, as well as other financial realities, into a single comparative and comprehensive annual measure (AAE).

Each analysis incorporates an annual discount rate of 6.125% to account for inflation and the time value of money, which consists of an annual inflation rate of 2.043% for continued expenses and a discount factor of 4.00% to account for social-time preference.[7,8] Risk is ignored due to the government-entity aspect of the decision. Refer to Rister et al. (2008) for an explanation of the selection of these rates.

Implementation of financial analyses

To complete a NPV analysis, two Microsoft Excel spreadsheets were created by Texas AgriLife Research and Texas AgriLife Extension Service agricultural economists. The model DESAL ECONOMICS© was developed to analyze the financials of desalination facilities by providing life-cycle costs for functional expense areas and the entire facility. The particular desalination facility for which life-cycle costs were considered in this undergraduate thesis is the Southmost Facility that is located outside of Brownsville, Texas (Rogers et al. 2008). A similar Microsoft Excel spreadsheet analysis was conducted for a conventional surface water treatment facility, the McAllen Northwest Facility, in McAllen, Texas. The spreadsheet used in that analysis is titled CITY H_20 ECONOMICS© and uses a NPV and annuity equivalent analysis approach similar to that of the previously mentioned spreadsheet (Sturdivant et al. 2008).

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[7] The calculation of inflation rates are based on Rister et al. (2008).

[8] As stated on page 27 in Rogers (2008), “To account for the social preference of present-day resource use, a 4.000% discount factor is utilized to convert future water flows into present-day terms. This discount factor is achieved by assuming a social preference rate of 4.000% (s), combined with a 0.000% risk premium (h) …, as well as a 0.000% inflation rate assumed for water (i). For further discussion of this topic, refer to Rister et al. (2008), which includes references to Griffin (2002), and Griffin and Chowdhury (1993).”

Chapter summary

Through the Delphi method of interviewing, quantitative economic and financial analyses, and qualitative economic analyses, an appraisal for investigating the potential inadvertent impacts of Floor Amendment 60 to Senate Bill 3 is established. This methodological approach is directed toward identifying the potential implications for future decisions regarding adoption of brackish groundwater desalination technology in the Valley, along with possible impacts, both intended and unintended, on various stakeholders. The underlying economic theories and concepts to be employed are explained in more detail within Chapter III.

CHAPTER III

ECONOMIC THEORY AND CONCEPTS

Brief explanations of the various economic theories and concepts employed in the research application within this undergraduate thesis are presented in this chapter. The chapter's purpose is to provide adequate background so that the logic used in the analyses and conclusions presented in subsequent chapters are apparent.

Marginalism

Marginalism is a key underpinning of economic theory. It is the concept examining the effects of the changes in economic variables (Truett and Truett 2001). "Change" is the operative word in this explanation, i.e., the response or result of a change in one or more factors associated with the process of interest. The explanation of this concept usually lies within marginal value analysis. Marginal value is the change of a dependent variable caused by a one-unit change in an independent variable (Mansfield et al. 2002).

Utility curves

Utility is defined as the level of satisfaction that a consumer receives from the consumption of a good. It is assumed that consumers will strive to achieve the highest utility over a set of goods consumed (Penson et al. 2002). *Utility curves* can be developed to reflect achievement of a constant value of utility by an individual choosing among two or more goods (Penson et al. 2002). Figure 4 is an illustration of a utility

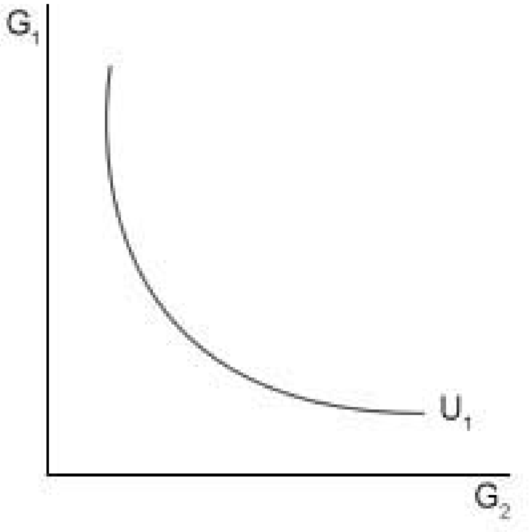

Figure 4. Example of a utility curve representing an equal level of utility for all combinations of two goods (G_1 and G_2)

curve, with equal utility being achieved by a consumer among all combinations of the two goods represented on U_1. The *law of diminishing returns* (Truett and Truett 2001) contributes to a general curvilinear shape of a utility curve. This means that an individual requires, at some point, greater amounts of one good (G_2) to substitute per unit of the other good (G_1) as he/she becomes satiated with the second good (G_2). For example, this is illustrated in Figure 5 as moving along the utility curve from the upper left (i.e., combination a_1a_2) to the lower right (i.e., combination d_1d_2). Higher levels of utility can be achieved by obtaining more of each good simultaneously (Figure 6). That is, an individual would prefer U_2 over U_1.

Edgeworth Box

An *Edgeworth Box* (Perloff 2004) illustrates the choice set existing between two decision makers competing for two economic goods, each seeking to maximize their utility while negotiating with the other. As illustrated in Figure 7, an Edgeworth Box (EB) is a visual representation of the competitive relationship between two economic agents who are competing/negotiating for a fixed amount of two goods in a pure exchange economy. Agent S's perspective is represented from the lower-left corner of the EB, with higher levels of utility achieved in his/her movement towards the upper-right corner of the EB. Agent T's perspective is displayed from the upper-right corner orientation of the EB, with successively-higher levels of utility realized in movements toward the lower-left corner of the EB.

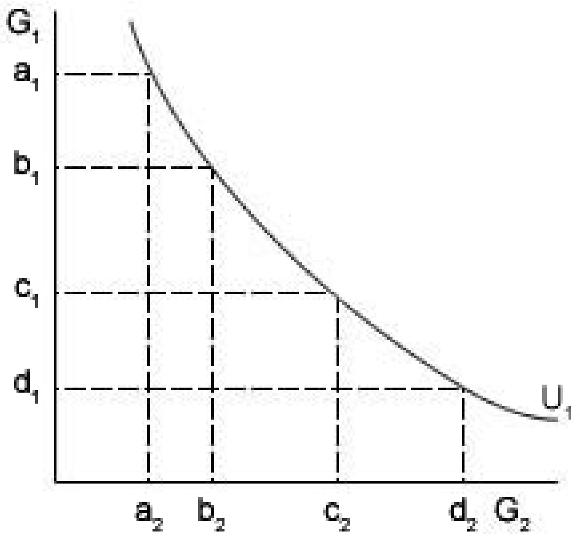

Figure 5. A utility curve example of decreasing rate of substitution between two goods (G_1 and G_2)

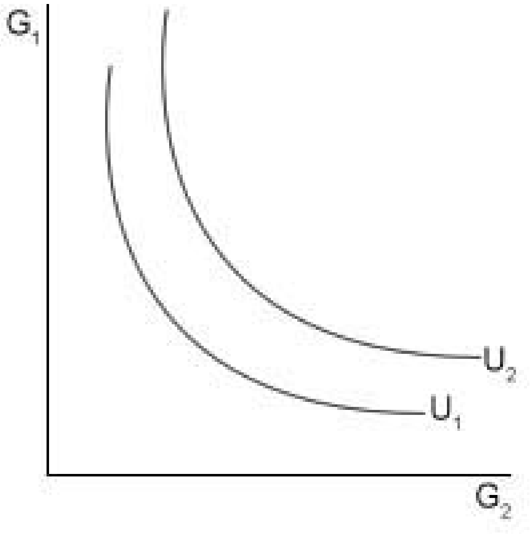

Figure 6. An example of multiple utility curves, with $U_2 > U_1$

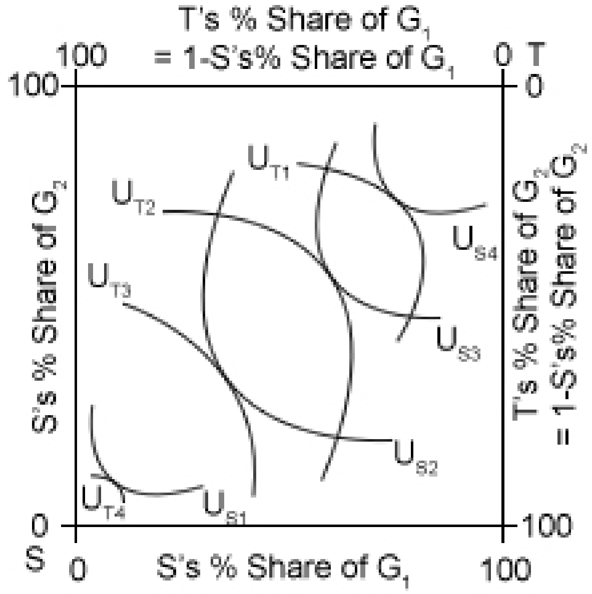

Figure 7. Edgeworth Box paradigm, representing two economic agents (S and T) competing for two goods (G_1 and G_2)

The EB portrays a zero-sum game, with all units of goods G_1 and G_2 shared between the two economic agents, S and T. Because of the law of diminishing returns and the associated nature of the agents' respective utility curves, there may be some opportunities for barter between the two agents, but that is not always the case.

Figure 8 is an advanced version of Figure 7, illustrating the *Contract Curve* (Perloff 2004) for this hypothetical situation. The Contract Curve is defined as the connection of those points within the EB whereby a utility curve for agent S is tangent to a utility curve for agent T. At all points along the Contract Curve, neither agent is able to improve his/her utility position without the utility position of the other agent being adversely affected. Such a *pareto optimal* situation is represented by the X_{on} point in Figure 9. Alternatively, at the point X_{off}, there are opportunities for both agents to reach higher levels of utility as they negotiate with each other and move toward the Contract Curve.

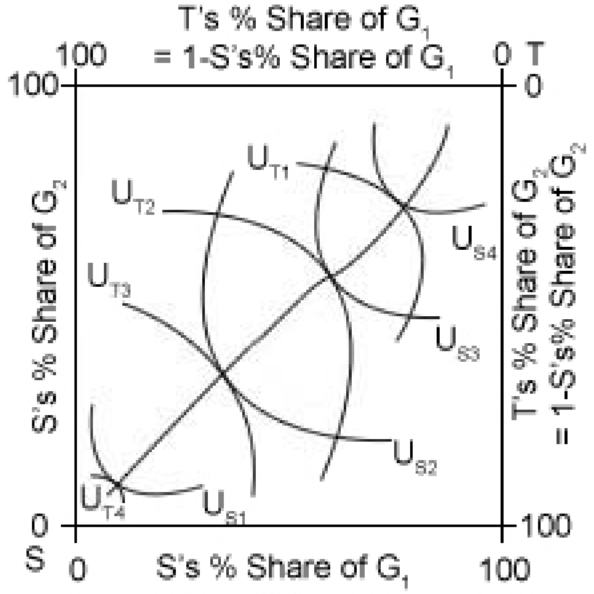

Figure 8. Edgeworth Box with contract curve, representing *pareto optimal* negotiation points between two economic agents (S and T) competing for two goods (G_1 and G_2)

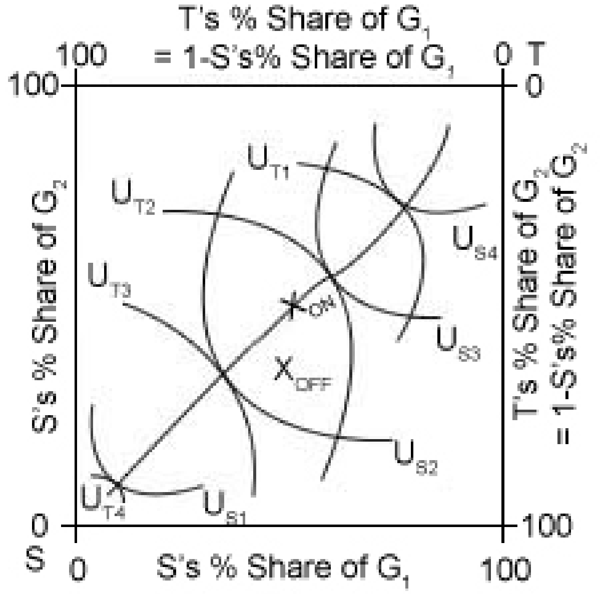

Figure 9. Illustration of negotiation possibilities within Edgeworth Box paradigm for two economic agents (S and T) competing for two goods (G_1 and G_2)

Game theory

Another important aspect of economic theory related to this undergraduate thesis and the parties involved is *game theory*. This theory also allows for inclusion of components of legal and policy examination. Game theory is the study of how individual decision makers evaluate and execute choices when they are fully aware that their actions affect other individuals (Waldman 2004). In markets where there are few numbers of competing firms, any one decision usually affects the actions and profits of all other firms. This type of situation requires strategic behavior to anticipate and react to the decisions of other firms (Thomas and Maurice 2005). The vital component to understanding game theory and economic decision making is illustrated through the classic prisoners' dilemma (adapted from Thomas and Maurice 2005):

> Two individuals simultaneously commit a crime and are arrested and questioned separately, without knowing what the other has said. If both remain silent, they will each only have to serve three years in jail. If one confesses and the other does not, the one who confesses will only serve one year and the other will serve fifteen years. If both confess, they will each have to serve five years. This situation is illustrated in Table 5, a payoff matrix of outcomes for the prisoners.

Table 5. Tabular Representation of the Payoff Matrix for the Classic Prisoners’ Dilemma, a Game Theory Application Example [a]

		Prisoner 2	
		Don’t Confess	Confess
Prisoner 1	**Don’t Confess**	**3 years** 3 years	**15 years** 1 year
	Confess	**1 year** 15 years	**5 years** 5 years

Source: Adapted from Thomas and Maurice 2005.

[a] Prisoner 1's payoffs are represented in boldface type above the dashed line in each cell and prisoner 2's payoffs are indicated in regular face type below the dashed line in each cell.

The idea behind a "game" such as this is that each individual will try to work in the most efficient manner, given a limited amount of information. This is also true of most firms within an economic setting. Generally, cooperation yields the most economically efficient outcome. In the prisoners' dilemma scenario, if both prisoners (i.e., the players) select the same action, they will experience the least amount of jail time (i.e., in total for both prisoners). It is unlikely that this outcome will happen, however, because the natural tendency is for each prisoner to attempt to receive the minimal amount of jail time, or maximize payoffs (Thomas and Maurice 2005).

Input substitution

The economic choice between two inputs or combination thereof to produce a given quantity of one product is characterized as *input substitution* (Perloff 2004). Figure 10 is an illustration of an *isoquant* (Perloff 2004) which represents an equal quantity of output of a good being produced with varying combinations of two inputs, A and B.

As illustrated by the set of isoquants IQ_0, IQ_1, and IQ_2 in Figure 11, one form of input substitution is constant substitution, whereby one input substitutes perfectly for the other; with an equal quantity of output being produced at all combinations of the two inputs.[9] Successively higher levels of output are represented in the isoquants as

---

[9] Other forms of substitution between inputs exist. Perfect complements are inputs that are only used in fixed proportions. Between the two extremes of perfect (i.e., constant) substitutes (e.g., Figure 11) and perfect complements are imperfect substitutes. These types of substitution relationships are illustrated using convex isoquants (e.g., Figures 10 and 12) because of the changing rate of substitution along such isoquants.

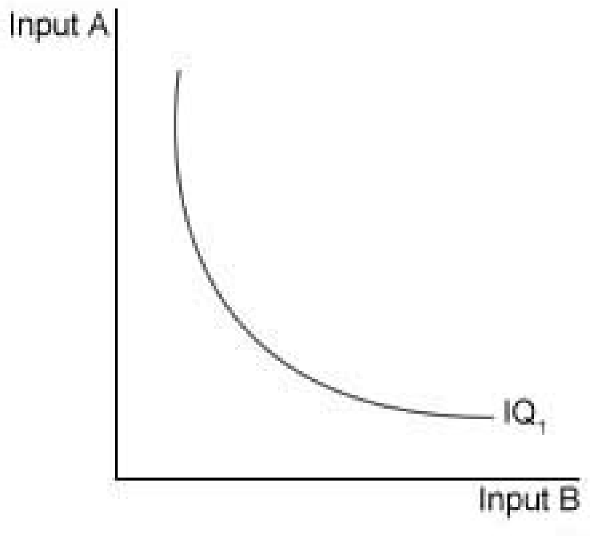

Figure 10. An isoquant representing an equal level of production for a product for alternative combinations of two inputs

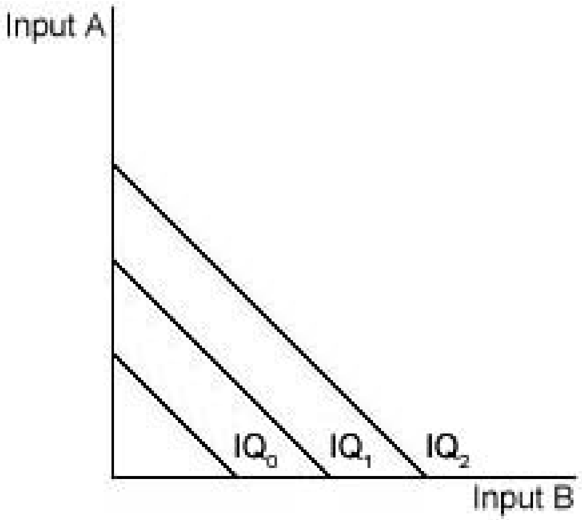

Figure 11. Multiple isoquants representing constant substitution to produce Q output using two inputs (A and B)

movement occurs out from the origin toward the upper-right corner of the illustration, i.e., $IQ_2 > IQ_1 > IQ_0$.

Decreasing substitution and the associated form of isoquant representation are depicted in Figure 12. Similar to the form of utility curves previously presented, isoquants for this form of input substitution are of a convex curvilinear form.

Another aspect of importance in input substitution relates to cost. Figure 13 is an illustration of an *isocost line* (Penson et al. 2002), which illustrates an equal level of cost for all combinations of the two inputs A and B represented on the line.

Higher levels of costs are represented by isocost lines lying further from the origin, i.e., $IC_2 > IC_1 > IC_0$ (Figure 14). Cost minimization of production occurs when production occurs at the origin (i.e., no cost) or on the isocost line as close as possible to the origin which allows for production of the desired quantity of output.

A major issue involves ascertaining which combination of inputs is the most economical (i.e., least expensive) for producing a given quantity of output. This concern can be graphically illustrated through superimposing an isoquant of production of output Q on the series of isocost lines illustrated in Figure 14; refer to Figure 15.

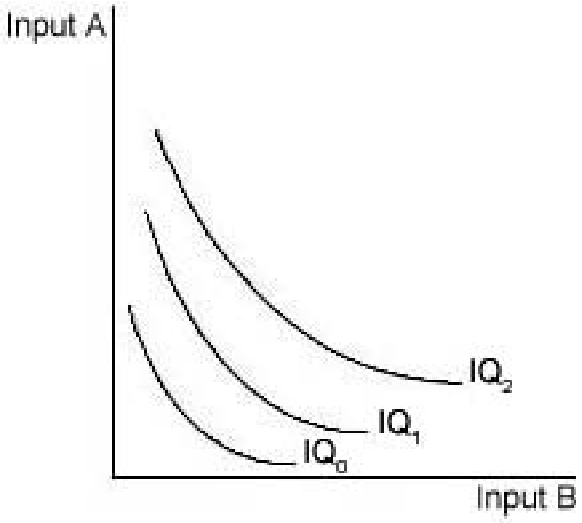

Figure 12. Multiple isoquants representing decreasing substitution to produce Q output using two inputs (A and B)

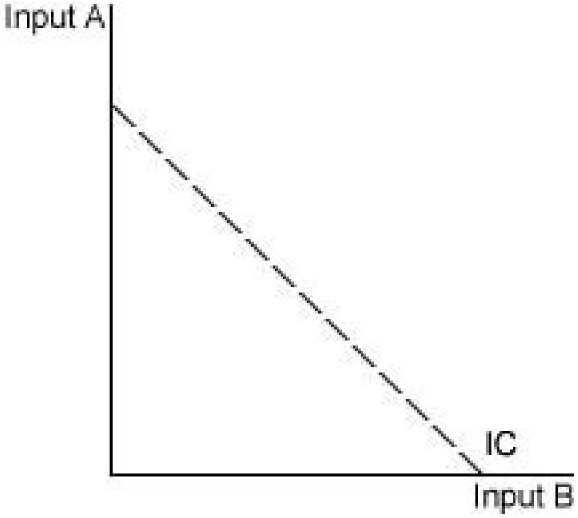

Figure 13. An isocost line representing equal cost of production at all combinations of two inputs (A and B)

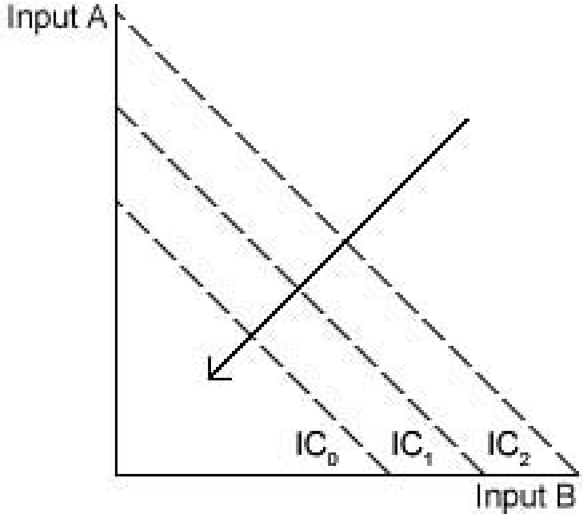

Figure 14. Multiple isocost lines illustrating cost minimization concept, $IC_0 < IC_1 < IC_2$

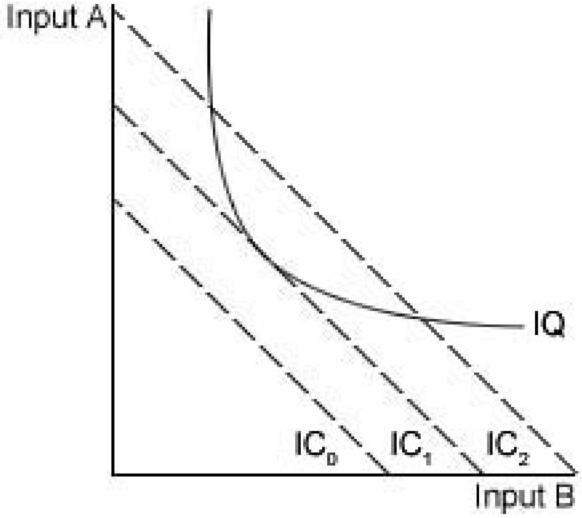

Figure 15. Cost minimization concept illustrated with isoquant and multiple isocost lines

With perfect substitutes such as that represented in the product isoquant illustrated in Figure 11, the least cost combination for a particular firm will usually either be all of one input or the other. In the rare instance in which the slope of the isocost line is equal to the slope of the isoquant, however, decision makers will be indifferent in their choice as all combination of inputs produce the same given quantity of output and will cost the same.

The mathematics identifying the least cost combination of inputs on a given product or output isoquant are relatively simple to derive (Rister 2001b). With Input A on the vertical axis and Input B on the horizontal axis and moving downward from the upper portion of the isocost line, the isocost line is mathematically defined as:

$$TC_{ICi} = P_A A_j + P_B B_j,$$

where

TC_{ICi}: total cost that is the same all along the isocost line i;

P_A: price of input A;

Aj: quantity of input A being replaced;

P_B: price of input B; and

B_j: quantity of input B being added.

That is, total costs for isocost line IC_i are the same for all combinations of inputs A_j and B_j, with P_A and P_B representing the per unit costs of the two inputs, A_j and B_j, respectively. Mathematical adjustments to this equation leads to:

$P_A A_j = TC_{ICi} - P_B B_j$, and

$A_j = TC_{ICi}/P_A - (P_B/P_A)B_j$.

The last equation above reveals that the slope of the isocost line is $-(P_B/P_A)$. Similarly, the slope of the product isoquant IQ_1 is simply the change in amount of input A divided by the change in input B on the isoquant. This is indicated by $\triangle q_A/\triangle q_B$.

The point of equilibrium (i.e., cost minimization for a specified level of output) occurs on the lowest possible isocost line, where the slopes of the isocost and isoquant are equal. Mathematically, this conclusion can be developed using the following steps, referring to movements along the isoquant so long as its slope is less than that of the isocost line. In outline format (Rister 2001b),

How to Produce a Given Product:

- Is it physically possible to substitute and at what rate? Identify the isoquant.

- Calculate the Substitution Ratio:

$$\frac{\text{Change in input replaced } [\triangle q_A]}{\text{Change in input added } [\triangle q_B]}$$

- Calculate the Price Ratio:

$$- \frac{\text{price of input being added } [P_B]}{\text{price of input being replaced } [P_A]}$$

- The Decision Rule
  - Beginning with maximum amount of input being replaced (A), make substitution (add the other input (B) to replace the first input (A)) while maintaining equal level of output so long as:

    substitution ratio $[- \triangle q_A / \triangle q_B] \geq$ price ratio $[- P_B/P_A]$

How Do These Mathematics Result in a Profit-Maximizing (Cost-Minimizing) Rule?

- Rule: Substitute so long as

  substitution ratio ≥ price ratio

- When replaced with ratios:

$$\frac{\text{amount of replaced input (A)}}{\text{amount of added input (B)}} \geq \frac{\text{price of added input (B)}}{\text{price of replaced input (A)}}$$

- Next, cross-multiply:

  Amount of replaced input (A) times price of replaced input (A)

  ≥

  Amount of added input (B) times price of added input (B)

- This translates into:

  Substitute so long as replaced costs (A) ≥ added costs (B)

What Happens When Input Prices Change?

- Assume P_A increases
  - Price ratio of isocost line decreases since P_B / P_A is now a smaller number
  - Isocost lines are now less steep
  - Favors using more B_j and less A_j
  - Same consequences if P_B decreases
- This situation is illustrated in Figure 16.

In Panel A, a declining rate of substitution is represented on the IQ_A isoquant, and IC_1 represents the original isocost budget constraint. Production occurs at input combination *a* where there is a tangency of the slopes of the IQ_A isoquant and IC_1 isocost line. With a price decrease in input B (i.e., P_B decreases), the slope of the isocost line changes as reflected in IC_2 in Panel B of Figure 16, resulting in input combination *b* as the new equilibrium production point on isoquant IQ_A. The difference in the amount of Input B used between production points B_a and B_b is referred to as the *substitution effect* of the change in P_B; more of Input B is used and less of Input A is used, with the same level of production occurring, and achieving this production level at a lower cost ($IC_2 < IC_1$).

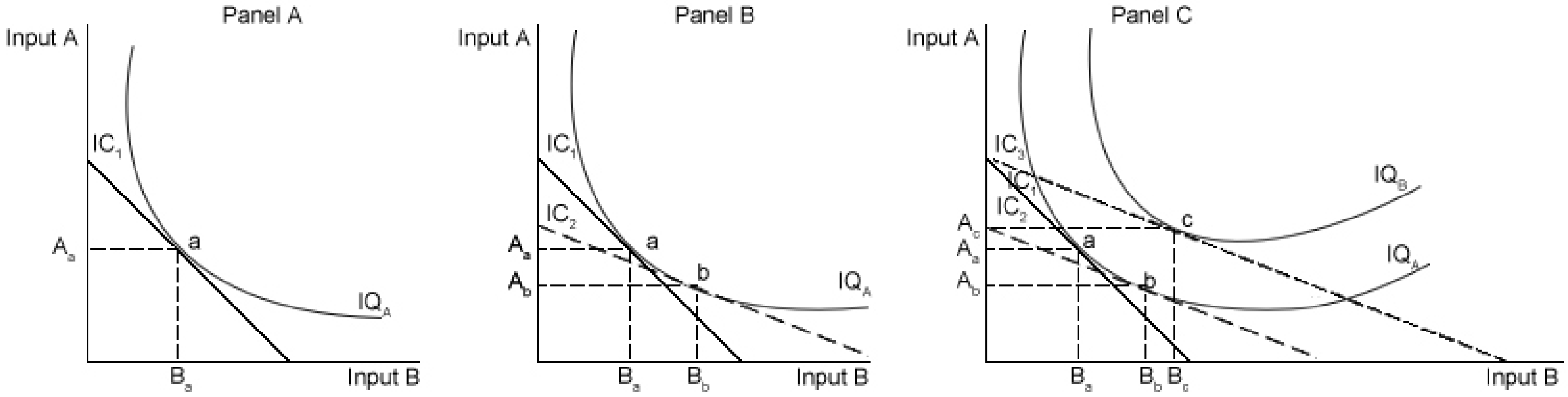

Figure 16. The substitution and income effects.

In panel C of Figure 16, the initial budget constraint associated with isocost line IC_1 is represented in IC_3, with the difference in the slopes of the two isocost lines resulting from the change in P_B. The two isocost lines represent the same amount of budget outlay (i.e., $IC_1 = IC_3$), as reflected by the vertical intercept for the two budget lines, which indicates that the same amount of input A can be purchased on both since the P_A is unchanged. In Panel C, the optimal production point is *c* on IQ_B, which is a higher level of production (i.e., $IQ_B > IQ_A$). This higher level of production is associated with the income (cost) effect of the change in P_B, whereby more inputs can be purchased because of P_B being lower. The difference in the amount of input B used between production points B_b and B_c is referred to as the *income (cost) effect* of the change in P_B. The total effect of the change in P_B is the sum of the substitution and income (cost) effects.

Firm cost curves

Firm cost curves illustrate the rational economic behavior of an individual or individual firm producing various quantities of output (Q) at different price levels (P) for the product produced (Kay et al. 2008; Mansfield et al. 2002). Figure 17 depicts the resulting levels of fixed, variable, and total costs for a firm of a specific size.

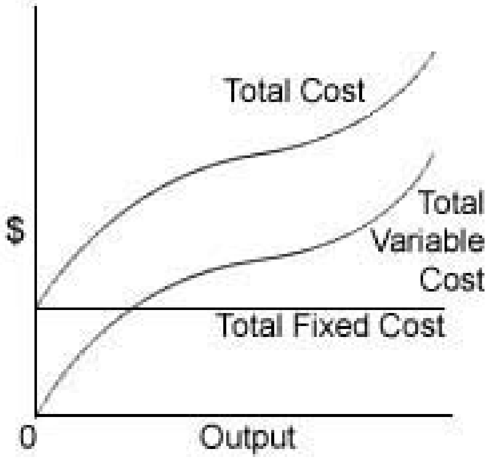

Figure 17. Total cost curves for a single firm or individual

Figure 18 translates the total costs illustrated in Figure 17 into average and marginal cost relationships (Kay et al. 2008; Mansfield et al. 2002). Several economic "rules" are associated with the relationships illustrated in Figure 18 (Kay et al. 2008; Mansfield et al. 2002; Rister 2001a):

a) In the *long run*, all production inputs are variable. To maximize net returns, production will occur at the intersection of marginal revenue (MR) or price P of the product being produced and marginal cost (MC) if and only if the selling price (P) equals or exceeds the average total cost (ATC) of production, as represented by point $P_{LR}Q_{LR}$ in Figure 19. For this output case, MR equals the price of the output.

b) In the *short run*, at least one production input is fixed and production is expected to occur at the intersection of marginal revenue (MR or P) and marginal cost (MC) if and only if the selling price (P) equals or exceeds the average variable cost (AVC) of production, as represented by point P_{SR} Q_{SR} in Figure 19; and

c) The *firm supply curve* is represented by its marginal cost curve (MC) at and above the P_{SR} Q_{SR} point in Figure 19. Over this range of prices and quantities, rational economic behavior suggests production would occur, as illustrated in Figure 20.

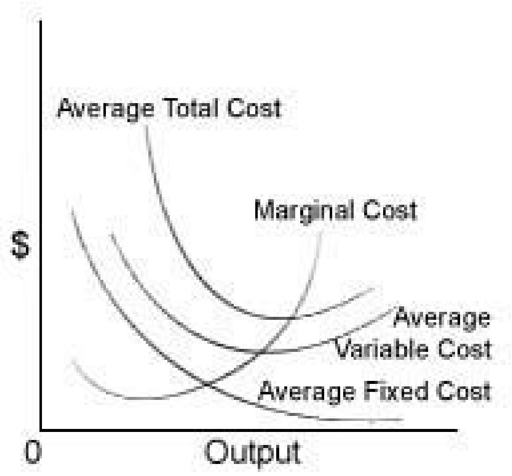

Figure 18. Average and marginal cost curves for a single firm or individual

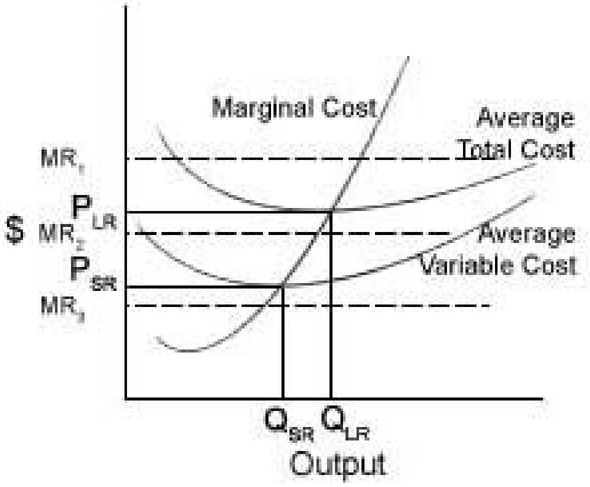

Figure 19. Economic production decision rules for a single firm or individual

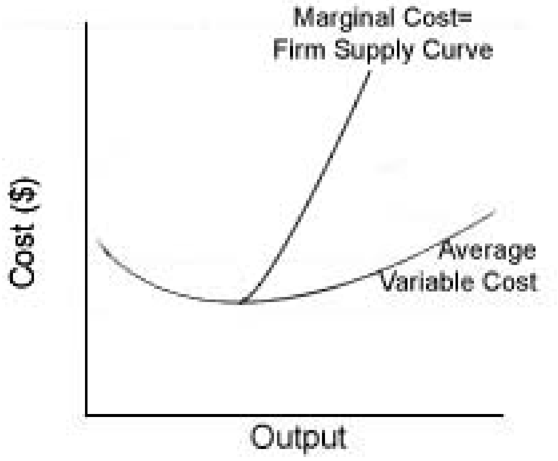

Figure 20. Firm supply curve

Industry supply curve

The summation of supply curves for all of the individual firms comprising an industry constitute the industry's supply curve (Figure 21). The aggregate supply curve represents the respective quantity (Q) of output that will be produced in total by all firms in the industry at any price (Thomas and Maurice 2005). For each respective firm, its own cost relationships and the associated firm supply curve demonstrate the level of production that will occur at each price for the firm.

Individual demand curve

An *individual demand curve* provides an explanation of a consumer's purchasing behavior for one good over a range of prices. It is the amount of a good that a consumer is both willing and able to purchase at every possible price (Economist.com 2008). The basic rule of rational consumer behavior is that the lower the price, the more an individual will purchase (Figure 22). Or, alternatively, the higher the price, the less an individual will purchase (Perloff 2004). For example, at P_a, consumers will purchase quantity Q_a, but for the lower price of P_b, they increase their purchases to Q_b.

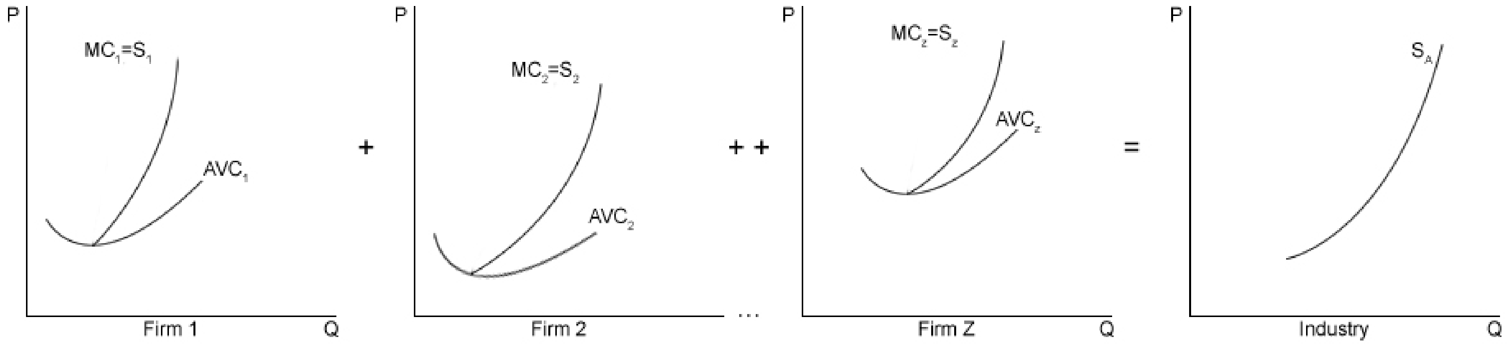

Figure 21. Industry supply curve

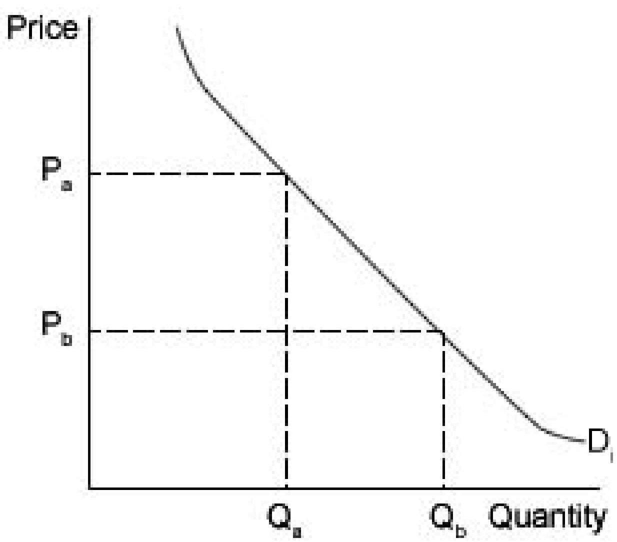

Figure 22. One individual's demand curve for a specific product

Industry demand curve

The summation of *individuals' demand curves* for a particular product constitutes the *industry demand curve* for that product (Truett and Truett 2001). This phenomenon is similar to the development of the industry supply curve resulting from summing the individual firms' supply curves. Figure 23 is a simplified graphical illustration of the aggregation of individuals' demand curves for a specific product into a total industry demand for that product.

Market equilibrium

The aforegoing discussions of supply and demand relate to the full range of possibilities for prices and quantities of a specific product. On any given day, in a specific location, generally only one effective price exists, with a resulting industry quantity of production and the individuals firms' corresponding levels of production at that price. The genesis of this industry-level price and quantity is referred to as *market equilibrium.* Such a market condition is illustrated in Figure 24, in which an industry's aggregate demand and aggregate supply curves are superimposed on each other in the same two-dimensional space. The equilibrium point P_EQ_E identifies the market price at which the quantity of production supplied in full by all firms in the industry exactly satisfies the aggregate demand for that product by all consumers.

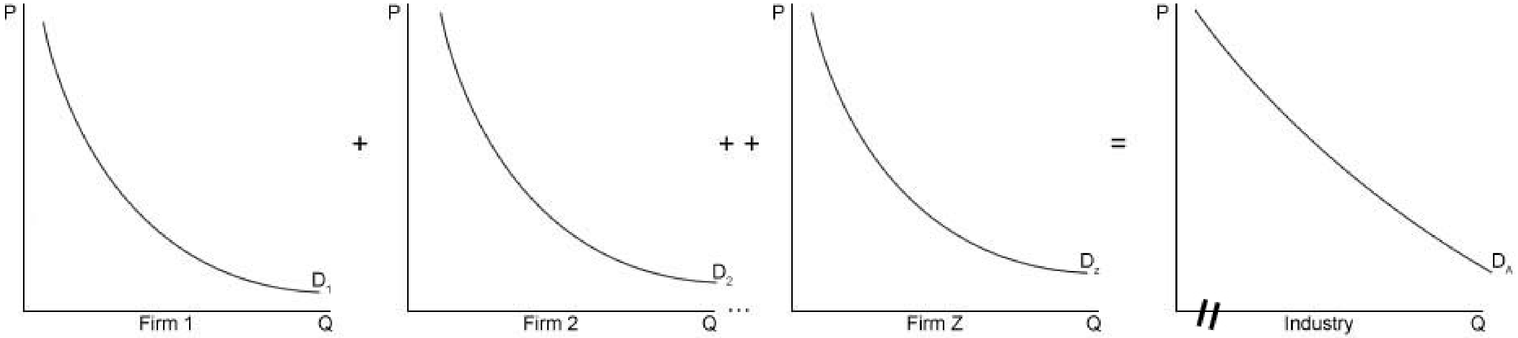

Figure 23. Industry demand curve

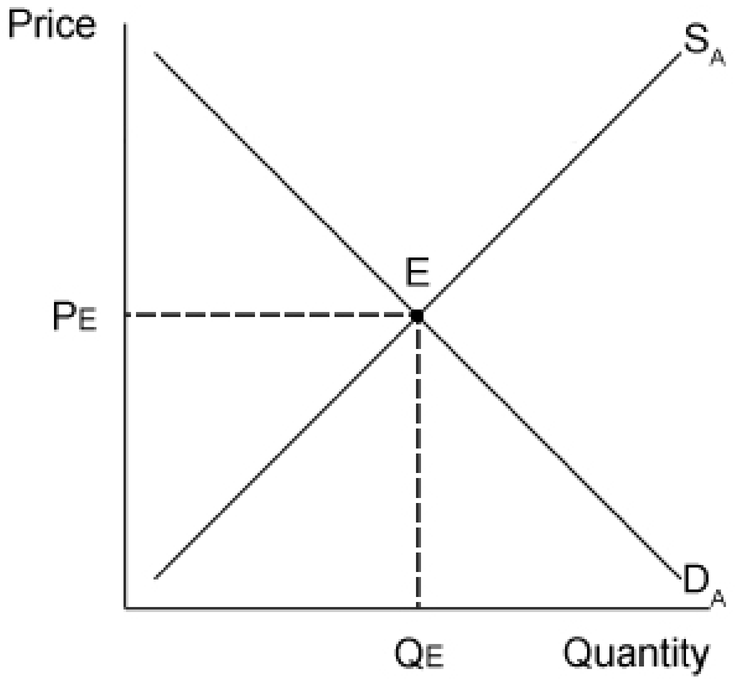

Figure 24. Market equilibrium for industry demand and supply

At a higher market price, such as P_H, more would be supplied than demanded (Figure 25). This results in a surplus of product. Alternatively, at a lower market price, P_L, more would be demanded than supplied, leaving a shortage (Figure 26).

Producer surplus and consumer surplus

Consumer surplus and *producer surplus* are two important concepts of relevance when interpreting the consequences of changes in factors that affect costs of production, the focus of this thesis. Consumer surplus refers to the difference between the value that consumers place on a good for a specific quantity, or the highest amount they are willing to pay for that good, and the actual amount paid at that quantity (Truett and Truett 2001). This concept is illustrated in Figure 27. Note that at low levels of production (S_A), consumers are willing to pay a high price, shown as the demand D_A, but actually only pay the market price or equilibrium price (P_E). This means the area of $P_F E_1 P_{E1}$ is consumer surplus.

Producer surplus refers to the difference between the price received by a producer for a specific quantity of a good and the actual cost per unit to produce that quantity of the good (Mansfield et al. 2002). This concept is also illustrated in Figure 27. At low levels of production, cost per unit is low (S_A) compared to the market price and that difference is the producer surplus. The area between the price level and supply curve (i.e., $P_D P_{E1} E_1$) is total producer surplus.

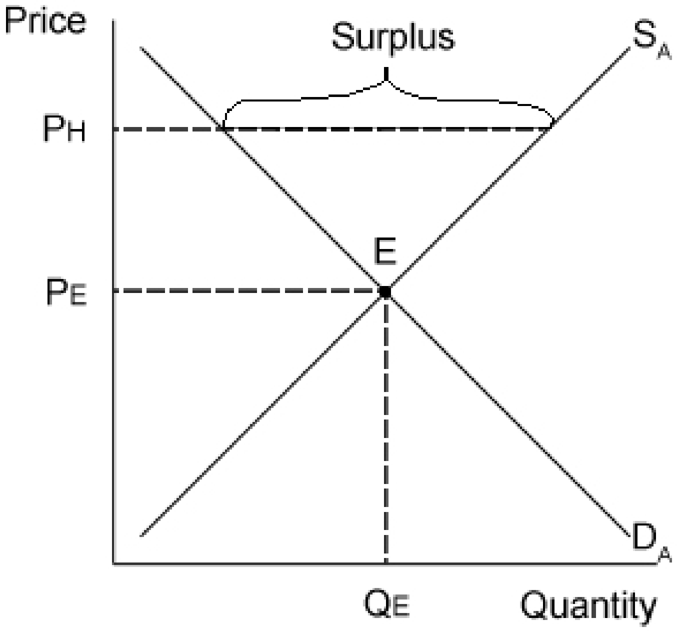

Figure 25. Excess supply for industry demand and supply

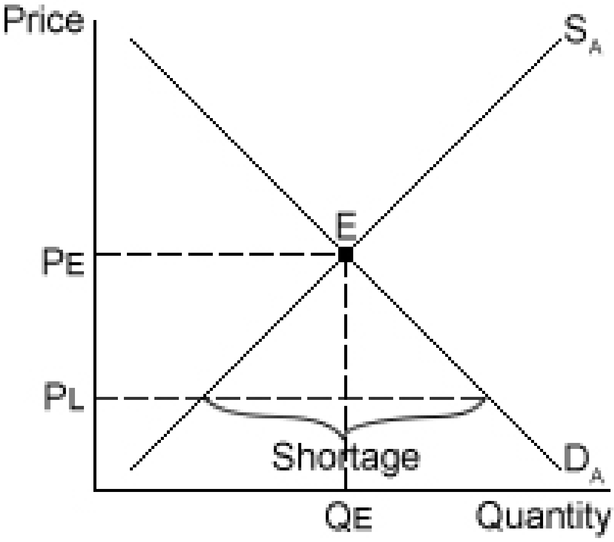

Figure 26. Excess demand for industry demand and supply

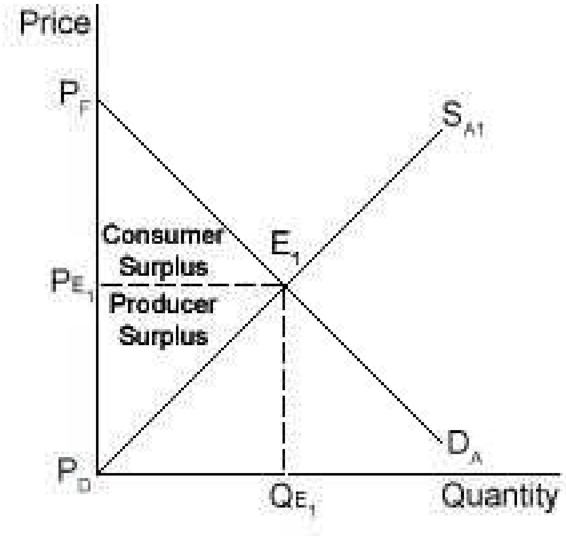

Figure 27. Illustration of consumer and producer surplus at market equilibrium for industry demand and supply

The concepts of consumer surplus and producer surplus are important in measuring and interpreting the effects of forces/phenomena which contribute to the shifting of either the aggregate demand and/or supply curve(s). For example, in Figure 28, in which the supply curve is shifted to the right (e.g., to S_{A2} where either more is produced for the same price or the same amount is produced at a lower cost), the resulting consumer surplus (i.e., changed from $P_{E1}P_FE_1$ to $P_{E2}P_FE_2$) and producer surplus (i.e., changed from $P_DP_{E1}E_1$ to $P_DP_{E2}E_2$) are altered in size, suggesting the effects of new market equilibriums on consumers and producers may vary depending on the sources and magnitude of the factors that impact costs of production. Such forces/phenomena may include economic-based changes in production inputs, advances in production technology(ies), changes in consumer wants, etc.

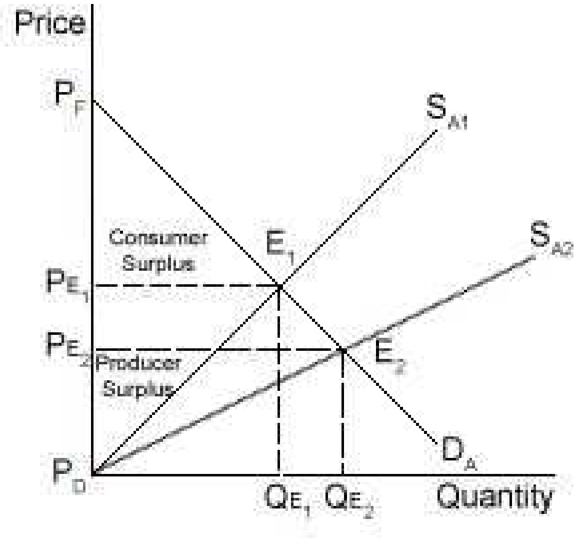

Figure 28. Illustration of change in consumer surplus and producer surplus resulting from a shift in industry supply

Chapter summary

The economic concepts and theories presented in this chapter are relevant to the analysis of the impacts of Floor Amendment 60 to Senate Bill 3 on the Valley water market and the stakeholders of interest. A solid understanding of these economic concepts and theories is valuable for comprehension of the paradigm used in the economic analysis portion of this undergraduate thesis, i.e., Chapter VI.

CHAPTER IV

THE PLAYERS: IRRIGATION DISTRICTS AND MUNICIPALITIES

As provided by specific wording in Floor Amendment 60 to Senate Bill 3, the two parties immediately affected by the implementation of this legislation are Texas Lower Rio Grande Valley (Valley) Irrigation Districts (IDs) and municipalities. To better understand the potential impacts (intended and inadvertent) of this legislation, the basic structures of these two parties, as well as their developmental background and relationship with one another, are described. The purpose of this chapter is to expand on these ideas and to illustrate the organization of the two key players studied within this undergraduate thesis.

History of Valley Irrigation Districts

Water districts in the Lower Rio Grande Valley were developed in 1904 by Article III, Section 52 of the Texas Constitution, which permitted public development of surface water resources. This amendment created many different types of districts that each provides its own varying set of services. The districts in Texas that provide irrigation services are the Irrigation Districts, Water Control and Improvement Districts (WCIDs), and Water Improvement Districts (WIDs) (Stubbs et al. 2003). Presently, 29 different IDs and WIDs (referred to hereafter as IDs) exist in the Valley. Although each ID must follow the same set of rules, each is unique and operates depending on topography, how and where water is diverted, past financial decisions, infrastructure, etc. (Stubbs et al. 2004).

The current set of institution rules and operating procedures for Valley IDs are a function of past actions beginning in the early 1900s. Valley irrigation and canal companies were formed by land developers. They sold land that was ready to be farmed with irrigation. With the establishment of irrigation networks, agriculture, and other economic development, the area quickly grew and the region became known as “The Magic Valley” (Strambaugh and Strambaugh 1954 in Stubbs et al. 2004). Once most of the land was sold, irrigation and canal companies were no longer motivated to continue providing irrigation services. Farmers needed the irrigation networks, however, so they began to purchase the irrigation and canal companies, acquiring ownership of their water rights in the process. From this process, IDs, WIDs, and WCIDs were formed (Strambaugh and Strambaugh 1954 in Stubbs et al. 2003).

After World War II, all irrigation and canal companies were sold to IDs, WIDs, and WCIDs. Many of these companies were forced to sell due to bankruptcy during the Stock Market Crash of 1929 and the Great Depression of the 1930s. Therefore, farmers were able to purchase the companies at relatively low prices and form Irrigation Districts (IDs). These purchases transferred all water rights to the districts, including riparian, Board of Water Engineers certified, old Spanish rights, and certified filings (Smith G. 1977 in Stubbs et al. 2003).

IDs could only provide limited services under the 1904 amendment, which included flood control, irrigation, drainage, and wholesale and untreated water supply. The first IDs were authorized by the Texas legislature in 1905 and could include cities and towns and one or more counties. A five-person elected board was required to oversee the ID. This law was replaced in 1913 with the Irrigation Act (Texas Commission on Environment Quality 2000 in Stubbs et al. 2003). Under this act, a district could be established by a two-thirds vote of qualified tax-paying voters upon completion of a preliminary examination by the commissioners' court. The governing body of the IDs consisted of three to five members who held the power to hire employees, implement proper irrigation management strategies, and exercise the right of eminent domain (Jasinski 2001 in Stubbs et al. 2003).

Under the conservation amendment of 1917, WIDs were authorized by the Texas legislature and replaced the IDs that were authorized by the 1905 and 1913 amendments. Upon the approval of the State Board of Water Engineers, a majority vote of qualified tax-paying voters would establish the district. The governing body of the WIDs consisted of a biennially-elected board of five directors. The WIDs could provide water for commercial and domestic use, contract for and distribute water supply, construct irrigation works, and buy previously existing improvements. They could also issue bonds without limit on an ad valorem[10] or specific benefit basis after a simple majority vote of the qualified tax-paying voters. WIDs did not include cities or towns unless they

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[10] "Ad valorem" translates from Latin as "based on value". It is used as a property tax method that is based on a percentage of the value of a property as determined by the county (Stubbs et al. 2003).

were specifically approved by the State Board of Water Engineers (Smith D. 2001b in Stubbs et al. 2003).

In 1925 and 1927, many WIDs were replaced with WCIDs, which were empowered with broader authority. WCIDs could tax the public by combining *ad valorem* and specific benefit bases, instead of separate use. Previously, these two types of taxing methods were not used together. Master districts were established by the State Board of Water Engineers in 1929 through authorization from the legislature. These Master districts were created to coordinate the districts' activities and included two or more WCIDs that controlled the water of a particular stream. WCIDs have separate taxing powers from the individual districts. Master water districts can become municipal districts if they encompass at least 30,000 people and have a real estate value of $50 million (Smith D. 2001a in Stubbs et al. 2003).

Rio Grande Watermaster

Texas Water Code (1963) 11.325 and 11.326 established the position of Watermaster in the 1950s. This code allowed the Texas Commission on Environmental Quality (TCEQ) to divide the state into water divisions to protect and administer water rights. The executive director of TCEQ has the power to appoint a Watermaster for each water division (Texas Water Code (1963) 11.326 and 11.327). Under Chapters 303-304 of the TCEQ rules, the duties of the Watermaster include monitoring, recording, and regulating the flow levels, patterns, and rates of diverted water use within his/her specified area.

The Rio Grande Watermaster controls, protects, and enforces water rights of the Rio Grande below Fort Quitman. Prior to diverting water, a diverter of the Rio Grande is required to notify the Watermaster's office in writing. Diverters must install proper measuring devices or must keep accurate records of water diverted that are available for review by the Watermaster. This aspect of the Watermaster's responsibilities involves ensuring that only an allotted amount of water is being diverted and that the diverters are the legal holders of the water rights (Texas Commission on Environmental Quality 2004 in Stubbs et al. 2004).

In 1997, an amendment to the Texas Water Code (1963) under sections 11.326 and 11.327 created the Rio Grande Watermaster Advisory Committee (RGWAC). The duty of this committee is to provide administration guidance and oversight to the Rio Grande Watermaster. It is the duty of the TCEQ executive director to appoint the Watermaster Advisory Committee. The RGWAC consists of nine to fifteen members who serve two-year voluntary terms. The executive director appoints members who hold water rights or represent those who hold water rights based on the amount of water rights held, water-use type, experience and knowledge in water management, and geographic representation. The duties of the RGWAC include providing recommendations to the executive director of TCEQ and the Watermaster, reviewing the annual budget, and conducting other activities requested by the executive director (Texas Water Code (1963) 11.326 and 11.327 and Texas Commission on Environmental Quality 2004 in Stubbs et al. 2004).

International Boundary and Water Commission

In 1848, the first International Boundary Commission (IBC) was created for the U.S.-Mexico border to survey the California-Baja California Border. The second IBC was created in 1853 to survey the New Mexico-Chihuahua border, and the third in 1882 to survey and study the U.S.-Mexico Border. The IBC was permanently established in 1889 between the U.S. and Mexico to fulfill the duties of the 1884 Convention. The IBC responsibilities were to conduct water investigations for the Colorado River and Rio Grande and resolve boundary disputes (U.S. General Accounting Office 1998 in Stubbs et al. 2004).

The 1944 Treaty changed the IBC to the International Boundary and Water Commission (IBWC). This treaty established additional duties and distributed the international segments of the Rio Grande from Fort Quitman, Texas to the Gulf of Mexico. In addition, the IBWC was authorized to construct and sustain two international dams on the Rio Grande to aid in flood control. These dams are the Falcon and Amistad, which were completed in 1953 and 1969, respectively (International Boundary and Water Commission 1999 and Stubbs et al. 2004).

The IDs in the Lower Rio Grande Valley rely heavily on the IBWC in daily operations involving water diversion. Because the IDs receive their water from the Rio Grande, an international river, they must abide by the rules set forth by the 1944 Water Treaty. For IDs to receive water diversions, the Rio Grande Watermaster, with whom they file a request, must contact the IBWC to request a release of water from the reservoirs (Stubbs et al. 2004).

Irrigation Districts’ organization

As authorized by Congress in 1905, IDs are overseen by a five-member Board of Directors. They are unpaid elected officials who vote on improvement projects and preside over district operations. In addition, IDs usually employ additional individuals to help with day-to-day operations. A general manager is hired by the board of directors to supervise ID operations in the office and in the field. Office staff members generally include a Tax Assessor Collector and a Graphic Information Systems (GIS) and Information Specialist. The field staff is managed by the Head Canal Rider who supervises the facility operations. Other field staff members may include a pumping facility operator, an excavator operator, additional support staff, and maintenance crews (Stubbs et al. 2004).

Water rights

The state of Texas is governed by two separate laws, depending on the type of water. Groundwater is governed by the “Rule of Capture.” A landowner has the right to the groundwater below the surface of his/her property. Although the landowners do not technically own the groundwater, they are allowed to pump and capture available water, regardless of the effect on surrounding landowners (Lesikar et al. 2006). Once at the surface, then the water is the property of the pumper (e.g., landowner).

Surface water in Texas is governed by the state of Texas and can only be used with permission from the State (Lesikar et al. 2006). Additionally, two separate surface water accounts exist in Texas. One account is for the Lower and Middle Rio Grande below Amistad Dam, and the other account is for the rest of Texas. The 1969 Valley Water Suit established the governing water rights system for the area below Falcon Dam. This lawsuit separated irrigation water rights from Domestic, Municipal, and Industrial (DMI) water rights. Within the category of irrigation water rights, two separate categories were created: Class A and Class B. Class A irrigation water rights were allocated to farmers and districts that could provide documentation of prior rights. Such documentation could consist of Spanish/Mexican land grant, riparian, and prior appropriation rights. Class B irrigation water rights were allocated to persons with proven historical water diversion from the Rio Grande (Stubbs et al. 2004). The priority of allocation of rights begins with DMI holding the highest priority, followed by Class A irrigation, and ending with Class B irrigation. The resulting water rights allotment for each farmer or irrigation district was based on historical-cropped acreages and associated typical levels of water applications (Stubbs et al. 2003).

Water allocation

Every ID in the Lower Rio Grande Valley is entitled to a specified amount of water rights, based on historical ownership, appropriations, and purchases/sales. The existing 29 IDs in the Lower Rio Grande Valley currently hold 1,401,572 ac-ft of irrigation water rights. Based on historical cropped acreage, 641,221 acres of agricultural land were assigned Class A irrigations rights, while 101,588 acres were assigned Class B rights (Stubbs et al. 2003). Proper records of the total amount of water in the Amistad and Falcon reservoirs, as well as the total amount water right holders are entitled to receive, are maintained by the Watermaster. The Watermaster follows a set of steps to allocate water each month (Stubbs et al. 2004):

Step 1: Dead storage, which is the amount that cannot be removed from behind the dams because of hydrologic restrictions, is deducted from the total storage of the reservoirs.

Step 2: The reserved DMI rights are then deducted. This reserve is re-calculated and reset at the end of each month.

Step 3: The designated operating reserve is then deducted from the remaining balance.

Step 4: Irrigation rights are allocated between Class A and Class B rights, with A holding the highest priority between the two.

To account for proper allocation amounts, the ID General Manager must place a request for a specific amount of water with the Watermaster for water to be released from the Amistad or Falcon reservoir. The time of advanced notice depends on the required travel time of the diverted water. The General Manager must only request the amount of water to which a holder has rights, which is determined by their annual authorized amount. The operating reserve, which is calculated in Step 3 of the allocation process, covers any loss of water that is incurred during transportation (Stubbs et al. 2004).

Specific allocation accounts

The manner in which each ID handles specific allocation accounts depends on the type of account and varies between districts. There are irrigation water accounts, municipal water accounts, lawn-water accounts, and out-of-district water sales. Of particular concern in this research study are the irrigation and municipal accounts.

Irrigation water accounts

Irrigation water allocations are determined on January 1 of each planning year. Water allocations are determined by the estimated acres a farmer intends to plant for the upcoming crop year. This number is established based on the acres planted in the previous year and any anticipated changes which must be reported to the Watermaster. Each irrigator is entitled to one acre-foot of water for each acre planted. If the total amount of planted acres is less than the predicted acreage, the ID will recalculate the allocated amount of water (Stubbs et al. 2004).

If any water is left in the irrigation account after the first round of irrigation allocations, the ID Board of Directors typically authorize additional irrigation allocations. Generally, the Board will allow an additional eight (8) to 12 inches for every account. To provide a safeguard throughout the year, the ID will maintain one year’s worth of irrigation water in the account (Stubbs et al. 2004).

Municipal water accounts

The major municipalities within the Valley are Brownsville, Harlingen, and McAllen. IDs are constitutionally responsible for providing (i.e., delivering) municipalities water. The municipalities are allocated water based on their pre-existing water rights and contracts with IDs. It is important to note that municipalities pay IDs for the cost of delivery of the water, not to purchase the actual water (Stubbs et al. 2004).

To account for the rapidly-growing municipal populations, irrigation water rights can be purchased and converted to municipal water rights. The required conversion ratio is 2-to-1, meaning two ac-ft of irrigation rights must be converted to realize one ac-ft of municipal rights. This is to reduce overappropriation of water rights that were originally established in the *State of Texas v. Hidalgo County Water Control & Improvement District No. 18* case (Stubbs et al. 2004). Overappropriation is explained through having adjudication of water rights during an above normal (i.e., above average) wet period of time for the Rio Grande. Therefore, to bring water rights more in balance with the expected flow over time, the 2-to-1 conversion factor was imposed.

Current issues between Irrigation Districts and municipalities

As mentioned above, municipalities pay IDs for the cost of delivery of water, rather than the actual water. In the early and mid-2005, Valley ID managers considered the delivery rate being charged as too low because they were only covering operational costs. This rate structure resulted in the costs of capital replacement and rehabilitation being ignored, thereby contributing to a gradual deterioration of the IDs infrastructures. Conversely, municipal managers believed they were paying too much to acquire water. The overall problem was the difference in value each party placed on the water (Hinojosa 2007).

Chapter summary

The background and structure of Valley IDs and municipalities are established in this chapter. This information is integral to understanding the legislative process and actions discussed in Chapter V, specifically Floor Amendment 60 to Senate Bill 3. The background elements of the amendment are discussed in Chapter V, with attention to how the legislation applies to IDs and municipalities.

CHAPTER V

THE EVOLUTION OF SENATE BILL 3 FLOOR AMENDMENT 60

Texas Senate Bill 3 was passed in 2007 during the 80th session of the Texas Legislature. Contained within this bill, which became effective September 1, 2007, is an amendment that impacted the cost of some water rights[11] between IDs and municipal water suppliers (municipalities) in the Lower Rio Grande Valley of Texas as of January 1, 2008. Floor Amendment 60 represented the accumulation of several months of interactions and negotiations between municipalities and IDs. The amendment is a set of compromises between the parties and involved a complex route through the legislature before being passed. The genesis for this undergraduate research project lies within this amendment to Texas Senate Bill 3. Due to the complexity and desire of all parties to develop a working relationship that would endure over time, the background and bill path are important for understanding the current status (Texas Legislature Online 2007b).

The purpose of Texas Senate Bill 3

Texas Senate Bill 3 has been referred to as the “Water Bill” because of its specialization in water policy. The goal of the bill is to provide water policy guidelines through three specific objectives: (1) increase water conservation, (2) protect instream flows, and (3) meet future water needs by implementing water projects recommended in the State Water Plan (Averitt 2007).

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[11] Addressed within this thesis are those municipal water rights converted from irrigation rights on or after January 1, 2008 as a result of the urban/residential development of agricultural land.

Valley water issues

Valley municipalities typically pay IDs for the cost of water delivery, rather than actually purchasing the water from the IDs. In early to mid-2005, Valley ID managers considered that the municipal delivery rates charged by some individual districts as being too low. The rates were only covering operational costs, with the cost of capital replacement and rehabilitation largely ignored. Extended over time, such a pricing position for the IDs water delivery services was contributing to a gradual deterioration of the IDs water delivery infrastructure system. Conversely, municipal managers believed they were paying too much for water delivery because the ID infrastructure was already in place. Some municipalities argued they were the largest customer of the ID and should therefore have some control over pricing policies/rates. The overall problem was the difference in the perspective of each party regarding the provision of water (Hinojosa 2007), without consensus agreement as to the underlying value of the associated water rights.

The intent of this undergraduate thesis was to focus on only those situations where a municipality was/is purchasing water rights from an ID, with such rights originating in association with the development of irrigated agricultural land into urban/residential property. There are situations in which an ID retains the water rights (i.e., it is not sold to a city) for irrigation water that is converted to municipal water. In such cases, some municipalities contract for the water on a yearly basis rather than purchase the rights. In other cases involving selected IDs and municipalities, water ownership is retained by the

ID, but the municipality receives the water at only the cost of delivery. These non-purchase agreements between selected IDs and municipalities are not addressed in this thesis.

A task force was created in 2005 to address select Valley water issues of concern to both IDs and municipalities. The Water Rights Task Force was an eight-member committee consisting of ID managers and representatives of the municipalities; the individual committee members are identified in Table 6. The committee met from June 2005 until coming to an agreement during December 2006, which was reviewed and approved by lawyers on each side (Hinojosa 2007). During this time, Texas AgriLife Research and Texas AgriLife Extension Service agricultural economists met with IDs and municipal stakeholders on three occasions regarding the topic, "What is the value of water?", addressing therein the differences between charges for delivering water and the values for water rights and leases (Sturdivant et al. 2005a, 2005b, 2006).

Afterwards, additional meetings between the IDs and municipal representatives were held, whereby a written agreement between the parties was developed. The task force's resulting agreement contributed to the language subsequently incorporated into an amendment to Senate Bill 3, which appears in Section 49.507 (Texas Legislature Online 2007b). This amendment established the price at which municipalities could purchase converted irrigation water rights associated with the urban/residential development of irrigated agricultural land at 68% of the current market value, effective January 1, 2008

Table 6. Texas Lower Rio Grande Valley Water Rights Task Force Committee Members, June 2005 - December 2006

Committee Member	Affiliation
Chuck Browning	North Alamo Water Supply Corporation
Wayne Halbert	Cameron County Irrigation District #1 (i.e., Harlingen Irrigation District)
Sonny Hinojosa	Hidalgo County Irrigation District # 2
Sonia Kaniger	Cameron County Irrigation District # 2
Brian McManus	East Rio Hondo Water Supply Corporation
Roy Rodriguez	City of McAllen
Ron Thomas	Harlingen Water Works
JoJo White	Hidalgo & Cameron County Irrigation District # 9

Source: Hinojosa (2007).

(Texas Legislature Online, 2007b). The 68% value is thought to have originated based on actual historical firm yield of the Rio Grande as related to the amount of water actually allocated. That is, due to overappropriations of the Rio Grande water resulting from the “Valley Water Suit”, approximately 68% of an irrigation water right is actually available in terms of historical firm yield (Jarvis 2007).

At first glance, it seems as if the municipalities may have been a net beneficiary of the referenced legislation. To completely understand the full consequences of the legislation, both intended and unintended, it is essential, however, to delve deeper into the many ramifications of the amendment. The Senate Bill 3 amendment was the culminating result of what could be interpreted or labeled as “game theory” negotiations between the two parties. Because of the increasing need for water by the Valley municipalities that are experiencing unprecedented population growth, IDs were concerned that a legislative “taking” might be the alternative course of action if they did not compromise with the municipalities. That is, the threat perceived by the IDs was that the water rights could be reallocated legislatively from the IDs to municipalities. The intent of the bill was to ensure a supply of water for the municipalities, while keeping a district whole. Municipalities were guaranteed a path for ensuring water supply with clear rules. Further, the key objective of the two parties to create a mechanism to keep the region’s collective water rights in the Valley was established.

“Abolishment Bill”

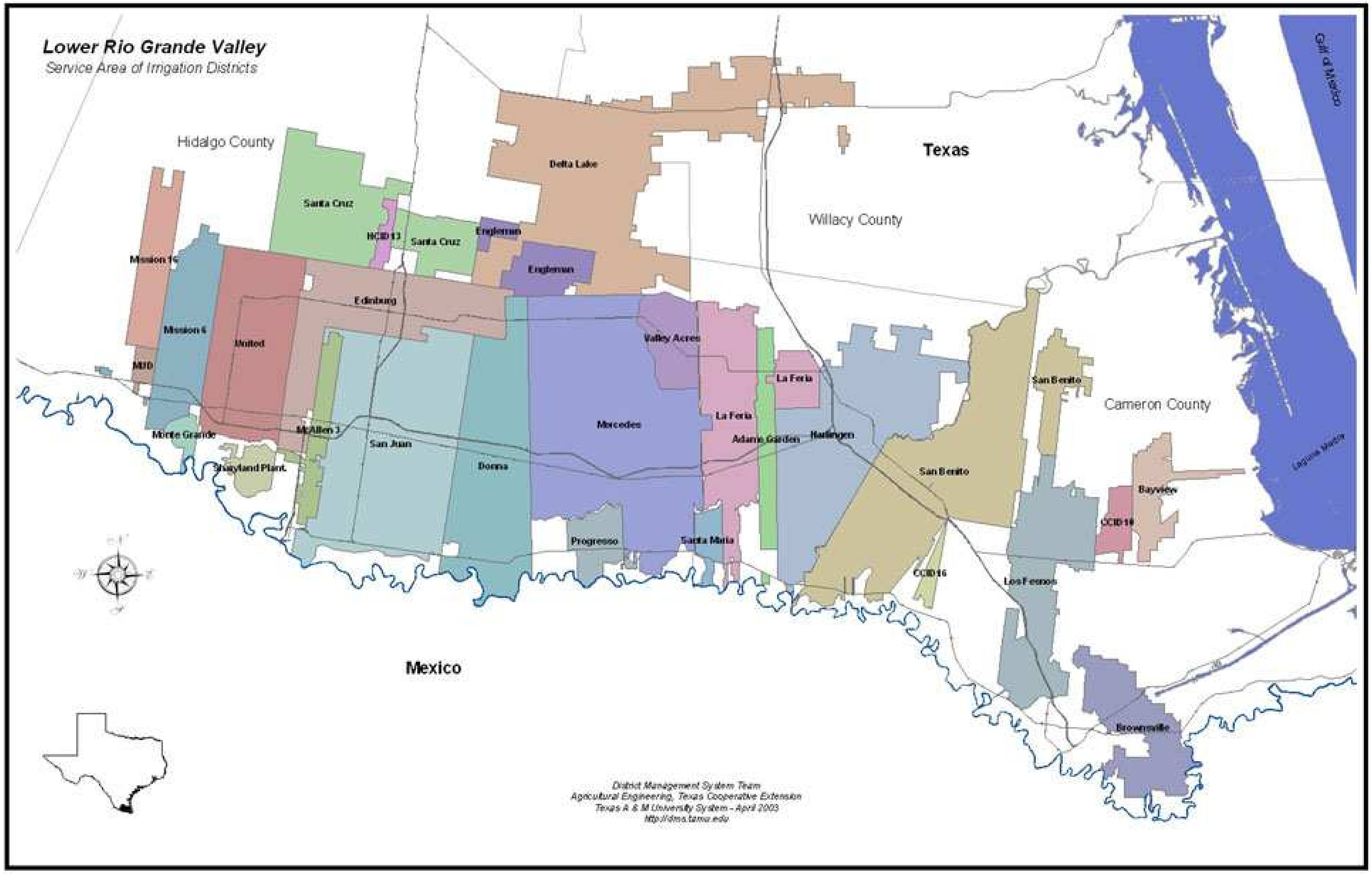
On February 8, 2007, House Bill 1271 was filed by Representative Kino Flores of District 36. The companion bill to this, Senate Bill 975, was filed on February 27, 2007 by Senators Juan “Chuy” Hinojosa of District 20 and Eddie Lucio, Jr. of District 27 (Texas Legislature Online 2007b). These bills were considered the “Abolishment Bill” because the goal of this legislation was to abolish the Hidalgo County Water Improvement District #3 (WID). This would mean a complete surrender of all rights and powers held by the WID to the local municipalities. Due to specific and careful wording, this bill would only affect Hidalgo County WID #3 and the City of McAllen (McAllen). The argument behind this action was that this WID was only serving about 13 farmers. As a consequence, 80% of the district’s water delivery service was being provided to McAllen. In addition, McAllen provided 89% of the revenue earned by Hidalgo County WID #3. McAllen wanted to eliminate the necessity of paying a middleman to deliver their water, and therefore pushed for the legislative abolishment of this WID.

Attention was drawn to the abolishment bill wherein rights and authority are stripped from an existing ID or WID. Several groups such as the Texas Irrigation Council, Lower Rio Grande Valley Water District Managers’ Association, and agricultural producers expressed their opposition based on their concern of such a precedent. As the 80th legislative session evolved, House Bill 1271 was left pending in committee on February 28, 2007, and failed to advance in the legislative process. The companion bill, Senate Bill 975, was passed in the Senate on April 19, 2007, but was not placed on the Calendar in the House. Although both of these bills failed to reach the floor for consideration, other bills were pending and came to the forefront (Texas Legislature Online 2007b).

“Conversion Bill”

Shortly after House Bill 1271 (i.e., the “Abolishment Bill”) was filed in the House, a competing bill was also filed. This was House Bill 1803, which was filed on February 21, 2007 by Representative Veronica Gonzales of Texas District 41. The companion bill, Senate Bill 847, was filed in the Senate on February 23, 2007, also by Senators Juan “Chuy” Hinojosa of District 20 and Eddie Lucio, Jr. of District 27 (Texas Legislature Online 2007b). The intention of this bill was to implement the “compromise” that was struck by the Water Rights Task Force, as previously mentioned. The “compromise” was to establish a mechanism to ensure a water supply for subdivided properties within IDs and keeping IDs whole. A municipality may petition an ID for the sale of the converted irrigation right associated with the subdivision or contract for the use of the water (Hinojosa 2007). As provided by specific wording in the bill, this legislation would only apply to Hidalgo, Cameron, and Willacy Counties. Figure 29 is a map of IDs within these counties.

Similar to House Bill 1271 (i.e., the “Abolishment Bill”), House Bill 1803 (i.e., the “Conversion Bill”) failed to advance to the House floor. Senate Bill 847 was passed in



Source: Irrigation District Engineering and Assistance Program, 2003. Approved for use by Guy Fipps, District Management System Team.

Figure 29. Irrigation Districts in the Texas Lower Rio Grande Valley, 2008

the Senate on April 19, 2007, the same day that the competing Senate Bill 975 was passed. Senate Bill 847, however, also failed to advance (Texas Legislature Online 2007b).

Passage of Floor Amendment 60

Although both the "abolishment" and "conversion" bills stalled in the process, as is often the case, the concepts and agreements reflected by the bill language remained part of the debate. With Representative Gonzales' leadership, language similar to House Bill 1803/Senate Bill 847 (i.e., the "Conversion Bill") resurfaced as a floor amendment to Senate Bill 3. In response, Representative Flores attached the previous "Abolishment Bill," Senate Bill 975, as an amendment to Floor Amendment 60. The outcome was passage of the Conference Committee Report for Senate Bill 3 as Floor Amendment 60, without the proposed abolishment component. Representative Gonzales' language was enacted with the passage of Texas Senate Bill 3 (Texas Legislature Online 2007b).

Implications

The issues of concern between IDs and municipalities regarding water in the Valley are not new, but the intensity of discussions has been elevating in recent years. As Valley population continues to experience extraordinary growth rates, the concern of IDs in regards to a "taking" of water rights due to shifts in political strength are more acute. Discussions among the parties in 2005-2006 suggested the possibility of future increases in political power for municipalities, thereby decaying the position of IDs. As a consequence, the time was right for compromises, leading to the Water Rights Task Force’s agreement and related Senate Bill 847 and House Bill 1803, at a time when other legislation aimed at abolishing one or more of the IDs (i.e., Senate Bill 975, and House Bill 1271) was introduced. Although these bills are local issues to the Valley, they introduce new issues and potential outcomes for other regions of Texas. These bills were viewed as having the potential of setting precedent for future negotiations between irrigation districts and municipalities.

CHAPTER VI

ECONOMIC AND FINANCIAL ANALYSES AND IMPLICATIONS OF FLOOR AMENDMENT 60 OF TEXAS SENATE BILL 3

Thus far in this undergraduate thesis, the examination of Floor Amendment 60[12] has been largely a qualitative investigation. The history of the Valley water market, including the establishment of IDs, municipalities, and water rights, as well as an explanation of the events leading up to the amendment, have been established. This piece of legislation potentially has financial and economic consequences, either intended or unintended. Included are the effects of legislation on the costs of Valley potable water, treatment options for municipalities, consequences of available water supply, and the overall impacts on stakeholders. These issues are evaluated in this chapter.

Pre-legislation potable water treatment economics

Texas AgriLife Research and Texas AgriLife Extension Service agricultural economists recently completed economic and financial analyses of the costs of producing potable water using the two prevalent technologies employed in the Valley: conventional

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[12] The focus of this undergraduate thesis is on the sale price of municipal water rights associated with the urban/residential development of irrigated agricultural land in the Valley and the consequences thereof. However, other components of Floor Amendment 60 need to be acknowledged. In accordance with Floor Amendment 60, the sale of municipal water rights by an ID is only one of three scenarios that could occur. A municipality can (1) purchase the rights, (2) contract for the water from the right, or (3) not petition the ID for the water (i.e., the municipal rights owned by the ID are unused). If the municipality elects to contract for the water, the ID can charge for the value of the water aside from the delivery charge. The value is equivalent to the charge/cost of four irrigations plus the flat rate equivalent. This was done to “keep a district whole”. The previously irrigated acre, on average, irrigated three times per year and paid a flat rate. The charge for the fourth irrigation was to allow for capital improvements to the district (Hinojosa 2008).

surface-water treatment and brackish groundwater desalination (Rogers et al. 2008; Sturdivant et al. 2008). The assumptions embodied in these analyses are those existing prior to the 80th Texas Legislature, i.e., prior to the passage of Senate Bill 3 and the accompanying amendment of interest in this undergraduate thesis. Full economic costs are calculated for each type of water treatment technology, accounting for initial construction costs, replacement of capital components over the total facility's useful life, annual operating/continuing costs, and the requisite investment in water rights.[13] Net present value (NPV) analyses and calculation of annuity equivalents are employed to determine the life-cycle costs of comparable quality potable water production for corresponding operational circumstances in Valley facilities using each of the technologies. The resulting modified life-cycle costs of production cited in Rogers et al. (2008) and Sturdivant et al. (2008) are considered suitable for comparison purposes.

The Microsoft® Excel® spreadsheet model CITY H_2O ECONOMICS© and the Microsoft® Excel® spreadsheet model *DESAL ECONOMICS*© have embedded net present value (NPV) analyses and calculations of annuity equivalents. The McAllen Northwest 8.25 mgd conventional surface-water treatment facility has a modified life-cycle cost of producing potable water equal to $667.74/ac-ft {$2.05/1,000 gallons}, basis 2006 (Rogers et al. 2008). The modified life-cycle cost of producing potable water for the Southmost (Brownsville) 7.5 mgd brackish groundwater desalination plant is

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[13] Purchase/ownership of water rights is a requirement only for conventional surface-water treatment facilities. For brackish groundwater desalination facilities, the costs of developing the groundwater well field is a component of the initial construction costs.

$615.01/ac-ft {$1.89/1,000 gallons}, basis 2006 (Sturdivant et al. 2008). The inference of these results is that prior to January 1, 2008, brackish groundwater desalination economics in the Valley were competitive with conventional surface-water treatment economics, even to the extent of a slight advantage for the brackish groundwater desalination alternative. These studies do not propose that desalination will replace conventional water treatment, but rather that desalination is an economically viable option for increasing potable water supply.

Drawing on the economic concepts and theories presented in Chapter III, municipalities' choice of which potable water treatment technology to utilize in meeting future expanded water demands in the Valley can be characterized using isoquant and isocost graphs. Considering Valley-wide potable water needs, a convex isoquant representation (IQ_1) is appropriate to illustrate the decreasing substitution nature existing among all potable water production situations in the Valley (Figure 30). Superimposing an isocost line [having a slope of -1.09 (i.e., $667.74/ac-ft for conventional surface water treatment /$615.01/ac-ft for brackish groundwater desalination)] on the isoquant in Figure 30 suggests a likely combination of the two designated technological inputs that can be expected to be adopted to meet future expanded potable water demand. In this case, LC_{1D} level of desalination effort will be used and LC_{1C} level of conventional water effort will be used to meet the total quantity of IQ_1.

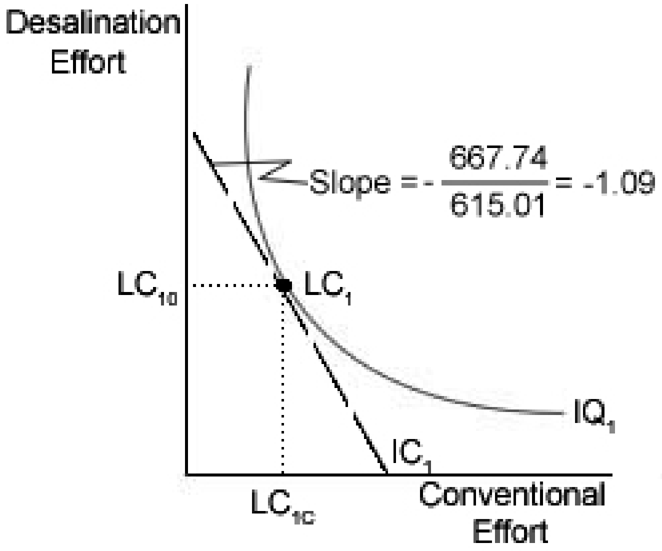

Figure 30. Valley potable water supply, conventional surface-water treatment and brackish groundwater desalination technologies, with isocost line, pre-Senate Bill 3 legislation

Events leading to legislation

The Water Rights Task Force that was formed in 2005 developed a compromise between IDs and municipalities during late 2006. This compromise was sponsored by a local Valley Texas Representative who guided the idea through the legislature. After additional compromise and negotiation plus an extensive path through the Texas Legislature, Floor Amendment 60 to Texas Senate Bill 3 was passed. The negotiations and compromise reached in the Water Rights Task Force are an example of game theory economics in practice. The goal of both IDs and municipalities was to individually obtain the highest possible utility on the price (low for municipalities and high for IDs) of irrigation water converted to a municipal right. A compromise was reached between IDs and municipalities on a price to be paid for municipal water rights originating from the conversion of irrigation water associated with agricultural land development into urban/residential property on or after January 1, 2008. This objective of two agents each attempting to competitively reach the highest utility is graphically illustrated in an Edgeworth Box Diagram described in Chapter III.

The goal of Floor Amendment 60 of Texas Senate Bill 3 was to provide a policy that would benefit and show responsiveness to the constituents (IDs and municipalities) of the affected region. The intent was to provide a consistent set of rules related to municipal water in the Valley. In the effort for efficiency and consistency, however, some inadvertent consequences may have been created.

The legislation

The specifics of Senate Bill 3 passed in the 80th Texas Legislature pertinent to this undergraduate thesis is Section 49.507. Previously, municipalities were given the right to purchase irrigation water under Sections 49.502 through 49.506. However, these transactions occurred at full market price. When irrigation water use is converted to municipal water use as a result of the development of agricultural land into residential and commercial use, the irrigation districts continue to retain the water rights. Section 49.507 establishes the price at which municipalities can buy this subset of municipal water rights from irrigation districts at 68% of the current market price effective January 1, 2008. According to Hinojosa (2008) and Texas Legislature Online (2007a), this pricing rule is applicable only to agriculture use (i.e., irrigation) water converted to municipal water use as a result of the development of agricultural property into residential and commercial use on or after January 1, 2008. Irrigation water previously converted continues to trade at full market price and it is sales of that prior (i.e., to January 1, 2008) converted water that establishes the basis against which the 68% factor is applied to determine the value of post January 1, 2008 converted water rights.[14]

Legislation impacts on economics of valley potable water treatment economics

The 68% factor in Section 49.507 of Senate Bill 3 effectively reduces the cost of future expansion of potable water production from conventional technologies while leaving the

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[14] As stated in Section 49.509 in Texas Senate Bill 3, at the beginning of each year, the three most recent sales of 100 or more ac-ft of pre-January 1, 2008 municipal water rights will be averaged and multiplied by 68% to determine the value of post-January 1, 2008 converted water sales for that year (Texas Legislature Online 2007a).

costs of brackish groundwater desalination unaffected. That is, the required investment in surface water rights for future development of conventional surface-water treatment plants is effectively reduced by 32%. Incorporation of this institutionally-induced cost reduction into the previously noted Rogers et al. (2008) analysis of the McAllen Northwest 8.25 mgd conventional surface-water treatment facility lowers the current \$2,300/ac-ft cost of surface-water rights (Kaniger 2007 and Barrera 2007 in Rogers et al. 2008) to \$1,564/ac-ft. Using this adjusted, lower surface-water rights investment along with the other cost data identified for the modified analysis in the Microsoft$_®$ Excel$_®$ spreadsheet model CITY H_2O ECONOMICS$^©$ results in a revised, “modified” life-cycle cost of producing potable water of \$609.33/ac-ft {\$1.87/1,000 gallons}, basis 2006 (Rogers et al. 2008). The cited legislation has no apparent effect on the costs for producing potable water via brackish groundwater desalination (i.e., \$615.01/ac-ft or \$1.89/1,000 gallons). Table 7 illustrates the pre-legislation and post-legislation cost per ac-ft of water for conventional surface water treatment and brackish groundwater desalination.

The economic consequences of the institutional lowering of the cost of surface water rights can be illustrated by adjusting the -1.09 slope of the prior-identified isocost line in Figure 30. This revised isocost line IC_2 with a slope of -.99 (i.e., \$609.33/ac-ft for conventional surface water treatment/\$615.01/ac-ft for brackish groundwater desalination) is illustrated in Figure 31. The noticeable result is the movement of the least-cost combination of desalination and conventional treatment technologies from LC_1

Table 7. Financial Results on the Cost Per Acre-Foot of Water Pre-Legislation and Post-Legislation

	$/Ac-Ft	
Treatment Technology	Before Legislation	After Legislation
Conventional[a]	$ 667.74	$ 609.33
Desalination[b]	$ 615.01	$ 615.01

[a] Source: Rogers et al. (2008).
[b] Source: Sturdivant et al. (2008).

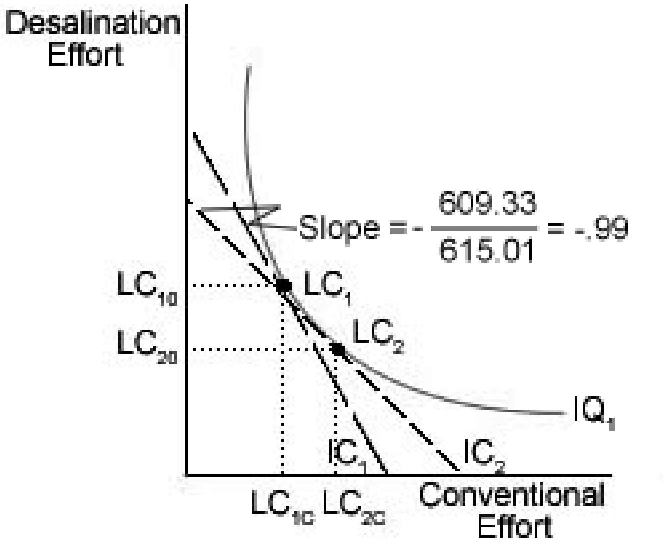

Figure 31. Valley potable water supply, conventional surface-water treatment and brackish groundwater desalination technologies, with two isocost lines, IC_1 representing pre-Senate Bill 3 and IC_2 representing post-Senate Bill 3

to LC_2, lowering desalination effort from LC_{1D} to LC_{2D} and increasing conventional treated water effort from LC_{1C} to LC_{2C}.

Valley-wide consequences of legislation

Industry supply

The summation of supply curves for all of the individual firms comprising an industry constitute the industry's supply curve. The supply curve for brackish groundwater desalination is illustrated as S_D in Panel A of Figure 32. This is a combination of the potable water supplied by brackish groundwater desalination plants in the Valley. The supply curve for conventional surface water treatment is illustrated in Panel B of Figure 32 as S_{C1}. It represents the supply of potable water from all conventional surface water treatment plants in the Valley. For each respective firm, its own cost relationships and the associated firm supply curve demonstrate the level of production that will occur at each price. The aggregate supply curve represents the respective quantities (Q) of output that will be produced in total by all firms in the industry. The aggregate supply curve for potable water created by brackish groundwater desalination and conventional surface water treatment is represented in Panel C of Figure 32 as S_{A1}. This is a horizontal summation of the industry supply curves of the two treatment methods in the Valley.

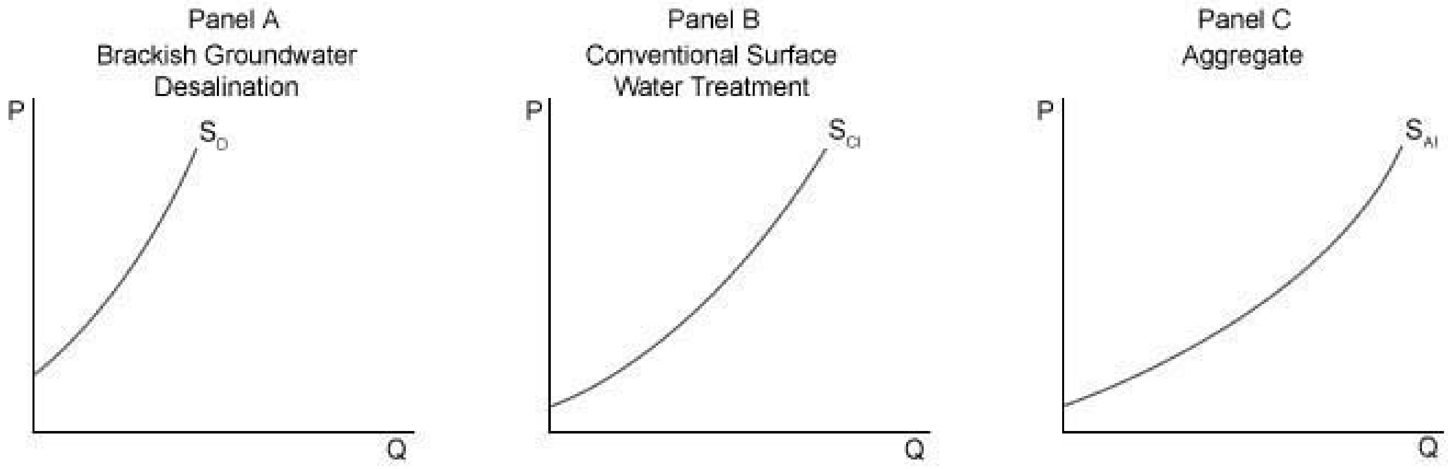

Figure 32. Industry and aggregate supply of Valley potable water

Industry demand

An individual demand curve provides an explanation for a consumer's purchasing behavior for one good over a range of prices. Generally, the lower the price, the more that an individual will purchase. Or, alternatively, the higher the price, the less an individual will purchase. The summation of individuals' demand curves for a particular product constitutes the industry demand curve for that product. This phenomenon is similar to the development of the industry supply curve resulting from summing the individual firms' supply curves. Figure 33 is an extension of Figure 32, with the addition of the industry demand curve for potable water. This is illustrated in Panel C of Figure 33 as curve D_A. The demand curve in this graph represents the amount of potable water desired by consumers in the Valley at alternative prices.

Market equilibrium

The previous discussions of supply and demand relate to the full range of possibilities for prices and quantities of a specific product. On any given day, in a specific location, there is generally only one effective price, with a resulting industry quantity of production and the individual firms' corresponding levels of production at that price. The intersection of this industry-level price and quantity is referred to as market equilibrium. It is graphically illustrated as the intersection between a market supply curve and a market demand curve. This equilibrium point is illustrated in Panel C of Figure 33, in which the potable water industry's aggregate demand curve and aggregate supply curve are superimposed on each other in the same two-dimensional space. The

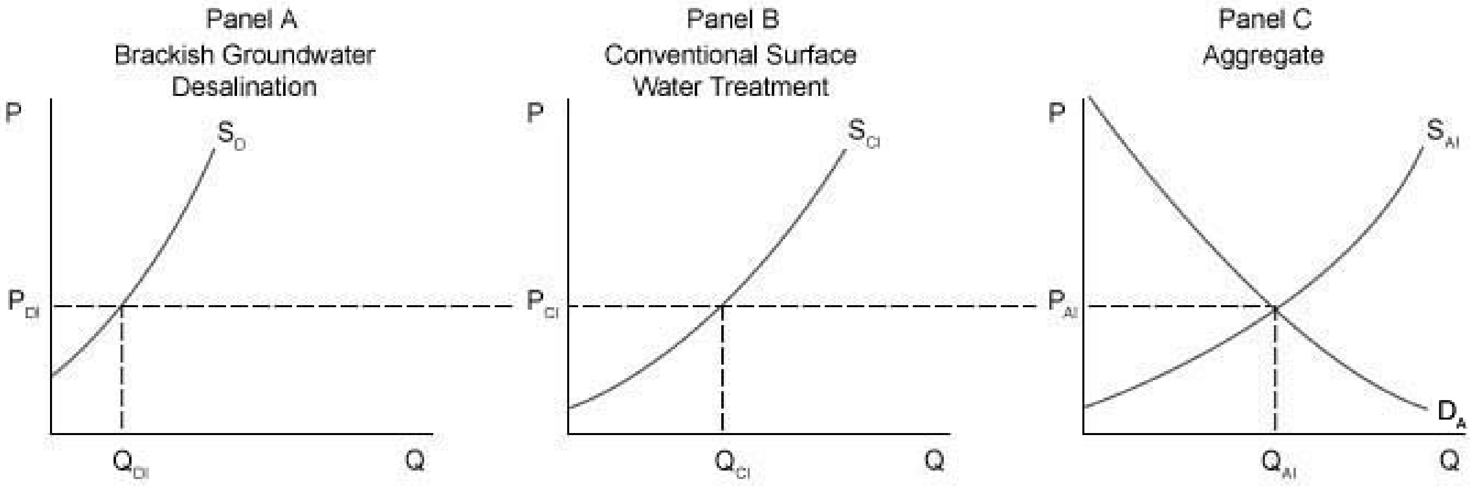

Figure 33. Industry demand and market equilibrium in the Valley potable water market, 2008, pre-Senate Bill 3

market-clearing price and quantity and this point are identified in the graph as P_{A1} and Q_{A1}. The equilibrium point $P_{A1}Q_{A1}$ identifies the market price at which the quantity of production supplied in full by all firms in the industry satisfies the aggregate demand for that product by all consumers. In this case, the demand for potable water in the Valley by consumers is fulfilled by potable water suppliers, which includes brackish groundwater desalination facilities and conventional surface-water treatment plants.

The equilibrium price that is determined by the aggregate supply curve and industry demand curve is the price charged by all suppliers within that market. Specifically in the case of the Valley, P_{A1} is charged by brackish groundwater desalination facilities and conventional surface-water treatment facilities. Panel A in Figure 33 illustrates this price, labeled as P_{D1}. The same price, P_{C1}, is charged in the conventional treatment market represented in Panel B of Figure 33. For this case, Q_{D1} will be supplied by desalination technologies and Q_{C1} will be supplied by conventional treatment to provide total supply of Q_{A1}.

Changes in supply

The previously identified market equilibrium at $P_{A1}Q_{A1}$ will change if an increase or decrease in aggregate supply occurs. Such a change in aggregate supply could be caused by an increase or decrease of one or more of the industry supply curves. The enactment of Floor Amendment 60 in Texas Senate Bill 3 has the potential to have such an effect on the supply of potable water created by conventional surface-water treatment in the

Valley. Because the legislated 68% price allows for a reduced cost of production in the conventional treatment method, the supply of potable water produced by this method has the propensity to increase. Such a development is graphically illustrated as a rightward, or outward, shift in the existing conventional surface-water treatment supply curve, S_{C1}, in Panel B of Figure 34. The new supply curve is then represented by S_{C2}. The aggregate supply curve for the potable water industry also increases, as it is a combination of all suppliers within that market. The supply of potable water available at all prices in the Valley effectively shifts to the right, or more water is supplied at a given price as compared to the pre-legislation conditions.

With the new aggregate supply curve, S_{A2}, a new equilibrium price and quantity are determined. This is, once again, determined graphically by the intersection of the aggregate supply curve and the industry demand curve. It is illustrated in Panel C of Figure 34 as $P_{A2}Q_{A2}$. Notice that the equilibrium quantity increases and the equilibrium price decreases. That is, at a lower price, consumers are more willing to purchase a larger quantity of potable water.

Just as in Figure 33, the market equilibrium price in Panel C of Figure 34 determines the industry prices. The new price for brackish groundwater desalination plants decreases in Panel A of Figure 34 to P_{D2}. The resulting change in quantity is a decrease to Q_{D2}. This represents the most extreme case in the potential decreased use of brackish groundwater

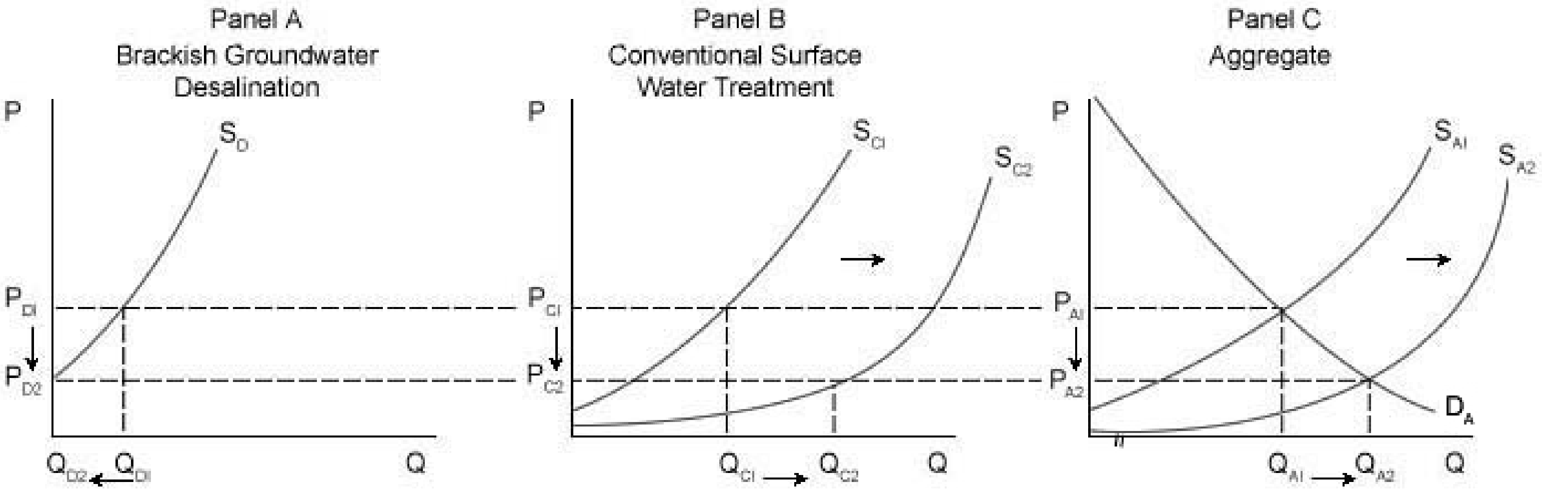

Figure 34. Change in market equilibrium in the Valley water market, 2008, post-Senate Bill 3

desalination associated with Floor Amendment 60 of Texas Senate Bill 3. Following the adjusted market equilibrium $P_{A2}Q_{A2}$, the price of potable water produced by conventional surface water treatment water also decreases in Panel B of Figure 34 to P_{C2}. Due to a shift in the supply of potable water produced by this method, however, an increase in the quantity supplied results. This is shown graphically by an increase from Q_{C1} to Q_{C2} in Panel B. This visual representation of the unintended consequences of legislation illustrates the extreme of potential impact on future supplies of potable water originating from brackish groundwater desalination. The direction of change (i.e., toward less future development of potable water via brackish groundwater desalination) is the point of relevance.

Stakeholder impacts

Prior to January 1, 2008, the industry market equilibrium for potable water can be conceptually illustrated in panel C of Figure 33, reproduced here as Figure 35. For this equilibrium situation, consumer surplus is represented in the area $bP_{A1}E_1$. The corresponding producer surplus is represented by the area $P_{A1}aE_1$. The potential effects of Senate Bill 3 resulting in more potable water production and a new industry market equilibrium is illustrated in Panel C of Figure 34 and reproduced here as Figure 36.

As a consequence of the shift in industry market equilibrium potentially precipitated by the legislation, the resulting consumer surplus changes from $bP_{A1}E_1$ to $bP_{A2}E_2$ and producer surplus changes from $P_{A1}aE_1$ to $P_{A2}0E_2$. The resulting increase in consumer

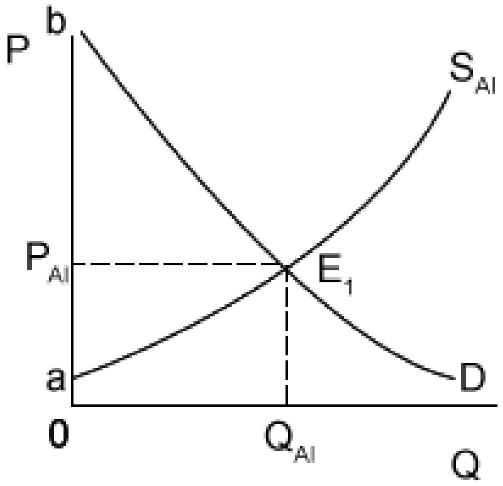

Figure 35. Illustration of consumer and producer surplus in Valley potable water market, pre-Senate Bill 3

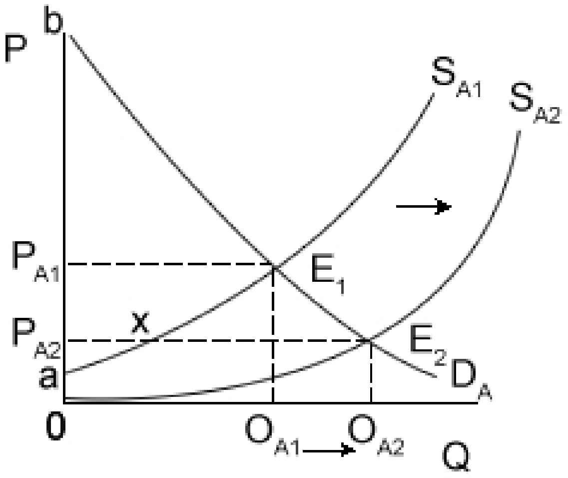

Figure 36. Supply shift impact on consumer and producer surplus in Valley potable water market, pre-Senate Bill 3 to post-Senate Bill 3

surplus is illustrated as trapezoid $P_{A2}P_{A1}E_1E_2$. This is an advantage to consumers of potable water in the Valley. Part of the original area that represented producer surplus is lost (i.e., $P_{A1}P_{A2}xE_1$), but a new area is gained (i.e., axE_20). The area gained can be more, less, or the same as the area lost. The exact measurements of magnitude of effect on the consumers of potable water is unknown, and neither the magnitude nor the direction of effect on the producers of potable water are known. Figure 35 and 36 provide a conceptual representation of the consumer and producer surplus in the Valley water markets. This relates to the industry supply and industry consumers in aggregation. Municipalities with lower costs of production for their potable water supplies are anticipated as receiving benefits.

The discussion to this point has been directed to water treatment providers (i.e., municipalities) and consumers. Additional critical players in this water issue are IDs that supply water to conventional treatment facilities. The IDs are the producers (i.e., suppliers of the municipal water rights) and municipalities are the consumers (i.e., buyers of the municipal water rights). Figure 37 is a representation of how the legislation impacts IDs. Pre-January 1, 2008, the equilibrium point for IDs supply (of municipal water rights converted as a result of development) to municipalities was at point *b,* with price at P_{ID1} and quantity at Q_{ID1}. This suggests a consumer surplus to municipalities of $P_{ID1}ab$ and a producer surplus to IDs of $P_{ID1}b0$. With the passage of Senate Bill 3, however, the price of such water rights converted on or after January 1, 2008 was set at 68% of the previous

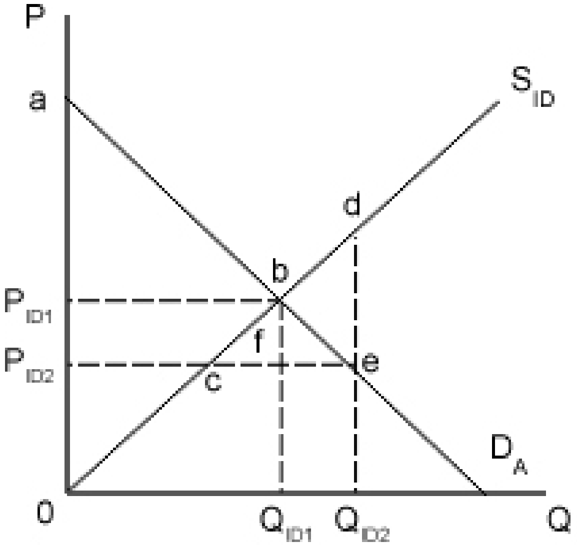

Figure 37. Illustration of implications of legislation on consumer and producer surplus as related to Irrigation Districts

market price, or P_{ID2}. If the IDs are expected to maintain Q_{ID1} supply of water, the producer surplus becomes $P_{ID2}c0$ minus the area of cbf after the implementation of Floor Amendment 60. Simultaneously, consumer surplus post-legislation increases by area $P_{ID1}P_{ID2}fb$ to become $P_{ID2}fba$. However, with the lower cost to municipalities resulting in a converted water rights price of P_{ID2}, consumers (i.e., municipalities) can be expected to increase the water rights they purchase to Q_{ID2}. This means that consumer surplus would be $P_{ID2}ae$. Alternatively, IDs producer surplus becomes $P_{ID2}c0$ less cde. This suggests that IDs are selling water rights at less than the cost to supply beyond point *c*.

Although only a graphical representation, the above discussion illustrates that IDs which were selling water rights converted as a result of development are made worse off than before the legislation was implemented. This is not to say the legislation is undesirable. It evolved between IDs and municipalities and resolved an issue of appropriate water rights price. The intent of the research presented herein was to illustrate how legislation might cause unexpected consequences and impede the adoption of new technology (e.g., brackish groundwater desalination).

The consumer and producer surpluses illustrated in this section are a demonstration of the potential effects on stakeholders in the short-run. These surpluses could potentially change in the long-run with an increase in potable water demand. Such dynamics would once again change the equilibrium point, and thereby affect the consumer and producer surplus. Producers could potentially gain more surplus due to an increase in equilibrium price, but theoretically the only opportunity for simultaneous realization of maximum producer surplus and maximum consumer surplus is in an open competitive market void of any governmental interference.

Chapter summary

The financial and economic implications of Floor Amendment 60 to Texas Senate Bill 3 are explained and illustrated to provide an example of how legislation might have impacts not anticipated, i.e., inadvertent or unexpected consequences. Financial analyses reveal that prior to the implementation of this legislation, the price per ac-ft of water each year for brackish groundwater desalination as compared to conventional surface water treatment was less costly. After implementation of the amendment, however, conventional surface water treatment holds a competitive economic advantage. This change in price also changes the least-cost combination between the use of brackish groundwater desalination and conventional surface water treatment, with an apparent advantage toward the conventional method. The decrease in cost of supplying potable water results in an increase in the supply produced by conventional surface water treatment facilities. This increase in supply is then transferred to consumers, which results in a reduced equilibrium price and expanded equilibrium quantity. The change in equilibrium will result in an increase in consumer surplus, but certainly a decrease in producer surplus from the IDs perspective. Therefore, Floor Amendment 60 has overall implications of benefiting consumers (i.e., municipalities and people), while adversely affecting some producers (i.e., IDs).

CHAPTER VII

CONCLUSIONS

For a region like the Valley with limited water and increasing demand, there is a continuing need for improved technology to provide potable water to the population. In an effort to ease tension among IDs and municipalities, legislation was passed during the 80th Texas Legislative Session that, in effect, created a probable unintended negative incentive for adoption of desalination technologies (which represents an added water source – brackish groundwater). This identified consequence is not to suggest there should not be legislation, but to illustrate there can be unanticipated consequences.

Overview and conclusions

This study provides an analysis of the potential financial and economic implications of Floor Amendment 60 to Texas Senate Bill 3 on the adoption of water treatment methods in the Lower Rio Grande Valley of Texas. An examination of the structure and background of the stakeholders, irrigation districts, and municipalities was conducted, followed by an assessment of the events leading up to the passage of this amendment. Financial analyses were then conducted and revealed the per ac-ft cost of brackish groundwater desalination and conventional surface water treatment before and after the implementation of Floor Amendment 60. This analysis illustrated the financial incentive for the increased use of conventional surface water treatment after the policy implementation.

The potential impact of the policy legislation on the reduced use of brackish groundwater desalination was then supported by a graphic economic analysis. The cost curves experienced by water supply firms were illustrated graphically, resulting in the post-legislation least-cost combination favoring increased use of conventional surface water treatment. The industry and aggregate supply curves and industry demand curve were used to illustrate the increase in supply that ultimately causes a decrease in market price and increase in potable water purchased by consumers in the Valley. Economic analyses of the consumer and producer surplus were then applied to reveal possible impacts on stakeholders. The conclusion was a positive change for consumers, but a less-than-positive change for IDs.

Both the financial and economic analyses indicate rejecting the original null hypothesis: "Floor Amendment 60 has no impact on the adoption of alternative potable water treatment methods in the Valley." Therefore, it is concluded that this piece of legislation does impact water technology adoption. The results of this study suggest that a disincentive for the adoption of brackish groundwater desalination was created, while an incentive to increase use of conventional surface water treatment occurred. Under such circumstances, economic and social efficiency are weakened, discouraging the adoption of new technology that can potentially provide water for future generations. Due to the complexity of the issue, however, it is not feasible to conclude that such legislation is a social good or a detriment.

Limitations and future research needs

The financial and economic analyses provided within this project do not cover every potential circumstance affected or created by Floor Amendment 60 to Texas Senate Bill 3. This study is focused on the economic implications in a short-run time period. It is known that supply and demand have the potential and are likely to change once again in the long-run situation. As a result, pricing, quantity, and consumer and producer surplus would also change. The effects on stakeholders in such instances are unknown.

It is also important to recognize that the supply, demand, and equilibrium graphs presented represent an extreme case. For example, the changes in market equilibrium due to Floor Amendment 60 were conceptualized in Chapter VI as causing the quantity of brackish groundwater desalination to reduce to zero, implying no use of this potable water treatment method. Other possible scenarios exist that would only slightly reduce the use of brackish groundwater desalination as a part of the Valley potable water supply. Issues of water availability and security enter the decision framework considering issues of drought, international agreements, and independence.

An additional concept that is not considered is the future actions of Valley municipalities relative to reliability of potable water for customers. This study implies that after Floor Amendment 60, brackish groundwater is relatively more expensive. The Valley municipalities could still adopt desalination, should the concerns over surface water disruptions still be present.

The study presented within this research is limited to Cameron, Hidalgo, and Willacy counties. Although this legislation has the potential to set precedent for water markets across the state, it is important to remember that this is a local issue, dealing with only a fraction of Texas. This study does not apply to any other IDs or municipalities.

To address the limitations noted above suggests opportunities for further research. Further analysis could examine possible long-term water supply, risk, and economic situations in the Valley water market. This includes potential changes in demand and supply that result in different equilibrium points and surpluses. It would reveal the long-term affects of Floor Amendment 60 on the Valley water market. Further quantitative examinations of the changes in supply could be conducted to reveal more precise changes in supply and demand and implementation of use of conventional surface water treatment and brackish groundwater desalination.

Additional investigations could also be conducted with respect to the impacts on IDs and others for those situations in which IDs previously supplied municipal water rights to municipalities for only the delivery charge, i.e., without receiving any remuneration for the value of the water itself. It is anticipated that such investigations might produce results of an opposite nature than those presented herein.

Care should also be exercised when conducting economic analyses of potential impacts of legislation. Further studies of legislative processes and their “real world” influences, both intended and unintended, are suggested to provide additional insights on impacts. This could potentially identify implications of a bill on all stakeholders and might precipitate adjustments to better serve all stakeholders.

REFERENCES

Averitt, K. 2007. Press Release: “Governor Perry signs Averitt’s groundbreaking water legislation.” Available at: http://www.senate.state.tx.us/75r/Senate/Members/Dist22/pr07/p071607a.htm. Accessed on March 18, 2008.

Barrera, J. 2007. General Manager, Brownsville Irrigation District. Brownsville, TX. Personal communications.

Boyer, C. N. 2008. “Examining for Economies of Size in Two Municipal Water Treatment Technologies Common to the Rio Grande Valley of Texas.” Master’s thesis. Texas A&M University. August (forthcoming).

Boyer, C. N., M. E. Rister, A. W. Sturdivant, R. D. Lacewell, C. S. Rogers, and B.L. Harris. 2008. “Identifying Economics of Size in Conventional Surface Water Treatment and Brackish-Groundwater Desalination: Case Study in the Rio Grande Valley of Texas.” Presentation at the Southern Agricultural Economics Association Annual Meeting, Dallas, TX. February 3-5, 2008. Department of Agricultural Economics, Texas A&M University and Texas Water Resources Institute. College Station, TX.

Busch, M., and B. Mickols. 2004. “Economics of Desalination – Reducing Costs by Lowering Energy Use.” *Water & Wastewater International.* June 2004 Vol.19 Issue 4.

Economist.com. 2008. “Utility.” Available at: http://www.economist.com/research/Economics/alphabetic.cfm?TERM=UTILITY. Accessed on March 30, 2008.

Environmental Protection Agency. 2005. *Membrane Filtration Guidance Manual*. Office of Water. Washington, DC. November. pp. 2-4.

Fipps, Guy. Agricultural Engineer, Texas AgriLife Extension Service, College Station, TX. Personal communications, Fall 2007.

Griffin, R. C. 2002. Professor of Natural Resource Economics, Department of Agricultural Economics, Texas A&M University. College Station, TX. Personal communications.

Griffin, R. C., and M. E. Chowdhury. 1993. “Evaluating a Locally Financed Reservoir: The Case of Applewhite.” *Journal of Water Resources Planning and Management* 119(6):628-44.

Günaydin, M. Undated. "The Delphi Method." Available at: http://www.iyte.edu.tr/~muratgunaydin/delphi.htm. Accessed on March 31, 2008.

Hinojosa, S. 2007. General Manager, Hidalgo County Irrigation District No. 2. San Juan, TX. Personal communications.

Hinojosa, S. 2008. General Manager, Hidalgo County Irrigation District No. 2. San Juan, TX. Personal communications.

International Boundary and Water Commission. 1999. "History of the International Boundary and Water Commission." Available at: http://www.ibwc.state.gov/About_Us/history.html. Accessed on November 6, 2007.

Investopedia. 2008. "Net Present Value (NPV)." Available at: http://www.investopedia.com/terms/n/npv.asp. Accessed on February 10, 2008.

Irrigation District Engineering and Assistance Program. 2003. "Lower Rio Grande Valley Service Area of Irrigation Districts." Available at: http://idea.tamu.edu/NADBank/map1.jpg. Accessed on March 18, 2008.

Jarvis, G. October 2007. Water Lawyer, Law Offices of Glenn Jarvis. McAllen, Texas. Personal communications.

Jasinski, L.E. 2001. "Irrigation Districts." Available at: http://www.tshaonline.org/handbook/online/articles/II/mwii.html. Accessed on November 7, 2007. The Handbook of Texas Online.

Jurenka, R., S. Martella, and R. Rodriguez. 2001. "Water Treatment Primer for Communities in Need." Available at: http://www.usbr.gov/pmts/water/media/pdfs/report068.pdf. Accessed on January 3, 2008.

Kaniger, S. 2007. General Manager, Cameron County Irrigation District #2. San Benito, TX. Personal communications.

Kay, R. D., W. M. Edwards, and P. A. Duffy. 2008. *Farm Management*, 6th ed. Boston: McGraw Hill Higher Education.

Lesikar, B., R. Kaiser, and V. Silvy. 2006. "Groundwater Conservation Districts in Texas." Texas Cooperative Extension. College Station, TX.

Mansfield, E., W. B. Allen, N. A. Doherty, and K. Weigelt. 2002. *Managerial Economics*, 5th ed. New York, NY: W. W. Norton & Company, Inc.

Michaels, P. A. 2007. “The Pros and Cons of Reverse Osmosis Desalination.” Available at: http://greennature.com/article69.html. Accessed March 20, 2008.

Norris, J. W. 2006a. *Southmost Regional Water Authority Regional Desalination Plant*. Available at: http://www.twdb.state.tx.us/iwt/desal/docs/The%20Future%20of%20Desalination%20in%20Texas%20-%20Volume%202/documents/D7.pdf. Accessed June 2007.

Norris, J. W. 2006b. *Chapter 14, Brackish Groundwater Desalination in South Texas: An Alternative to the Rio Grande*. Available at: https://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/R365/ch14-Desalination%20in%20South%20TexasR1.pdf. Accessed June 2007.

Norris, Bill. 2008. NRS Consulting Engineers. Harlingen, TX. Personal communications.

Penson, Jr., J. B., O. Capps, Jr., and C. P. Rosson III. 2002. *Introduction to Agricultural Economics*, 3rd ed. Upper Saddle River, NJ: Pearson Education, Inc.

Perloff, J. M. 2004. *Microeconomics*, 3rd ed. Boston, MA: Pearson Education, Inc.

Posner, R. 1977. *The Economic Approach to Law*, 2nd ed. Boston: Little Brown and Company. p.16.

Quinn, M. 2003. “Natural and Cultural History of the Lower Rio Grande Valley of Texas.” Available at: http://www.texasento.net/LRGV.htm. Accessed on March 31, 2008.

Rio Grande Regional Water Planning Group. 2001. “Regional Water Supply Plan for the Rio Grande Regional Water Planning Area (Region M), Vols. I and II.” Lower Rio Grande Valley Development Council and Texas Water Development Board.

Rister, M. E. 2001a. “Firms’ Production Decision Rules.” AGEC 325 class notes, Department of Agricultural Economics, Texas A&M University. College Station, TX.

Rister, M. E. 2001b. “Input Substitution and Cost Minimization.” AGEC 325 class notes, Department of Agricultural Economics, Texas A&M University. College Station, TX.

Rister, M. E., R. D. Lacewell, J. R. C. Robinson, J. R. Ellis, and A. W. Sturdivant. 2008. “Economic Methodology for South Texas Irrigation Projects-RGIDECON.” Texas Water Resources Institute. TR-203 (revised). College Station, TX.

Rogers, C. S. 2008. “Economic Costs of Conventional Surface-Water Treatment: A Case Study of the McAllen Northwest Facility.” Master of Science thesis. Department of Agricultural Economics. Texas A&M University. May.

Rogers, C. S., M. E. Rister, A. W. Sturdivant, R. D. Lacewell, and Javier G. Santiago. 2008. “Economic Costs of Conventional Surface-Water Treatment: A Case Study of the McAllen Northwest Facility." Texas Water Resources Institute. TR-311. College Station, TX.

Smith, D. 2001a. “Water Control and Improvement Districts.” Available at: http://www.tshaonline.org/handbook/online/articles/WW/mww1.html. Accessed on November 7, 2007. The Handbook of Texas Online.

Smith, D. 2001b. “Water Improvement Districts.” Available at: http://www.tshaonline.org/handbook/online/articles/WW/mww2.html. Accessed on November 7, 2007. The Handbook of Texas Online.

Smith, G. F. 1977. “The Valley Water Suit and Its Impact on Texas Water Policy: Some Practical Advice for the Future.” Texas Tech Law Review 3,3 (1977): 577-636.

Southmost Regional Water Authority. 2004. “Regional Solutions to Regional Water Solutions.” Brownsville, TX.

Strambaugh, J. Lee and Lillian J. Strambaugh. 1954. “The Lower Rio Grande Valley of Texas.” San Antonio, TX: Naylor Co.

Stubbs, M. J., M. E. Rister, R. D. Lacewell, J. R. Ellis, A. W. Sturdivant, J. R. C. Robinson, and L. Fernandez. 2003. “Evolution of Irrigation Districts and Operating Institutions: Texas, Lower Rio Grande Valley.” Texas Water Resources Institute. TR-228. College Station, TX.

Stubbs, M. J., M. E. Rister, A. W. Sturdivant, and R. D. Lacewell. 2004. “An Overview of the Operational Characteristics of Selected Irrigation Districts in the Texas Lower Rio Grande Valley: Brownsville Irrigation District.” Texas Water Resources Institute. TX-274. College Station, TX.

Sturdivant, A. W., M. E. Rister, and R. D. Lacewell. 2006. “The Value of Water, the Costs of Delivery, the Interaction of Rates, and Their Relevance to LRGV.” Members of the Lower Rio Grande Valley Water District Manager’s Association and Various Municipality Representatives. Weslaco, TX. January 23.

Sturdivant, A. W., M. E. Rister, R. D. Lacewell, J. W. Norris, J. Leal, C. S. Rogers, J. Garza, and J. Adams. 2008. "An Analysis of the Economic and Financial Life-Cycle Costs of Reverse-Osmosis Desalination in South Texas: A Case Study of the Southmost Facility." Texas Water Resources Institute. TR-295. College Station, TX. (forthcoming)

Sturdivant, A. W., M. E. Rister, R. D. Lacewell, and L. A. Ribera. 2005a. “The Value of Water, the Interaction of Rates, and Their Relevance to LRGVWDMA.” Lower Rio Grande Valley Water District Manager’s Association. Weslaco, TX. November 10.

Sturdivant, A. W., M. E. Rister, R. D. Lacewell, and L. A. Ribera. 2005b. “The Value of Water, the Interaction of Rates, and Their Relevance to LRGVWDMA - II.” Lower Rio GrandeValley Water District Manager’s Association. Weslaco, TX. December 9.

Texas Commission on Environmental Quality. 2000. “Chapter 303 – Operation of the Rio Grande Rule Log No. 2000-041-303-WT.” Austin, TX.

Texas Commission on Environmental Quality. 2004. “Watermaster Programs.” Available at: http://www.tnrcc.state.tx.us/enforcement/fod/wmaster/wmaster1.html. Accessed on November 8, 2007.

Texas Cooperative Extension. 2006. “District 12.” Annual Report. The Texas A&M University System. College Station, TX.

Texas Legislature Online. 2007a. “Rules and Precedents of the Texas House: Rule 6, Order of Business and Calendars.” Available at: http://www.house.state.tx.us/resources/hrrules.pdf. Accessed on April 1, 2008.

Texas Legislature Online. 2007b. “Senate Bill 3.” Available at : http://www.capitol.state.tx.us/BillLookup/History.aspx?LegSess=80R&Bill=SB3. Accessed on March 18, 2008.

Texas Water Code. 1963. Sections 11.325-11.326. Available at: http://tlo2.tlc.state.tx.us/statutes/wa.toc.htm. Accessed on October 9, 2007.

Texas Water Development Board. 2003. “Brackish Groundwater Manual for Texas Regional Water Planning Groups.” Section 1.0. Available at: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Brackish%20GW%20Manual/01-TOC-Intro.pdf. Accessed on March 31, 2008.

Texas Water Development Board. 2006. "2006 Regional Water Plan, County Water Demand Projections for 2000-2060 in ac-ft." Available at: http://www.twdb.state.tx.us/data/popwaterdemand/2003Projections/DemandProjections/County/county_demand_totals.htm. Accessed on October 2, 2007.

Texas Water Development Board. 2007. "2007 State Water Plan, Vols. I, II, and III." Available at: http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/2007StateWaterPlan.htm. Accessed on October 2, 2007.

The Texas County Information Project. 2006. "County Profile" Available at: http://www.county.org/resources/countydata/. Accessed on October 10, 2007. Texas Association of Counties.

Thomas, C. R., and S. C. Maurice. 2005. *Managerial Economics*, 8th ed. New York, NY: McGraw-Hill Irwin.

Truett, L. J. and D. B. Truett. 2001. *Managerial Economics: Analysis Problems, Cases,* 7th ed. Cincinnati, OH: South-Western College Publishing.

U.S. Census Bureau. 2001. Census 2000 PHC-T-3. Ranking Tables for Metropolitan Area: 1990 and 2000. Available at: http://www.census.gov/population/cen2000/phc-t3/tab05.pdf. Accessed on September 19, 2007.

U.S. Census Bureau. 2006. "State and County QuickFacts." Available at: http://quickfacts.census.gov/qfd/index.html. Accessed on October 3, 2007.

U.S. General Accounting Office. 1998. "International Boundary and Water Commission: U.S. Operations Need More Financial Oversight." U.S. General Accounting Office. Washington D.C. GAO/NSIDAD-98-238.
Waldman, D. E. 2004. *Microeconomics*. Boston, MA: Pearson Education, Inc.

Younos, T. 2005. "The Economics of Desalination." *Journal of Contemporary Water Research and Education*. Issue 132, p. 42. December.

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