An economic analysis of the 160 acre limitation in District One of the Lower Yellowstone Irrigation Project with policy implications
by George Walser Haynes

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University
© Copyright by George Walser Haynes (1980)

Abstract:
Recent litigation in the Federal Courts concerning the enforcement of the Reclamation Act of 1902 and the Omnibus Adjustment Act of 1926 prompted this study to be undertaken. This thesis examines economies of size and the relationship between farm size and net income on irrigated farms in District 1 of the Lower Yellowstone Irrigation Project. Chapters one and two include a brief historical account, a problem statement and a review of relevant economic literature. The economic rationale and mathematical model are presented in chapter three. Chapters four and five contain the conclusions drawn from the linear programming model and subsequent financial analysis in considering various policy scenarios.

STATEMENT OF PERMISSION TO COPY

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or, in his absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature George Walser Haynes

Date 8/2/80

AN ECONOMIC ANALYSIS OF THE 160 ACRE LIMITATION IN DISTRICT ONE OF THE LOWER YELLOWSTONE IRRIGATION PROJECT WITH POLICY IMPLICATIONS

by

GEORGE WALSER HAYNES

A thesis submitted in partial fulfillment
of the requirements for the degree

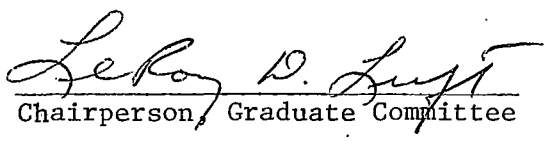
of

MASTER OF SCIENCE

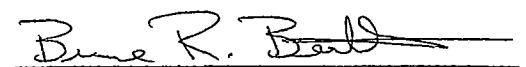
in

Applied Economics

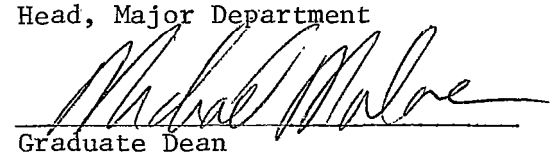
Approved:



Chairperson, Graduate Committee



Head, Major Department



Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

August, 1980

ACKNOWLEDGMENTS

I wish to express my sincere thanks to my thesis advisor, Dr. LeRoy Luft and committee member, Dr. M. S. Stauber for their professional counseling and inexhaustible patience throughout the project. Thanks are also due for the other past and present committee members, Drs. R. J. McConnen, Daniel Dunn and Douglas Young for their assistance in completing the study. Special thanks are extended to Mrs. Leslie Fort and Mrs. Evelyn Richard for the initial typing and to Mrs. Peggy Olson for her expert typing of the final draft.

A very special thanks is extended to my parents for their ever present encouragement and support in my academic pursuits.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd.)

LIST OF TABLES AND FIGURES

LIST OF TABLES AND FIGURES (cont'd.)

ABSTRACT

Recent litigation in the Federal Courts concerning the enforcement of the Reclamation Act of 1902 and the Omnibus Adjustment Act of 1926 prompted this study to be undertaken. This thesis examines economies of size and the relationship between farm size and net income on irrigated farms in District 1 of the Lower Yellowstone Irrigation Project. Chapters one and two include a brief historical account, a problem statement and a review of relevant economic literature. The economic rationale and mathematical model are presented in chapter three. Chapters four and five contain the conclusions drawn from the linear programming model and subsequent financial analysis in considering various policy scenarios.

CHAPTER 1

INTRODUCTION

Evolution of the 160 Acre Limitation

Settlers of the American West found water to be a very scarce and consequently precious resource. The pre-Columbian Indians adapted to the arid environment of the Southwest by capturing storm runoff and irrigating their crops. Spanish colonialists and Missionaries, in the 17th and 18th centuries, employed water preservation techniques practiced in their homeland for centuries.[1] The next several decades were marked by controversy as land and water were enjoined.

Following the formation of the thirteen colonies, the new government was posed with problems of disposing of a vast public domain. The new government needed money, thus prompting Secretary of the Treasury Alexander Hamilton to suggest that land be sold to settlers to raise revenue. Hamilton's notion coupled with Thomas Jefferson's vision of an agrarian economy, with production in the hands of small producers, to determine congressional policy. In 1784, a congressional policy was approved suggesting that an attempt be made to dispose of this vast public domain.[2] With the adoption of the Constitution,

---

[1] Michael G. Robinson, "Water at Work: Reclamation, 1902-1977." 1976 Summary Report, United States Department of the Interior (Bureau of Reclamation). p. 41.

[2] Alan Stanford Kezis, "An Examination of Economies of Size and Net Revenues on Columbia Basin Farms: Implications for Acreage Limitation Policy," Unpublished doctoral dissertation, Washington State University, (1978), p. 1.

Congress, via the property clause, had unlimited power over public lands. This clause gave Congress proprietary power to "dispose of and make all needful Rules and Regulations respecting the Territory or other property belonging to the United States."[3]

Federal involvement in the settlement of the western lands was prompted by a goal of rapid growth and development. The fundamental policy involved was that of making western lands capable of supplying their own reclamation. Until 1841 land was disposed of by selling various sized tracts, thus leading to the Preemption Act of 1841. The Preemption Act allowed the head of each household to acquire 160 acres of western land at a price fixed by the government. Squatting on unsurveyed land was illegal. This coupled with no outright land grant made the westerner dissatisfied. Nevertheless, western land policy was about as liberal as it could be, consistent with the demand that the public domain be a continuing source of revenue.

Agitation for free land continued throughout the 1850's, finally leading to the Homestead Act of 1862. This Act allowed the head of a family or anyone over 21 years of age to have 160 acres of public domain by paying a small fee. The only stipulation was that the homesteader either live on or cultivate the land for five years. However, the Homestead Act said nothing about the appropriation or use of the

---

[3] U.S. Constitution, Article IV, Section 3, Clause 2.

water. No clear line could be drawn between Federal or State authority at this point because the Federal government chose to stand by, allowing the State and Territorial courts to declare what western water law would be. The Act of July 26, 1866 stated:

> "Whenever, by priority of possession, rights to the use of water for mining, agriculture, manufacturing, and other purposes have vested and accrued, and the same are recognized and acknowledged by the local customs, laws and decisions of courts, then the customary users are recognized as being legally valid."[4]

This Act was followed by the Act of 1870, the Desert Land Act of 1877 and Carey Act of 1894.[5]

The Act of 1870 further defined the Act of July 26, 1866 by subjecting all patented lands and homesteads to "any vested and accrued water rights."[6] The Desert Land Act allowed anyone to purchase 640

---

[4] Act of July 26, 1866, Ch. 262, Sect. 9, 14 Stat. 253, Rev. Stat., Sect. 2339, 3 U.S. Cong. 661.

[5] The notion of an acreage limitation for irrigated lands was implemented in Lassen County, California on March 3, 1875. This first acreage limitation attempt also stipulated that land not reclaimed would then be sold back to the government at a nominal price. This information came from the following source: Richard Moss Alston, "Commercial Irrigation Enterprise: The Fear of Water Monopoly and the Genesis of Market Distortion." Unpublished doctoral dissertation Cornell University, January, 1970. p. 161.

[6] Act of July 9, 1870, Ch. 235, Sect. 17, 16 Stat. 218, Rev. Stat., Sect. 2340, 43 U.S. Cong. 661.

acres of land at $1.25 per acre with one stipulation: to irrigate the land within three years. The Desert Land Act offered too much land to the small operator to effectively operate and not enough land to interest large corporations in water supply investments.[7] Congress continued its encouragement of capitalists investment in reclaiming the western lands by enacting the Carey Act in 1894. Senator Carey envisioned the Act as an aid to the public lands states for the reclamation, supplementation and cultivation of these lands by small operators. The Act allowed the states to contract for construction work on irrigation projects, to fix water prices and to sell land only to persons owning water rights in the irrigation canal region.[8] While the Carey Act essentially left irrigation development in the hands of the states and effectively prevented speculation, the primary goal of rapid western development wasn't being realized. The Act simply was unable to (1) guarantee an effective demand for land, (2) guarantee purchases of water or (3) provide adequate financial arrangements to repay the construction costs of the irrigation project.

---

[7] Elwood Meade, "Rise and Future of Irrigation in the United States," Yearbook of the Department of Agriculture, Government Printing Office, Washington, D.C., 1899, pp. 603 - 604; and Moss, p. 164.

[8] The arrangement between the State and the construction company allowed the construction company to sell water rights that granted water purchasers an interest in the project. Moss, op. cit., p. 181.

The apparent failure of the Carey Act, linked with a conservation movement, pressured Congress into considering direct federal aid to reclaim the western lands. This movement led to the organization of the National Irrigation Association, supported by dues from individual members and large railroad contributions, which pressed for Federal monies to develop the western lands. Their wishes were satisfied by the enactment of the Reclamation Act of 1902, providing for the use of receipts from land sales in the arid western states to finance the construction of reservoirs and irrigation works, with repayment to be made by settlers over a period of years.[9] The Federal government was now directly involved in irrigated agriculture. The policy objectives are reflected in the Bureau of Reclamation's internal guidelines which state:

> "The policy of limiting the area of land for which project water may be supplied under the Reclamation laws is designed to (1) provide opportunity for a maximum number of settlers on the land, (2) distribute widely the benefits from public-supported reclamation where interest free money is involved, and (3) promote the family sized farm as a desirable form of rural life."[10]

---

[9] At the Montana Irrigation Convention in January of 1892 (Ten years prior to the Reclamation Act), the delegates to the Salt Lake convention were criticized for supporting the Salt Lake Convention platform calling for a cession of all public lands to the states. They, in turn, adopted a resolution calling for proceeds of land sales to be allocated for western water development. Moss, op. cit., p. 175.

[10] Reclamation Instructions, (Series 210 Land, Part 219 Excess Land), p. 15.

The above guidelines were based on the following provision contained in the original Reclamation Act of 1902:

> "No right to the use of water for land and private ownership shall be sold for a tract exceeding 160 acres to any one individual landowner, and no such sale shall be made to any landowner unless he be an actual bona fide resident on the land, or occupant thereof residing in the neighborhood."[11]

The acreage limitation provision places an ownership limitation of 160 acres on irrigated land obtainable by an individual. The law has been loosely interpreted to allow 320 acres of land jointly owned by a husband and wife to be allocated water from the irrigation project. Any irrigated land owned over the 160 acre limit (or 320 acres for husband and wife) is called excess land. The owner of excess land is not eligible for project water unless the excess land is placed under recordable contract or the lands are eligible by statute.[12] The provision for disposal of excess lands became law through section 46 of the Omnibus Adjustment Act, passed in 1926.[13]

A general lack of regard for the original Reclamation Act and

---

[11] D. Seckler and R. A. Young. "Economic and Policy Implications of the 160 Acre Limitation in Federal Reclamation Law," American Journal of Agricultural Economics, November 1978, p. 575.

[12] The recordable contract forces the owner to sell the excess land at a price not including the value added by the irrigation project within five years of the inception of the contract.

[13] The Omnibus Adjustment Act of 1926 also stipulated that all water contracts must be with the irrigation district association, not with individuals.

subsequent amendments was to follow. As suggested by Colorado State University Professor Robert Young, "There are few, if any, examples in American jurisprudence where the gap between de jure and de facto looms so large."[14] The root of the enforcement problem appeared to lie in a 1912 Amendment to the Reclamation Act and two subsequent letters from the Department of the Interior in 1933 and 1947. The 1912 Amendment contained ambiguous language, thus making it unclear whether it was illegal in all cases for an individual to own more than 160 acres or only in cases where the final payments for building charges remain unpaid.[15] A 1933 letter from Secretary of the Interior Wilbur to the Imperial Irrigation District states that the limitation didn't apply to lands "...now cultivated and having a present water right."[16] In 1947, referring back to the 1912 Amendment, Solicitor of the Interior Cohen in a letter to the Commissioner of Reclamation stated the 1912 Amendment meant that the full and final payment of construction charges against excess lands would free the lands of the acreage provision.[17]

---

[14] Statement made as a discussant at the Western Agricultural Economics Association meetings at Montana State University in July 1978.

[15] Nancy Jones. "Proposed Rules for Administering the Acreage Limitation of Reclamation Law." Natural Resource Journal, October 1978. p. 934.

[16] Ibid, p. 937.

[17] Ibid, p. 935.

The Cohen letter (1947) and the 1912 Amendment were tested in the courts in the United States v. Tulare Lake Canal Company in 1976, introducing a trend in litigation aimed at enforcement of the Omnibus Act (1926). The Court rejected the Cohen interpretation of the 1912 Amendment and ruled that all excess land owners must come into compliance with Section 46 of the Omnibus Adjustment Act by executing recordable contracts to dispose of the excess land.[18] In August 1977, a three judge panel from the Ninth Circuit Court denied the validity of the 1933 letter by Secretary Wilbur and ruled that the Imperial Irrigation District was subject to the 160 acre limitation.[19]

In 1976, National Land for the People, Inc. filed a suit against the Bureau of Reclamation questioning the approval of excess land sales in the Westlands Irrigation District.[20] An injuction was granted, in favor of National Land for the People, Inc., enjoining the Secretary of the Interior from approving land sales in the Westlands Irrigation District until administrative rules were established.[21] These suits provided the necessary impetus for an

---

[18] 535 F2d. 1093 (9th Circuit 1976).

[19] U.S. Department of the Interior Proposed Rules for Enforcement of the Reclamation Act of 1902: An Economic Analysis. Staff report by E.S.C.S., U.S.D.A. February 1978. E.S.C.S. - 04. p. 3

[20] 417 F. Supp. 449 (1976) U.S.D.C. This suit was initiated in 1967.

[21] U.S. Department of the Interior, p. 3.

examination of the 160 acre limitation on United States Bureau of Reclamation Irrigation Projects.

The Problem

There are nearly 11 million acres of irrigable land under U.S. Bureau of Reclamation Projects with nearly 393 thousand acres of this total found in Montana. Nationwide, irrigated agriculture accounted for 8.9 percent of total livestock production, 22.4 percent of total crop production and 15.9 percent of total agricultural production in 1977. In Montana, irrigated agriculture accounted for 33 percent of total value of crop production with around 20 percent of this total generated by lands irrigated from U.S. Bureau of Reclamation Projects.[22] Federally funded irrigation projects, under the U.S. Bureau of Reclamation, represent about 7% of Montana's irrigated agricultural production.

Montana is a land of diversity. There are differences in soil condition, climate, crop mix and market potential for each of the 14 irrigation districts under the U.S. Bureau of Reclamation, yet all the federally funded irrigation projects fall under the 160 acre limitation. The 160 acre limitation was largely ignored by the

---

[22] Montana Agricultural Statistics, Vol. XVII (1976-77), Montana Department of Agriculture, W. Gordon McOmber, Director, p. 21 and 1976 Summary Report, p. 70.

irrigated farming community as well as the Bureau of Reclamation until recently. According to the Department of the Interior there are 2.3 million acres of land classed as excess land on projects governed by Federal Reclamation law out of eleven million acres served by the Bureau of Reclamation. California has over 80 percent of all excess lands with Texas, Arizona, Nebraska, Montana and Wyoming accounting for a total of 7 percent of the total excess land.[23]

Excess land disposal is the major issue raised by National Land for the People, Inc. The realization by Secretary of the Interior, Cecil Andrus, that enforcement of the 160 acre limitation may be realized, prompted him to propose the following plan in August of 1977:

(1) An individual may own 160 acres of land receiving project water.

(2) An individual can lease up to 160 acres.

(3) In family-related multiple ownerships, each individual may own 160 acres of land receiving project water.

(4) Purchasers of excess land must reside within 50 miles of it.

(5) All land sales must be approved by the Bureau of Reclamation.[24]

---

[23] U.S. Department of the Interior, p. IV.

[24] Ibid. p. 2-5.

Current revisions to the August 1977 plan include the following:

(1) Individuals may lease up to 480 acres or own and lease not more than 480 acres. Multiple ownerships may lease up to 960 acres or own and lease not more than 960 acres.[25]

The current revision offers significantly larger upper bounds on irrigated farm ownership and leasing. However, the crucial characteristic to be recognized is the emphasis on farm size, not land ownership. The critical consideration now becomes economies of size in a farming operation, rather than economies of size for land ownership.

The Reclamation Act of 1902 provided a significant subsidy to American irrigated agriculture and led to the controversy over the distribution of that subsidy. Proponents of rigorous enforcement of the limitation advocate a more widespread distribution of opportunities provided by the reclamation program. While opponents of the limitation, mainly farmers already benefiting from nonenforcement of the limitation, are demanding freedom to exercise their ingenuity within the limits of the free enterprise system. In essence the argument boils down to the "family farm" ideology of the proponents

---

[25] These revisions were included in a letter from Dr. C. V. Moore in September of 1978.

versus the "efficiency" argument posed by the opponents. Political compromise will require establishing an "adequate farm size" without eliminating the idea of the family farm. This objective was well stated by Dr. Roy Huffman in the following:

> "The family farm should remain as a basic objective in the expenditure of public funds for irrigation development, but it should be a concept consistent with modern agriculture. The combination of resources which can be managed efficiently by the family farm has changed through the years. If an obsolete standard for the family farm is maintained in connection with public irrigation development it may result in the creation of a segment of agriculture which is at a competitive disadvantage not only with highly commercialized agriculture, but the other family farms as well."[26]

The goals of efficiency and equity both warrant consideration. An apparent tradeoff exists. The equity goal requires that a maximum number of people realize the project's benefits, while the efficiency goal requires that farm size be of sufficient size to realize economies of size and minimize production costs per unit of output. This study provides some of the essential information necessary for policy formation concerning the 160 acre limitation in the Lower Yellowstone River Project in Montana. To illuminate the aforementioned policy considerations, economies of size in farming and the relationship between farm size and net farm income will be examined.

---

[26] Roy E. Huffman, Irrigation Development and Public Water Policy, Ronald Press Co., New York, 1953. p. 305.

This analysis employs a linear programming model to (1) estimate the long run average cost curve and (2) estimate the net farm income obtained on alternative farm sizes. The estimation of the long run average cost curve will be used to determine the relationship between the costs of production and farm size. At each point along the curve, net farm revenue can be estimated. From this information policymakers can objectively evaluate the tradeoff between efficiency and equity by considering the net farm revenues available on a given farm size and the corresponding efficiencies obtained.

Research Objectives

The objectives of this study are to:

(1) Develop enterprise cost budgets for the major crops grown in District 1 of the Lower Yellowstone Irrigation Project;

(2) Estimate short and long run average total cost curves for irrigated farms in District 1 of the Lower Yellowstone Irrigation Project under specific product price and resource assumptions;

(3) Estimate net farm revenue obtainable on various farm sizes under specific product price and resource assumptions; and

(4) Determine the required payments to land and capital at selected levels of net farm revenue.

CHAPTER 2

LITERATURE REVIEW

The basic methodology reviewed in this study for estimating long run average cost curves and consequently economies of size extends from H. O. Carter and G. W. Dean's work in the early 1960's to the most recent work of A. S. Kezis in the 1970's. Three general methods are employed in economies of size studies: (1) descriptive, (2) statistical and (3) economic-engineering or synthetic firm method.

The descriptive method involves either a direct analysis of actual firm records or an analysis of composite firm budgets from actual firm records. The direct analysis of actual firm records requires sampling records from firms of various sizes. If firm records are readily available, this procedure is relatively quick and easy. However, this direct accounting method has some rather severe shortcomings. Records are not compatible across all firms. Various accounting methods are employed and the utilization of capacity varies among firms. These shortcomings confuse attempts to examine the firm size efficiency relationship and thus provide little useful information about the affect of firm size on average production costs.

Moran employed the direct analysis of actual records of nonfeed costs for several Arizona feedlots in 1957. At each of the sampled feedlots the average cost per ton of feed was calculated. The feeding

operations were grouped according to the tons of feed used per year to establish a relationship between size and efficiency. Moran found that large feedlots had less than one-third of the nonfeed costs per ton of feed fed when compared to the smaller feedlots. The results of the study were clouded by the fact that (1) feedlots employed various percentages of their total capacity and (2) the observed average costs for the feedlots varied with the length of the feeding period, classes of feeders fed and the types and quantities of feed used.[27]

The composite firm budget from actual firm records procedure involves only a slight modification from the direct analysis procedure. Firm records are separated into size classes and a "typical firm" is developed for each firm size using average acreage, investment, acres in each crop, yield, application rates, etc. The size-efficiency relationship is established by comparing costs across each composite or "typical firm". This procedure is quick and easy and it sheds some light on the internal structure of the firm. However, this procedure has some inherent problems: (1) the same basic accounting records are used as in the direct analysis and thus it suffers the same problems with the compatibility of the basic cost data; (2) the classification of firms according to size require making a subjective judgment of

---

[27] Leo J. Moran, "Nonfeed Costs of Arizona Cattle Feeding." (Arizona Agricultural Experiment Station Technical Bulletin No. 138, December 1959.)

the width of class intervals, therefore the "typical firm" may not represent the actual average cost of firms in their respective class sizes; and (3) firms operate at various percentages of full capacity and often employ inefficient combinations of resources. Therefore, the size-efficiency relationship does not accurately reflect the potential efficiency attainable by firms of various sizes.

Maier and Loftsgard employed the composite firm procedure in analyzing the costs and practices of potato producers in the Red River Valley of North Dakota. Average costs were calculated per hundred weight of potatoes. The farms analyzed were grouped into three major groups, based on the acres of potatoes cultivated, to compare the costs and practices of potato producers as farm size increased. The larger farms were found to have the lowest average cost. The difference in average costs were attributed to difference in size and cultural practices.[28]

The second method commonly used to estimate the long run average cost curve is the statistical method, i.e. ordinary least squares. Costs are regressed on outputs to estimate the parameters determining the relationship between firm size and cost. This method is employed to compensate for limited cost data available from firms, specifically to account for excess capacity or underutilization of facilities and

---

[28] Melvin G. Mayer and Laurel D. Loftsgard. "Potato Production Costs and Practices in the Red River Valley." (North Dakota Agricultural Experiment Station Bulletin, No. 451, September 1964.)

differences in reported costs and prices from firm records. Kezis cited several problems with this approach: (1) as with the descriptive method, accounting data from farm records are used and caused some of the same problems; (2) regression fallacy may arise when costs are regressed on output and capacity is not considered in the problem formulation and (3) linear regression is an averaging technique, therefore the long run average cost curve is an average LRAC curve, rather than an efficiency frontier as it should be.[29]

Carter and Dean employed this method in analyzing cash crop farms in the Imperial Valley (1962). In the cash crop farm study, they compensated for the excess capacity problem by including a degree of utilization variable in the multiple regression model. By fixing the utilization variable, each farm size could be evaluated on a comparable basis. They found that (1) economies of size could be realized up to around 1500 to 2000 irrigated acres, (2) highly mechanized larger farms often underutilize their capacity and consequently may have higher per unit costs than smaller operations better utilizing their capacity; and (3) farms of any size could operate efficiently and make a reasonable

---

29 Alan S. Kezis, op. cit., p. 33.

profit under the conditions in 1959.[30]

The third method considered in this literature review is the synthetic firm, or economic engineering method. This method allows the researcher to construct firms from the best estimators available on production parameters and resource requirements. Budgets are generated from available input-output data in an attempt to isolate the firm size - efficiency relationships without interference from the degree of plant utilization, use of obsolete technologies, substandard management practices, etc. When a few alternative choices are considered simple budgeting is adequate, however as the number of input and output options increase mathematical programming becomes appropriate.

A host of studies, including ones authored by H. O. Carter and E. W. Dean, R. Barker, and J. P. Madden and B. Davis have employed synthetic firm budgeting and mathematical programming. A variable capital programming model was employed by Carter and Dean (1961) to calculate the maximum gross income per dollar of capital at various levels of investment. Variable resource and price techniques were employed by Barker in 1960 to estimate average cost curves. Mixed integer programming was employed by Madden and Davis in 1965 to better handle fixed costs in their economies of size analysis.

---

[30] Harold O. Carter and Gerald W. Dean, "Cost-Size Relationships for Cash Crop Farms in Imperial Valley, California." (California Agricultural Experiment Station, Giannini Foundation Research Report, No. 253, May 1962.)

The Madden and Davis study of irrigated cotton farms on the Texas High Plains employed synthetic firm budgeting and mathematical programming. Irrigation wells, land, permanent laborers, tractors and machinery complements were available only in discrete units, which was made possible by the use of mixed integer programming. Short run average cost curves were generated by varying output, proxied by total revenue, and thus enabling the firm size-efficiency relationship to be considered by examining the long run average cost curve. They found, given available capital, that a one man farm could be as efficient as any larger farm.

Carter and Dean in a study of California cling peaches (1963) compared two analytical methods, (1) statistical, or regression analysis, and (2) synthetic-firm budgeting. The most significant difference between the two methods is that the synthetic firm budgeting method indicated smaller reductions in average cost as farm size increased. The ability of synthetic firm budgeting to better fit machinery to requirements, and thus reduce excess capacity, enables a more accurate estimation of the potential efficiency attainable by different size firms.

A. S. Kezis in a study of irrigated farms in the Columbia River Basin provided the basic approach employed in this study. Kezis employed a synthetic firm-mathematical programming to approximate the long run average cost curve and net revenues for various farm sizes. In his formulation, the crop mix, machinery complement and irrigation

system are allowed to vary on a given farm size. In this study, Kezis found that (1) economies of size are realized by a 320 acre farm; (2) net revenue is responsive to changes in product prices and the level of land payments; (3) average costs and net revenue vary considerably on a given farm size; (4) net revenue increases at a ratio slightly more than in proportion to farm size and (5) required capital investments are high for all farm sizes considered.[31]

The review of literature highlights the most widely used methods for examining economies of size. These studies, done largely in the 1960's, are the principle works employed on more recent studies addressing the 160 acre limitation.

---

[31] Kezis, op. cit., p. v.

CHAPTER 3

THEORY AND METHODS

In this chapter, the theory and methods employed for this study are reviewed. The theory section reviews the neoclassical price theory relevant to the study. The methods section outlines the data collected, major assumptions, the model and subsequent analysis employed in this study.

Theory

The theoretical framework for viewing efficiency is provided by neoclassical price theory. The basic relationship in considering these production efficiencies is the production function which relates the level of output to the quantity of variable inputs employed. Production efficiency is traditionally divided into three categories: (1) technical efficiency, (2) price efficiency, and (3) scale efficiency.

Technical efficiency results from more adequate utilization of the resources productive capacity. If a single output is produced utilizing one variable input with all other variables held constant, the relationship between the quantity of output produced and the quantity of the variable input used defines the concept of technical efficiency. In Figure 1, the area shaded under the production function represents possible production. Any points below the

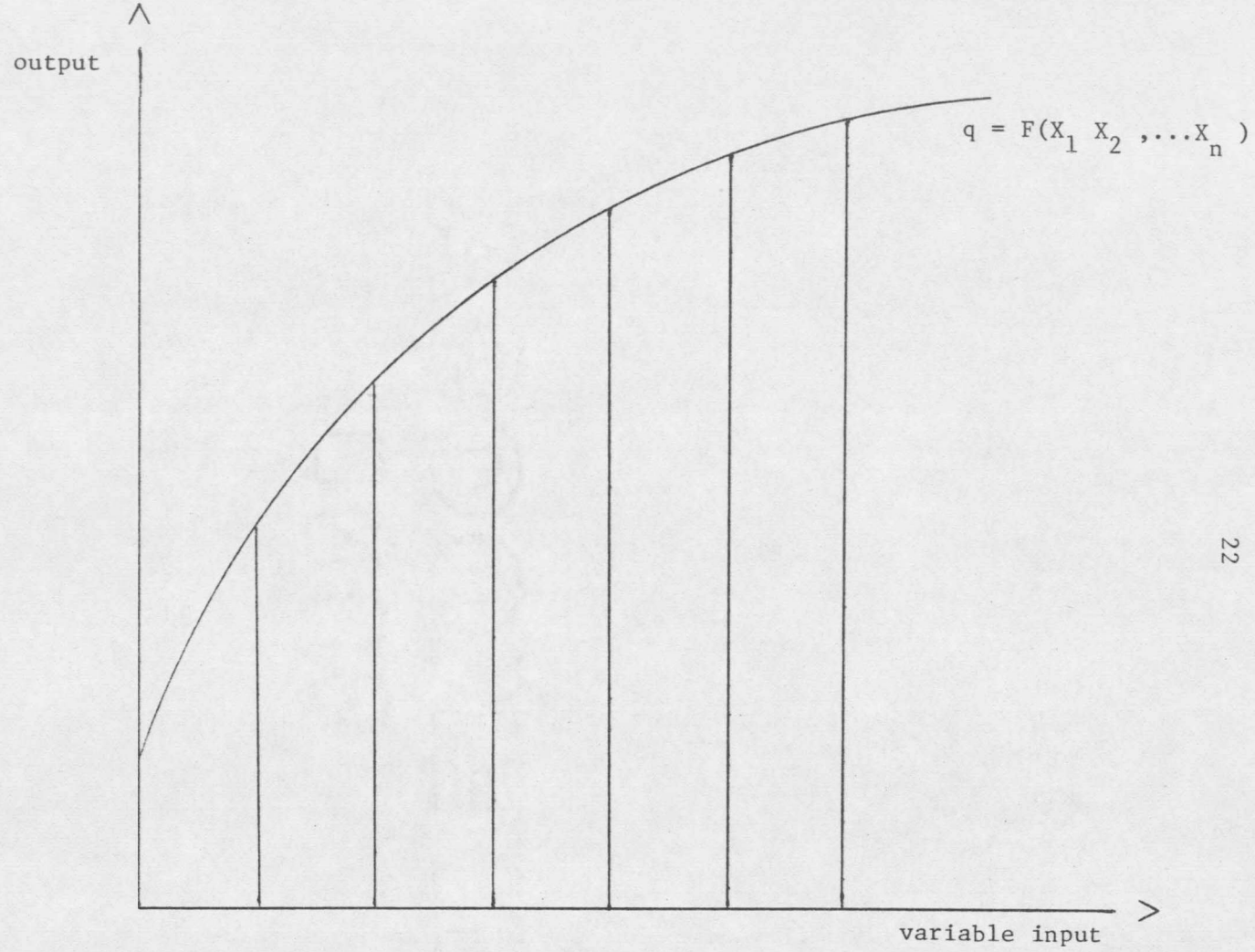


FIGURE 1. Production Function With One Variable Input.