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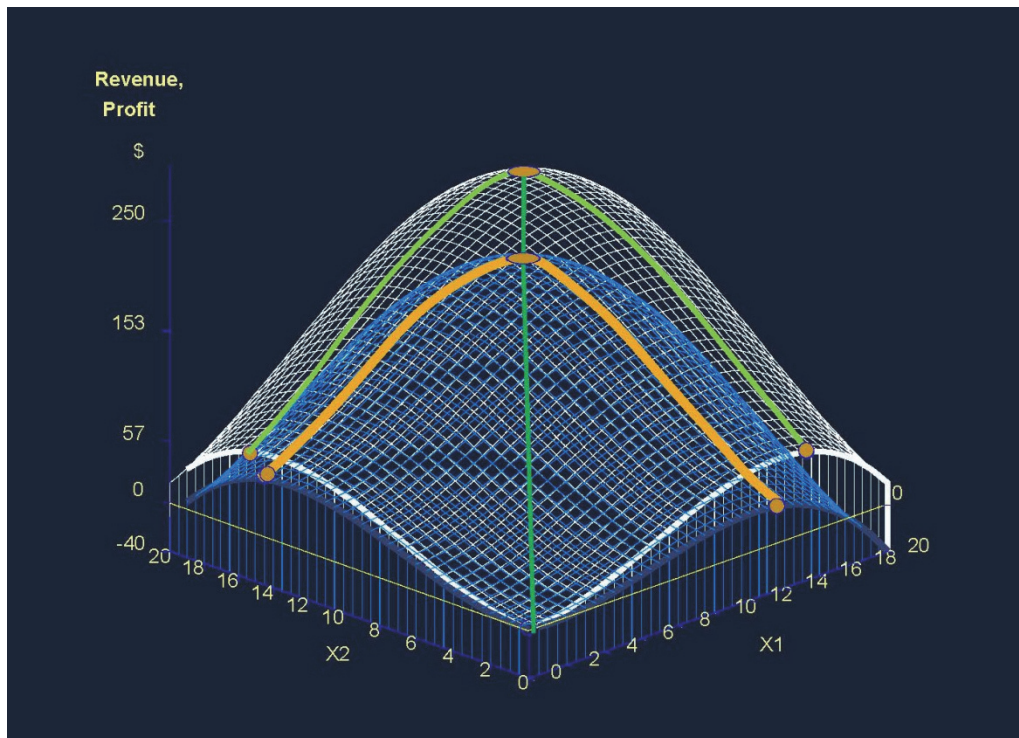
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Agricultural Production Economics

The Art of Production Theory



David L. Debertain

Agricultural Production Economics

The Art of Production Theory

Agricultural Production Economics (The Art of Production Theory) is a companion book of color illustrations to *Agricultural Production Economics* (Second Edition, Amazon Createspace 2012) and is a free download. A bound print copy is also available on amazon.com at a nominal cost under the following ISBN numbers:

ISBN- 13: 978-1470129262
ISBN- 10: 1470129264

This is a book of full-color illustrations intended for use as a companion to *Agricultural Production Economics, Second Edition*. Each of the 98 pages of illustrations is a large, full-color version of the corresponding numbered figure in the book *Agricultural Production Economics*. The illustrations are each a labor of love by the author representing a combination of science and art. They combine modern computer graphics technologies with the author's skills as both as a production economist and as a graphics artist. Technologies used in making the illustrations trace the evolution of computer graphics over the past 30 years. Many of the hand-drawn illustrations were initially drawn using the Draw Partner routines from Harvard Graphics®. Wire-grid 3-D illustrations were created using SAS Graph®. Some illustrations combine hand-drawn lines using Draw Partner and the draw features of Microsoft PowerPoint® with computer-generated graphics from SAS®. As a companion text to *Agricultural Production Economics, Second Edition*, these color figures display the full vibrancy of the modern production theory of economics.

This is one of three agricultural economics textbooks by David L. Debertin. *Agricultural Production Economics (Second Edition, Amazon Createspace 2012)* is a revised edition of the Textbook *Agricultural Production Economics* published by Macmillan in 1986 (ISBN 0-02-328060-3). and a free pdf download of the entire book. As the author, I own the copyright. Amazon markets bound print copies of the book at amazon.com at a nominal price for classroom use. Bound paper copies of the book can also be ordered through college bookstores using the following ISBN numbers:

ISBN-13 978-1469960647 or
ISBN-10 1469960648

The third book is aimed at upper-division undergraduate students of microeconomics in agricultural economics and economics. It is a 242-page book titled *Applied Microeconomics (Consumption, Production and Markets)* and is a free download. Bound print copies are also available at amazon.com and through college bookstores at a nominal cost under the following ISBN numbers:

ISBN-13: 978-1475244342
ISBN-10: 1475244347

This book *Applied Microeconomics* is much newer than *Agricultural Production Economics*, having been completed in 2012. As the author, I would suggest downloading and studying this *Applied Microeconomics* book *before* diving into *Agricultural Production Economics*. This book uses spreadsheets to calculate numbers and draw graphs. Many of the examples and numbers are the same ones used in *Agricultural Production Economics*, so the two books are tied to each other.

If you have difficulty accessing or downloading any of these books, or have other questions, contact me at the email address, below.

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David L. Debertin is Professor Emeritus of Agricultural Economics at the University of Kentucky, Lexington, Kentucky and has been on the University of Kentucky Agricultural Economics faculty since 1974 with a specialization in agricultural production and community resource economics. He received a B.S. and an M.S. degree from North Dakota State University, and completed a Ph.D. in Agricultural Economics at Purdue University in 1973. He has taught the introductory graduate-level course in agricultural production economics in each year he has been at the University of Kentucky. The first edition of Agricultural Production economics was published in hardback by Macmillan in 1986. He began work on the second edition of the book after the Macmillan edition went out of print in 1992, taking advantage of emerging two-and three-dimensional computer graphics technologies by linking these to the calculus of the modern theory of production economics. This is a book of full-color illustrations intended for use as a companion to *Agricultural Production Economics, Second Edition*. Each of the 98 pages of illustrations is a large, full-color version of the corresponding numbered figure in the book *Agricultural Production Economics*.

Agricultural Production Economics

THE ART OF PRODUCTION THEORY

DAVID L. DEBERTIN
University of Kentucky

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Debertin, David L.
Agricultural Production Economics
The Art of Production Theory

1. Agricultural production economics
2. Agriculture–Economic aspects–Econometric models

ISBN- 13: 978-1470129262 2
ISBN- 10: 1470129264

BISAC: Business and Economics/Economics/Microeconomics

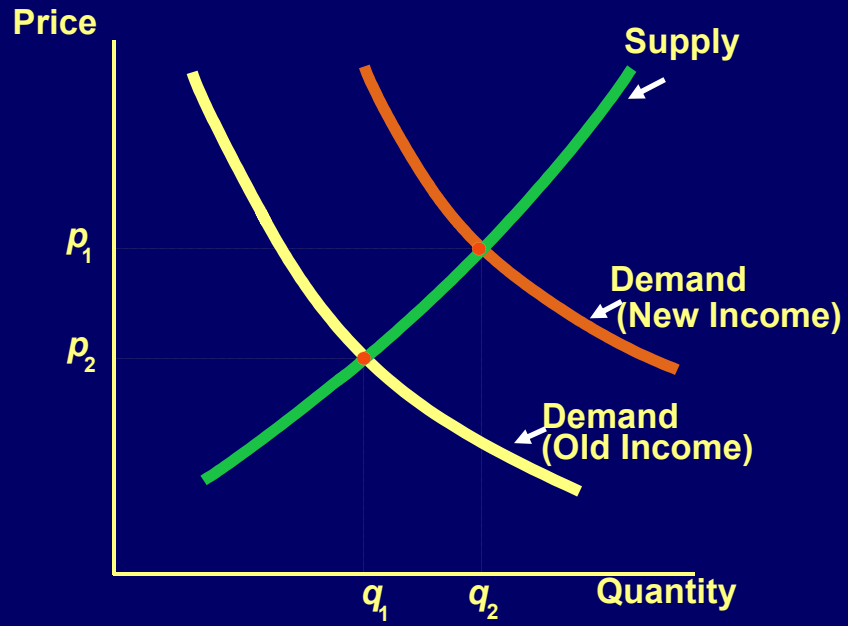


Figure 1.1 Supply and Demand

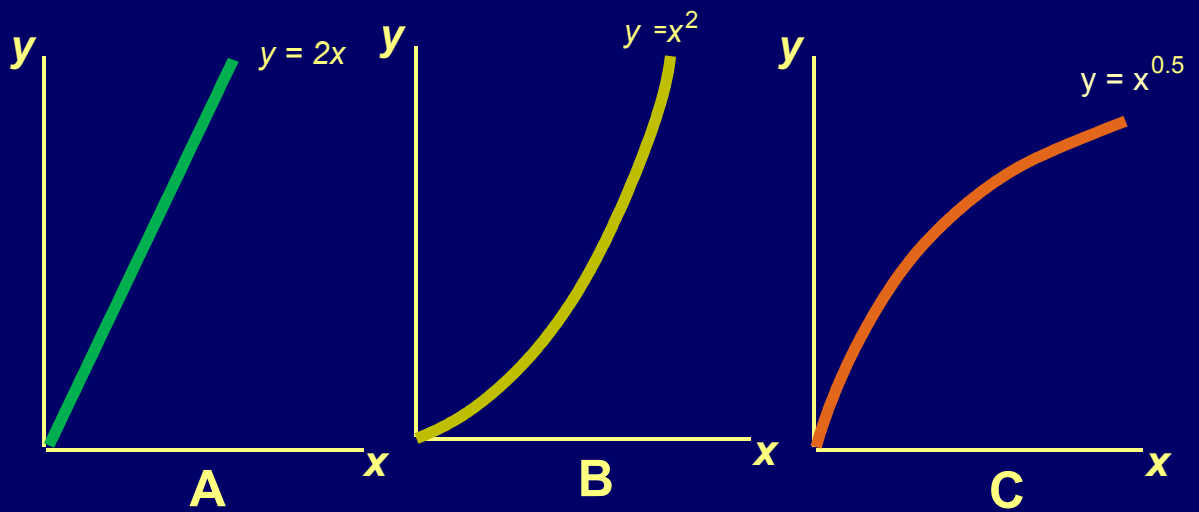


Figure 2.1 Three Production Functions

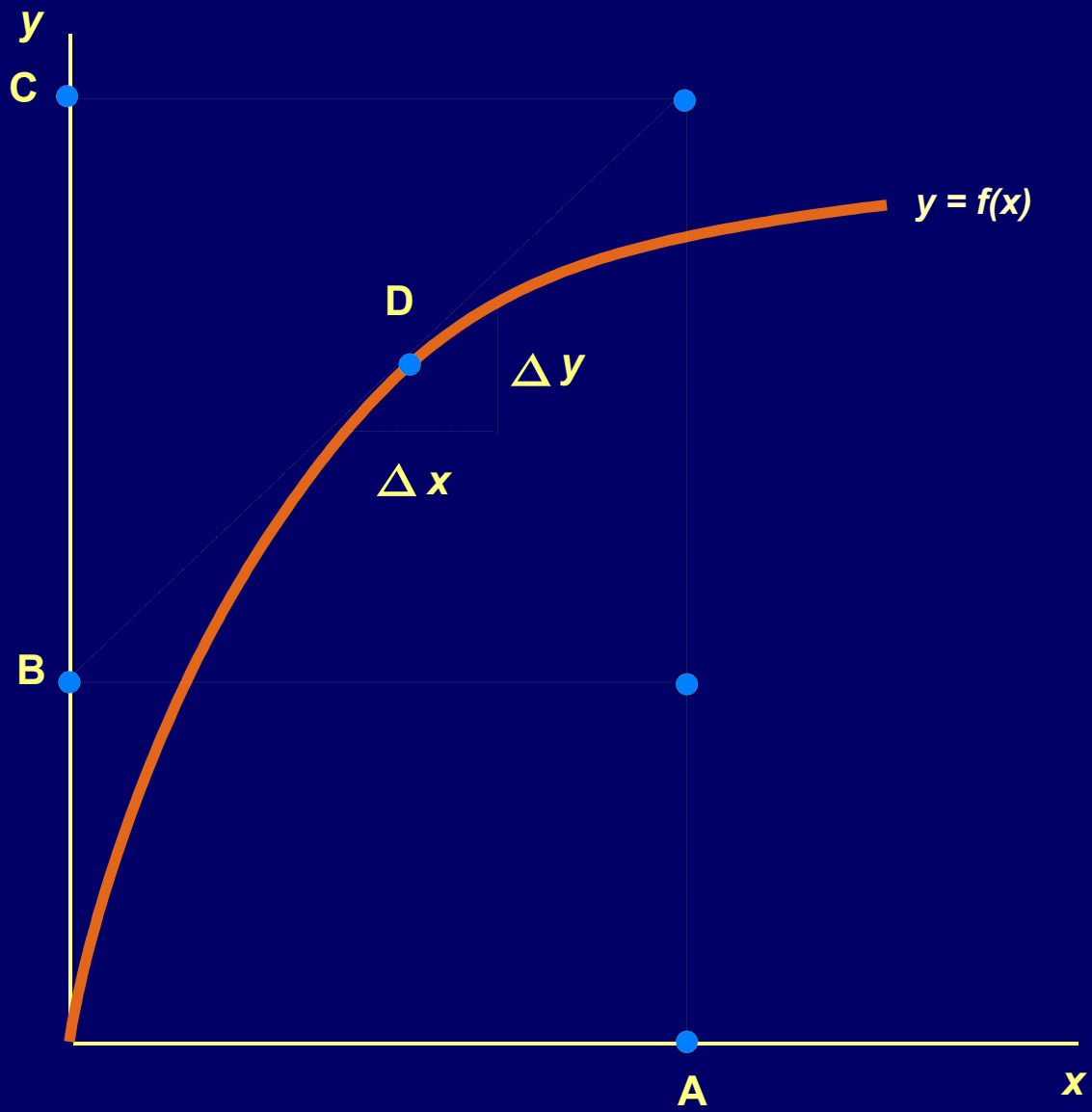


Figure 2.2 Approximate and Exact *MPP*

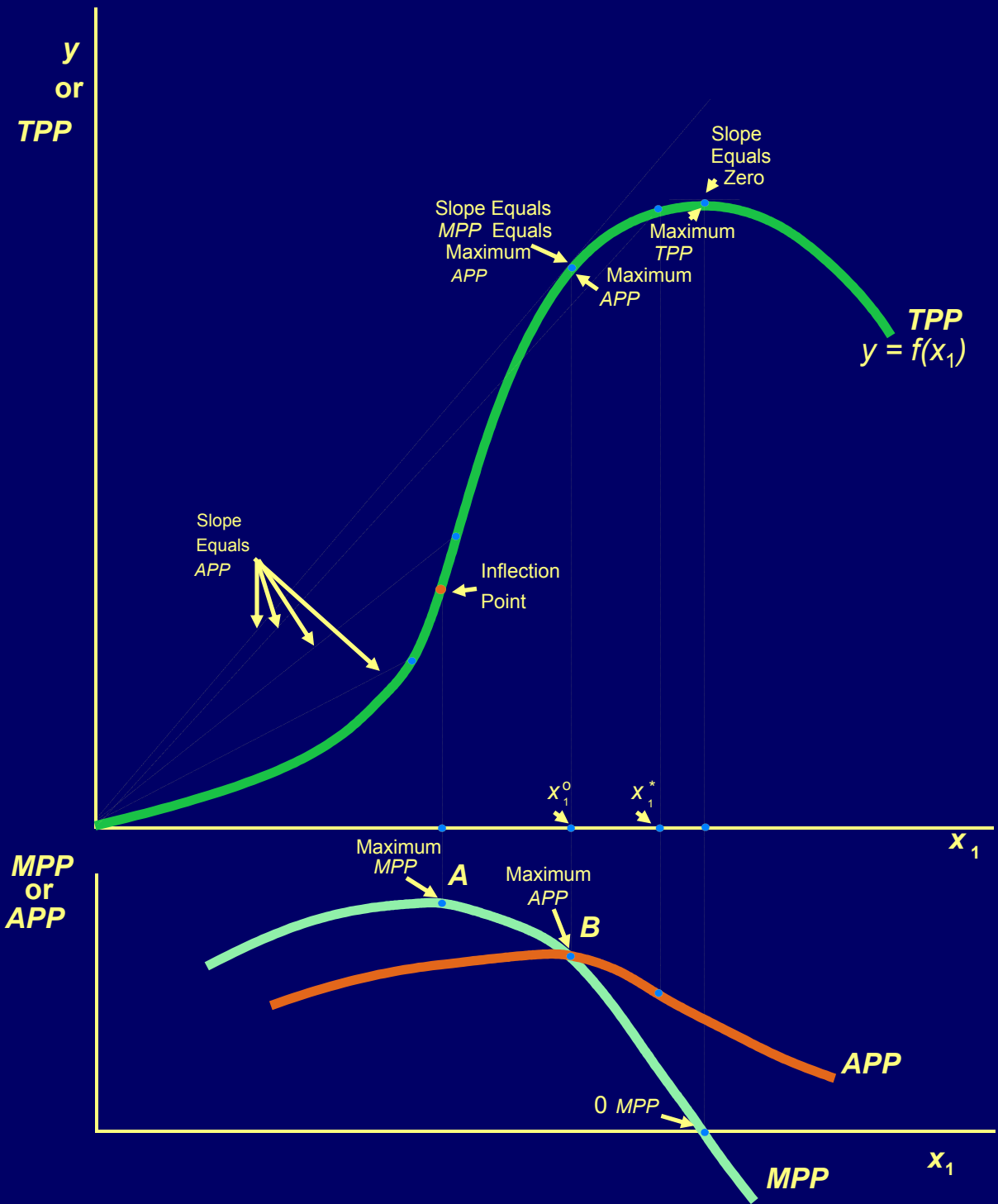


Figure 2.3 A Neoclassical Production Function

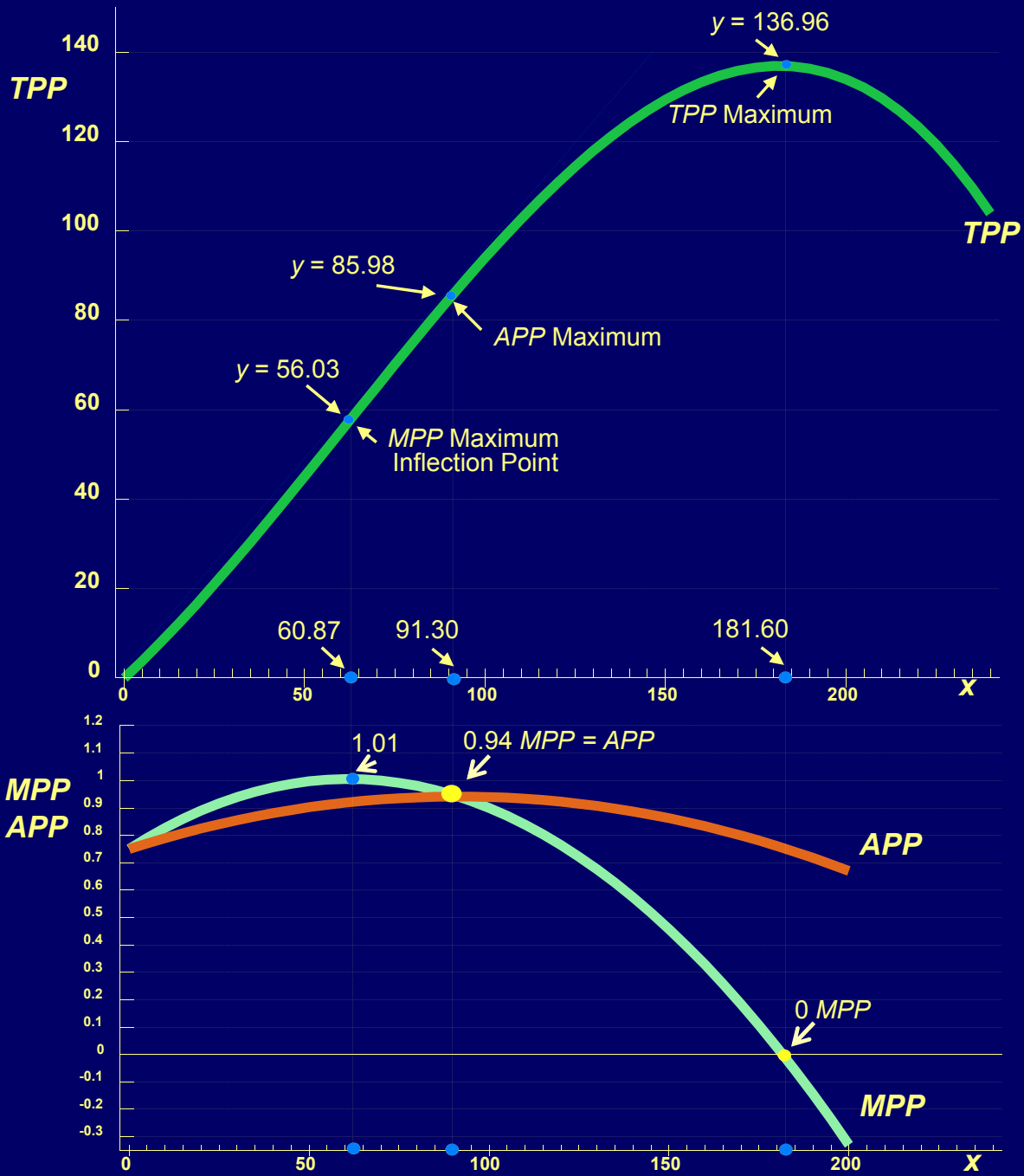


Figure 2.4 *TPP*, *MPP* and *APP* for Corn (y) Response to Nitrogen (x) Based on Table 2.5 Data

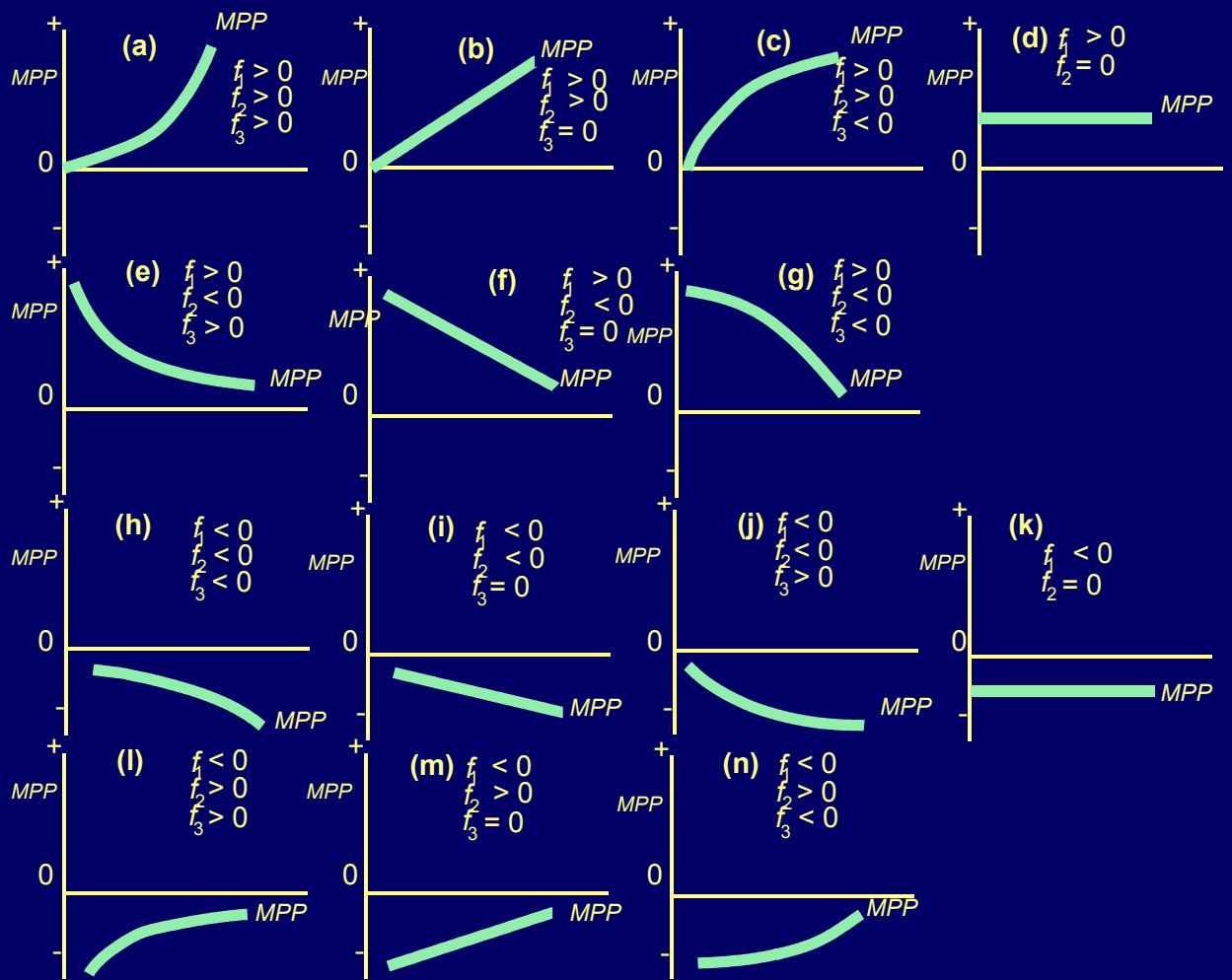


Figure 2.5 MPP's for the Production Function $y = f(x)$

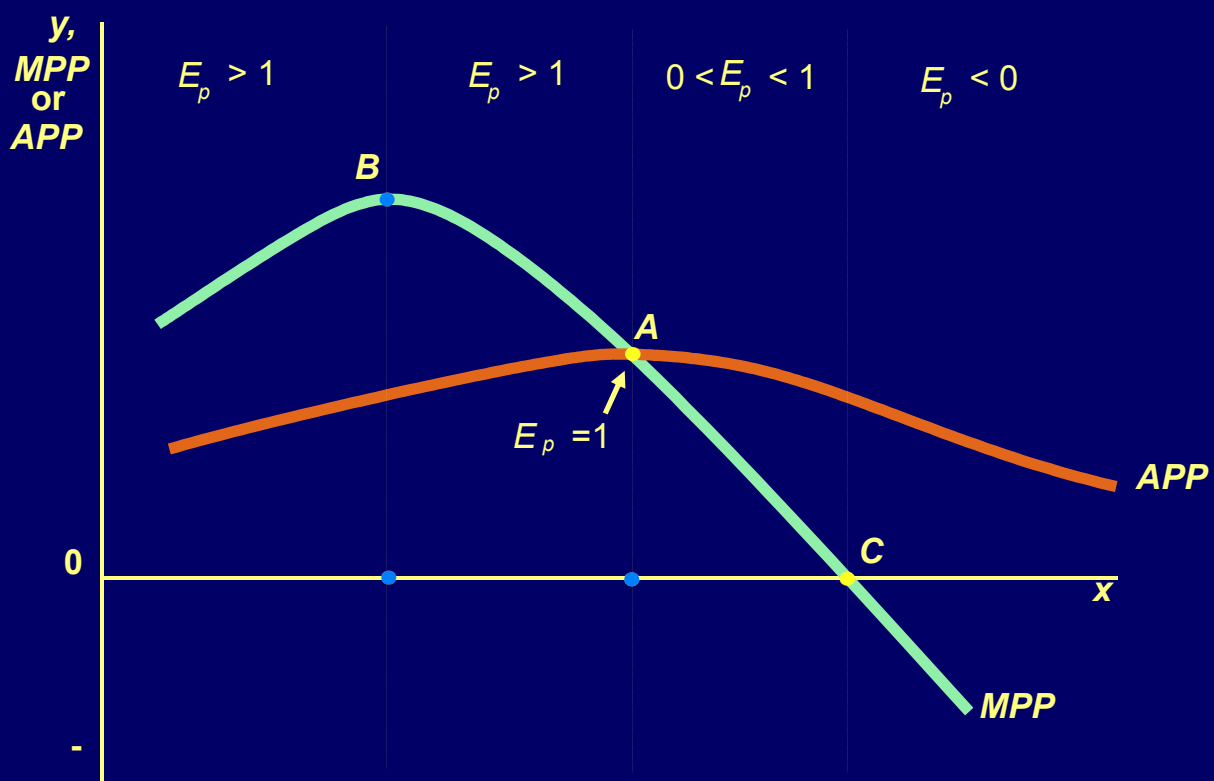


Figure 2.6 *MPP, APP and the Elasticity of Production*

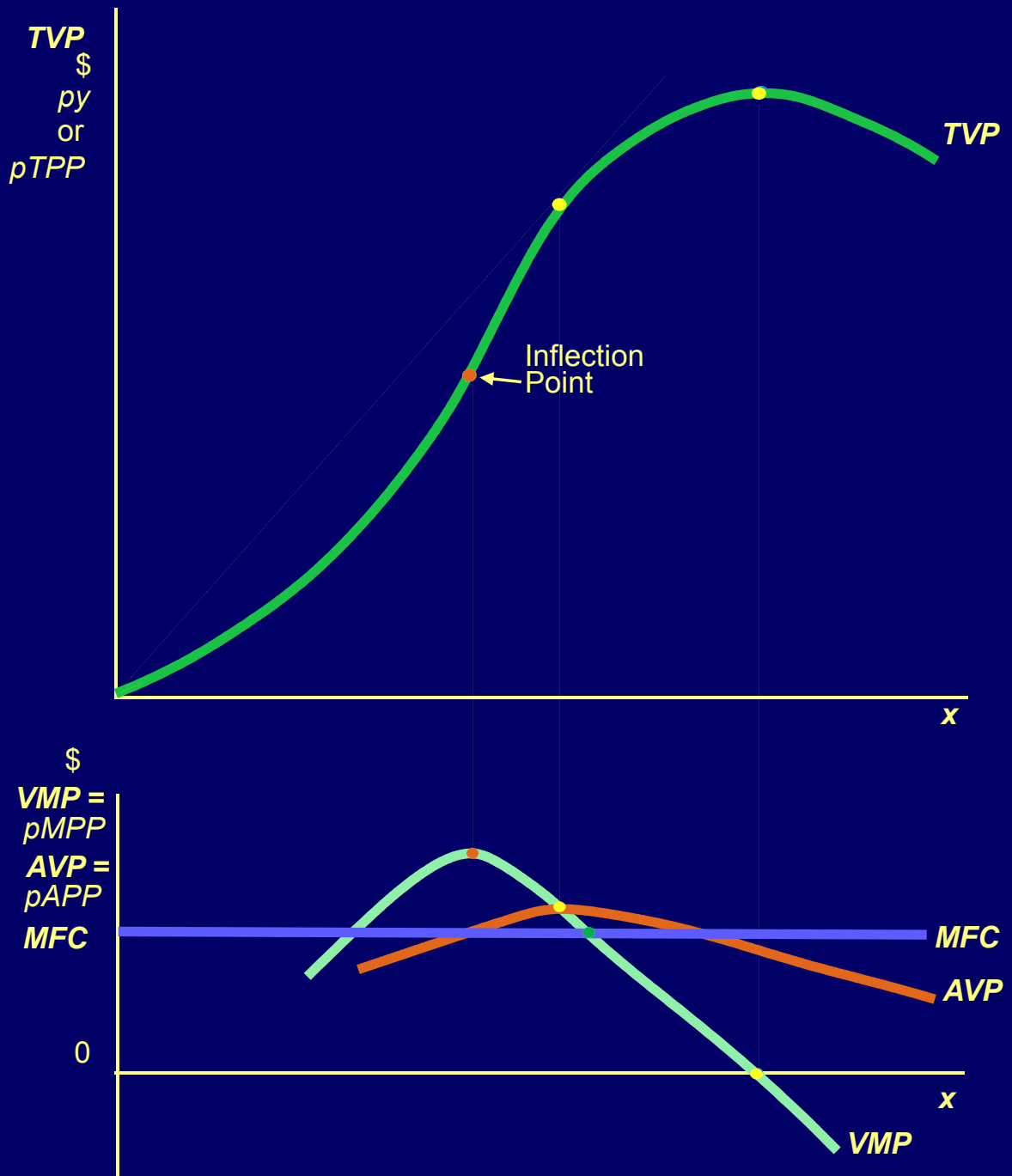


Figure 3.1 The Relationship Between TVP , VMP , AVP , and MFC

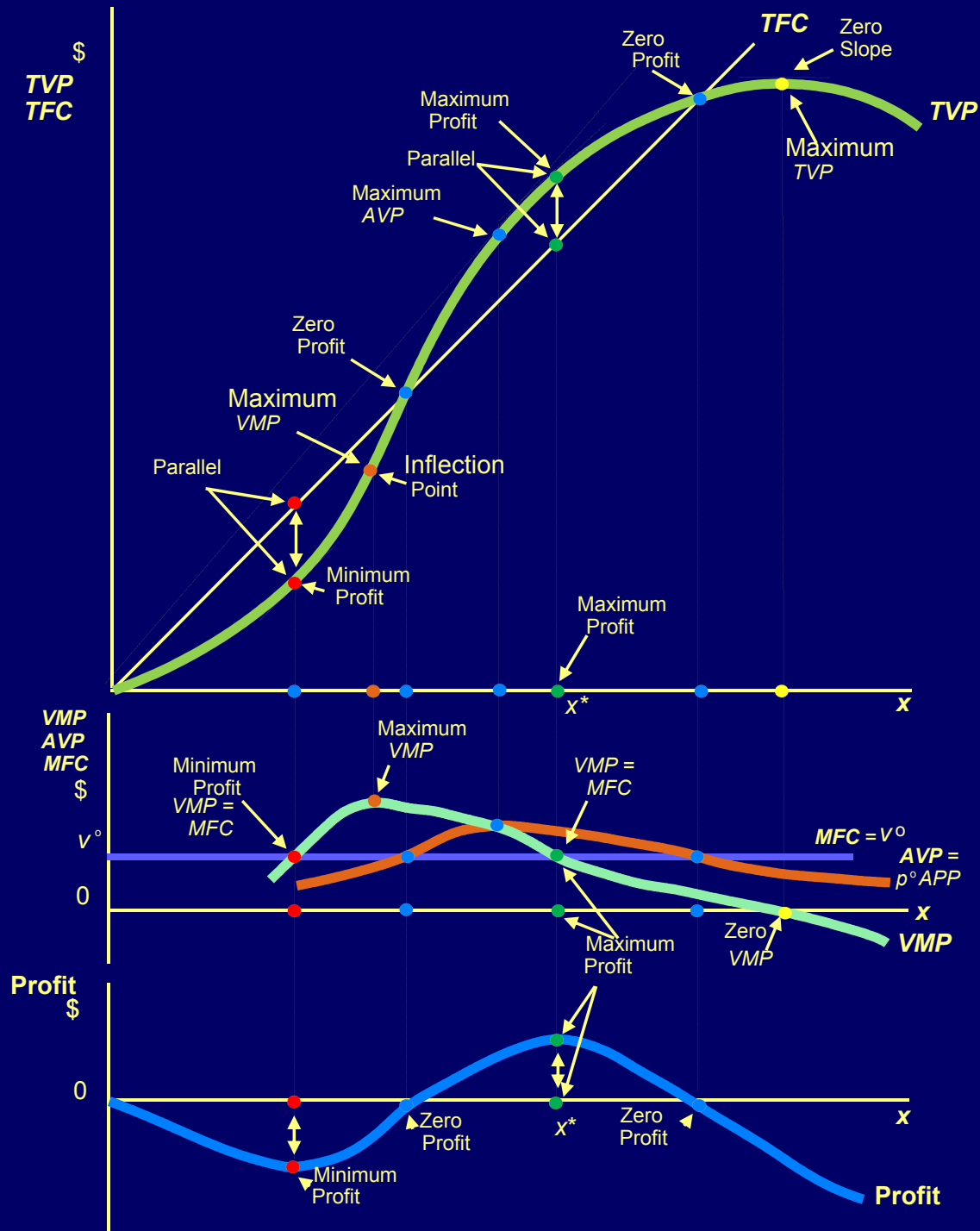


Figure 3.2 TVP , TFC , VMP , MFC and Profit

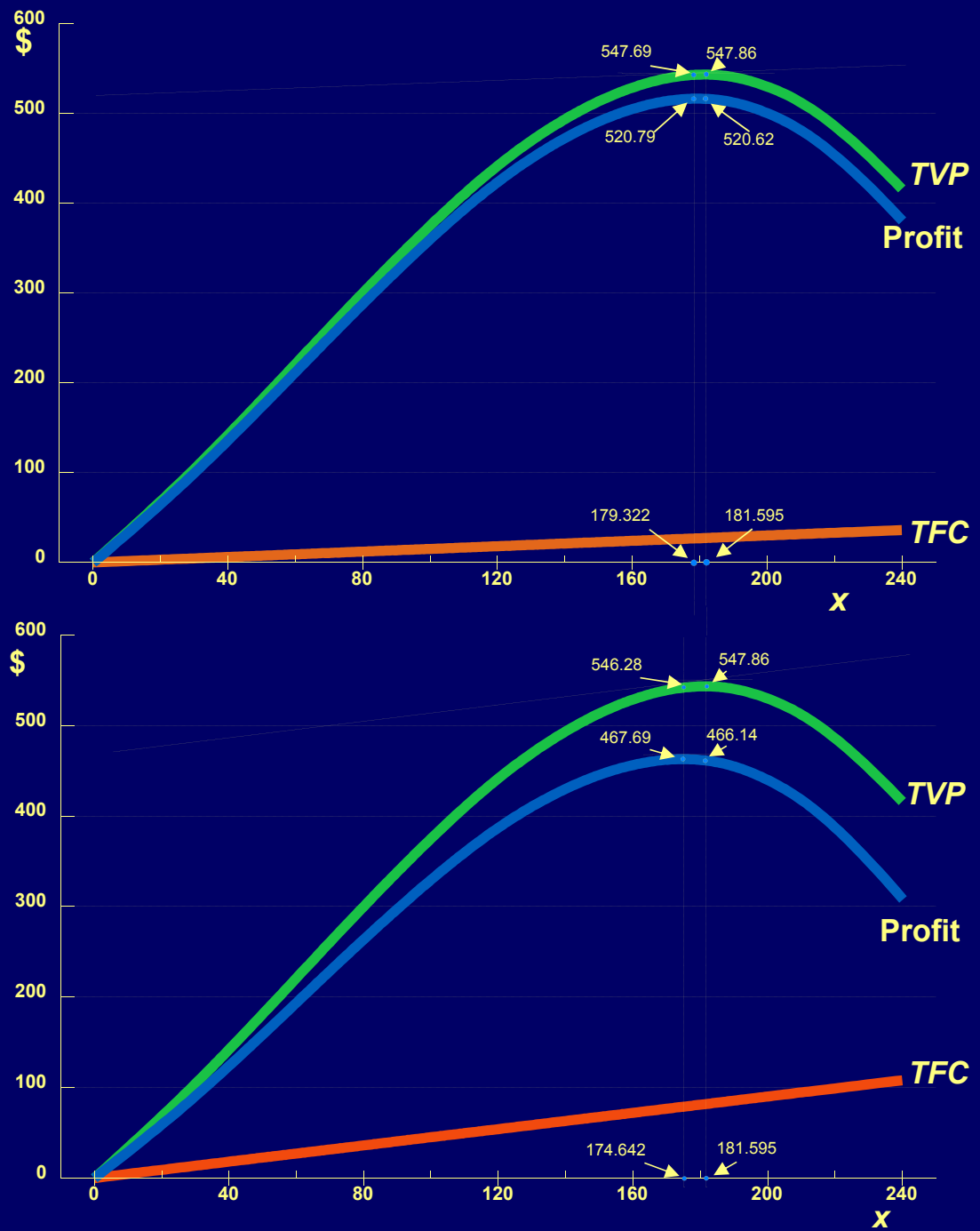


Figure 3.3 *TVP*, *TFC* and Profit (Top and Second Panel)

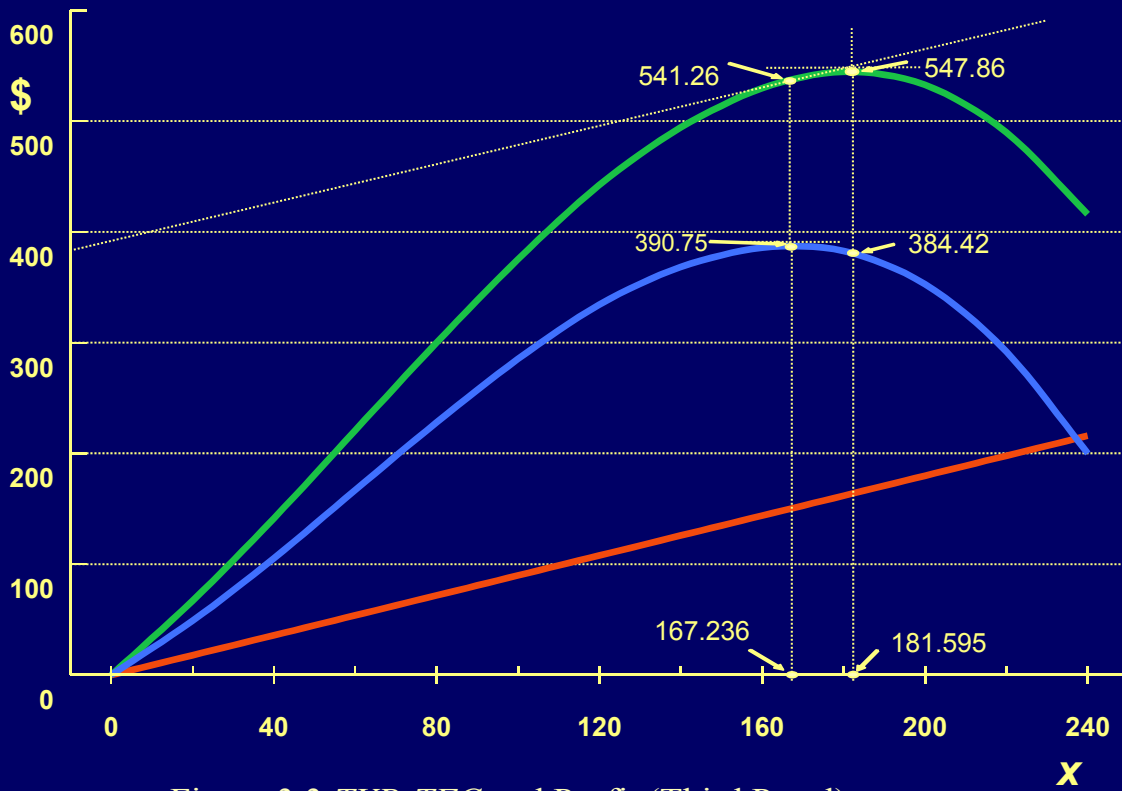


Figure 3.3 *TVP, TFC and Profit (Third Panel)*

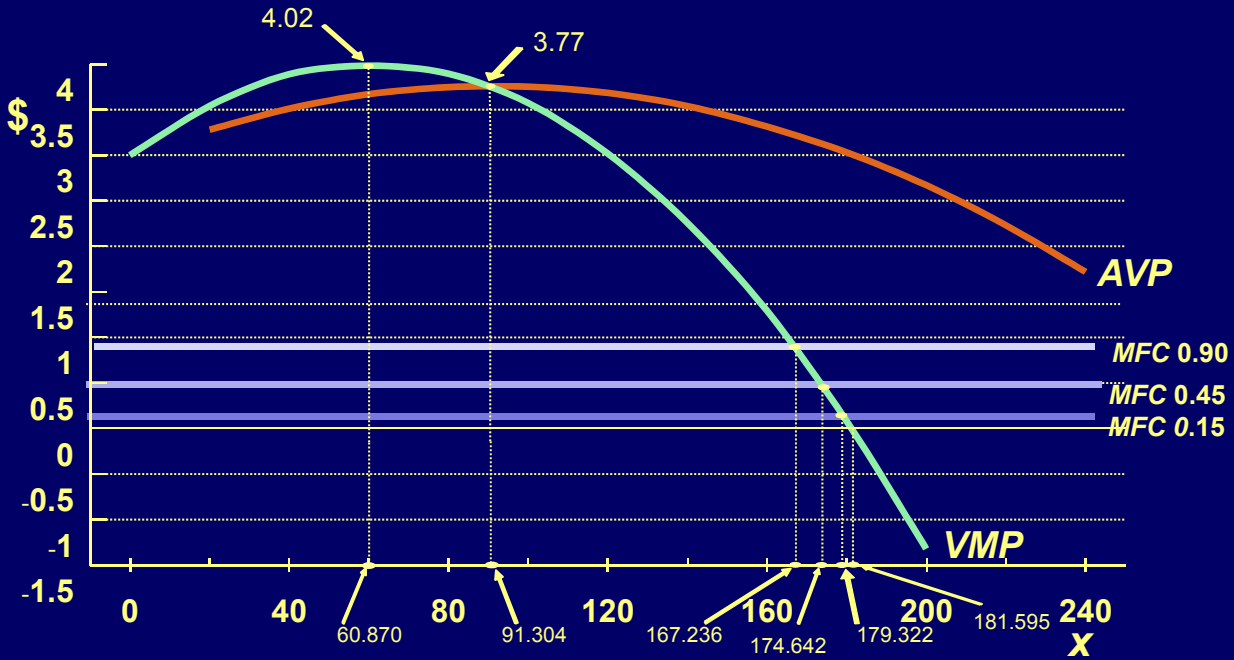


Figure 3.3 Profit Maximization under Varying Assumptions with Respect to Input Prices (Bottom Panel)

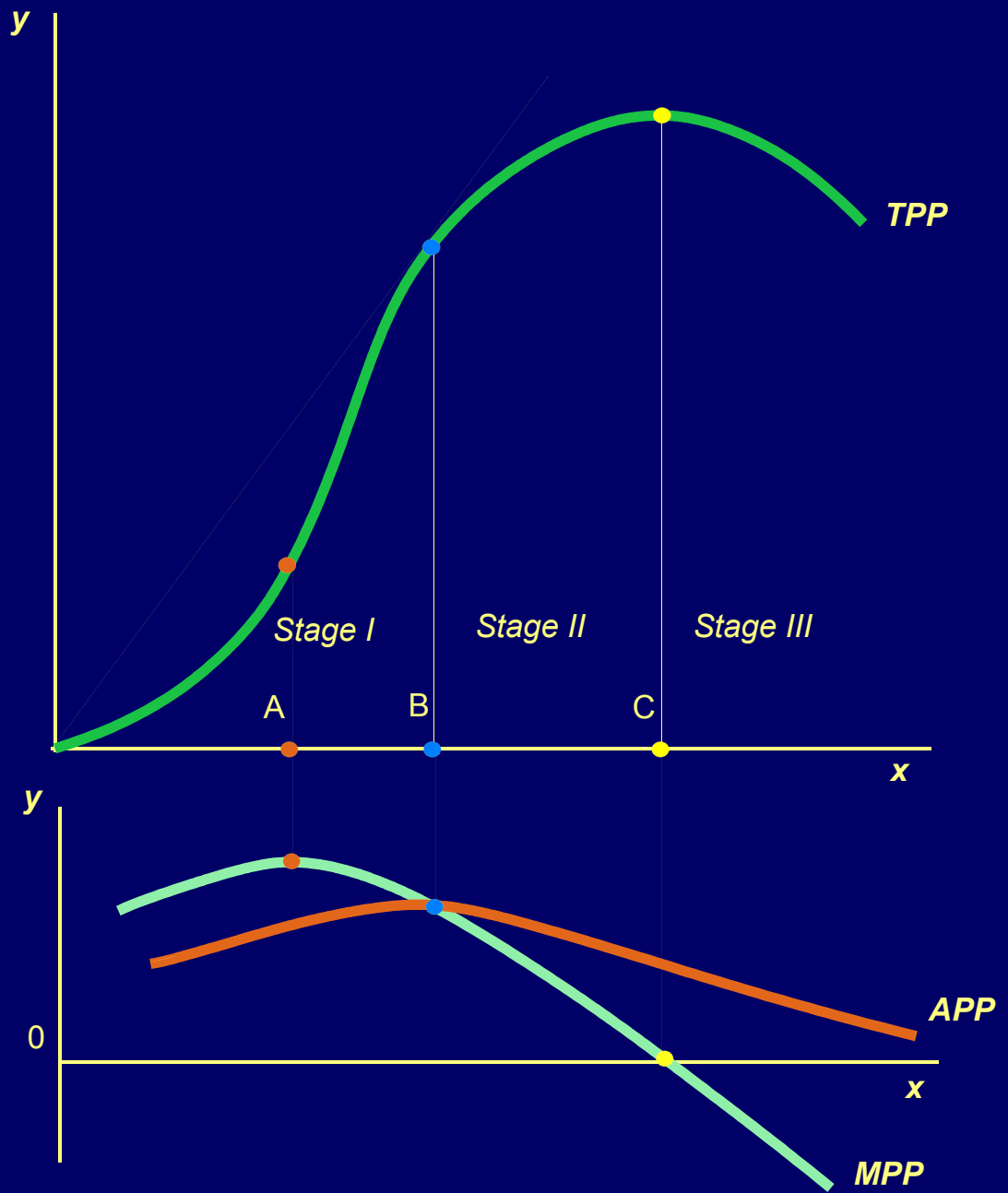


Figure 3.4 Stages of Production and the Neoclassical Production Function

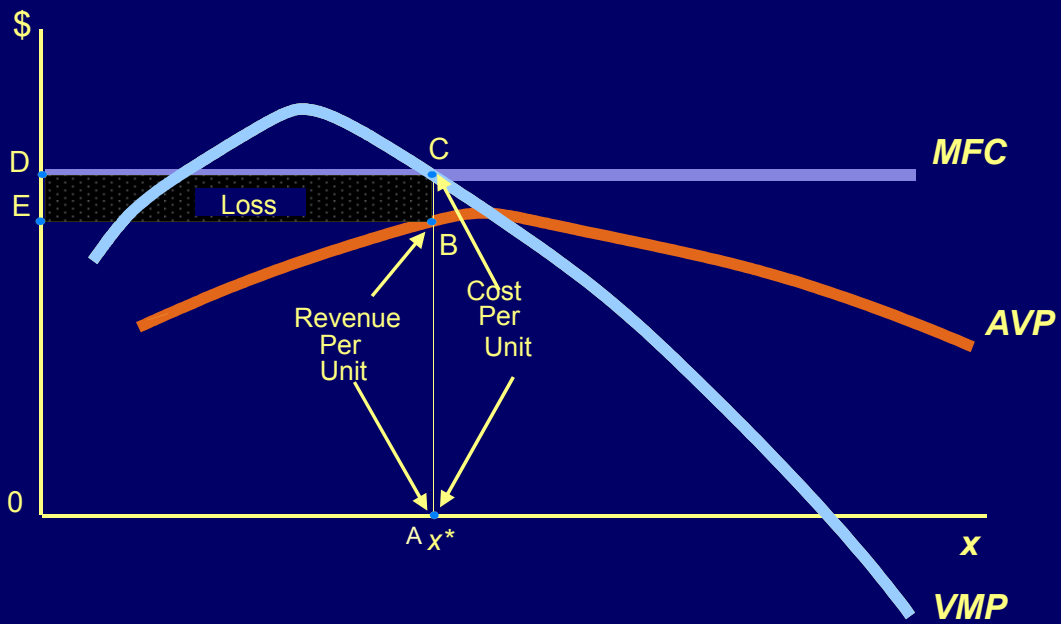


Figure 3.5 If *VMP* is Greater than *AVP*, the Farmer Will Not Operate

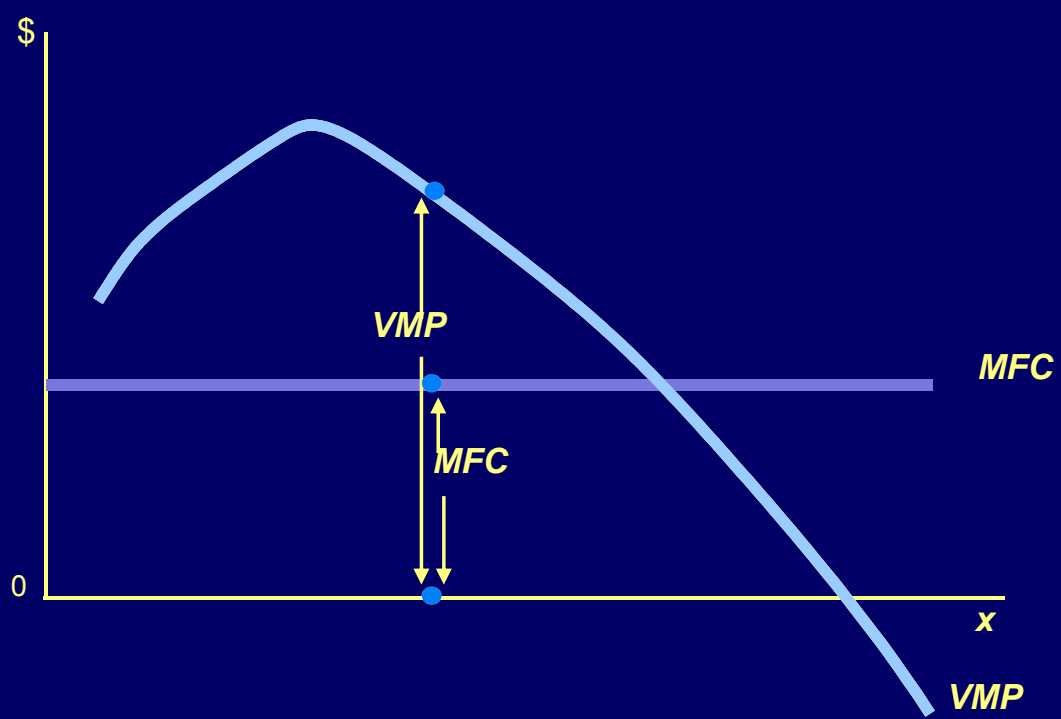


Figure 3.6 The Relationship Between *VMP* and *MFC* Illustrating the Imputed Value of an Input

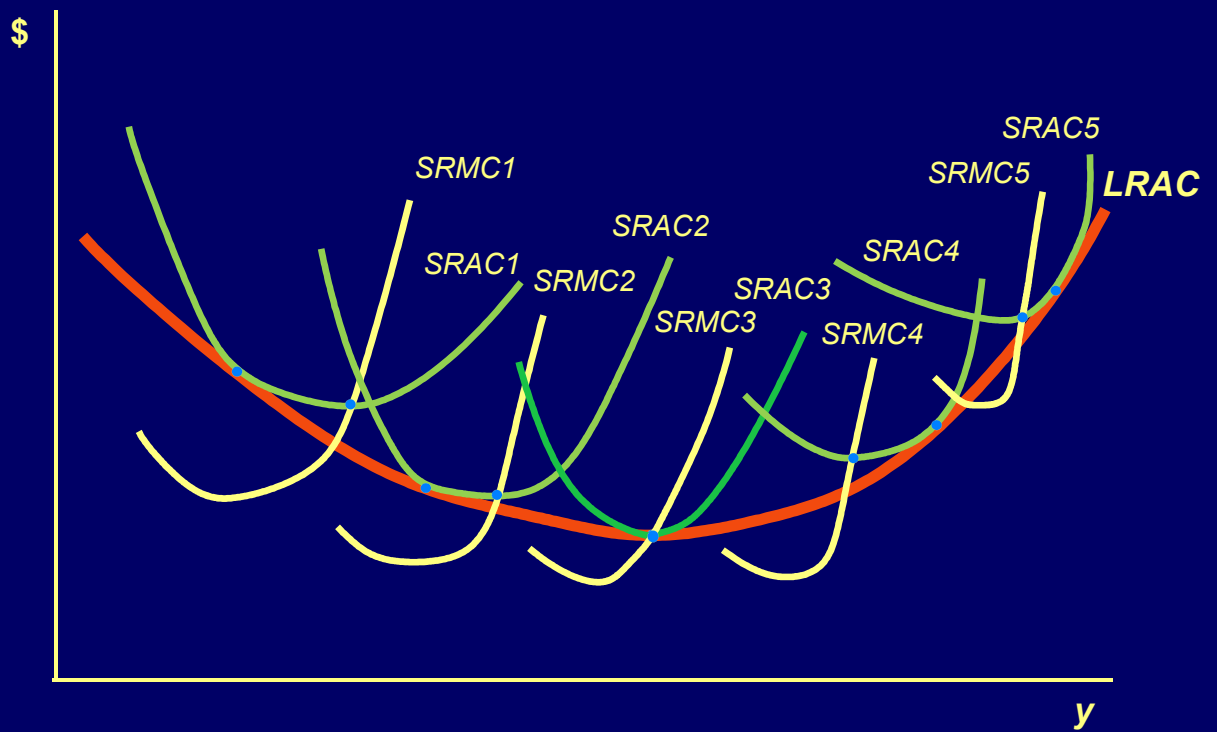


Figure 4.1 Short and Long Run Average and Marginal Cost with Envelope Long Run Average Cost

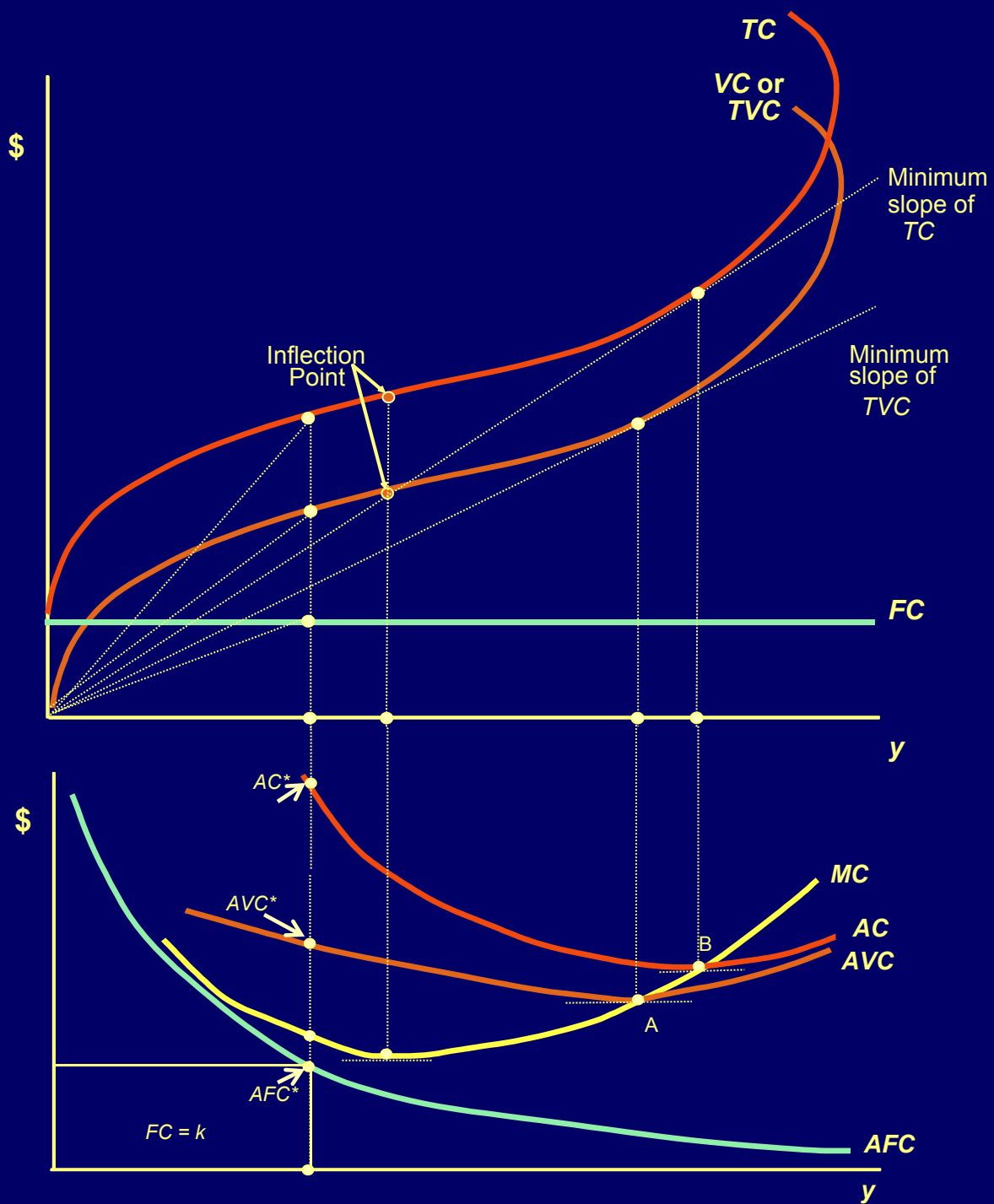


Figure 4.2 Cost Functions on the Output Side

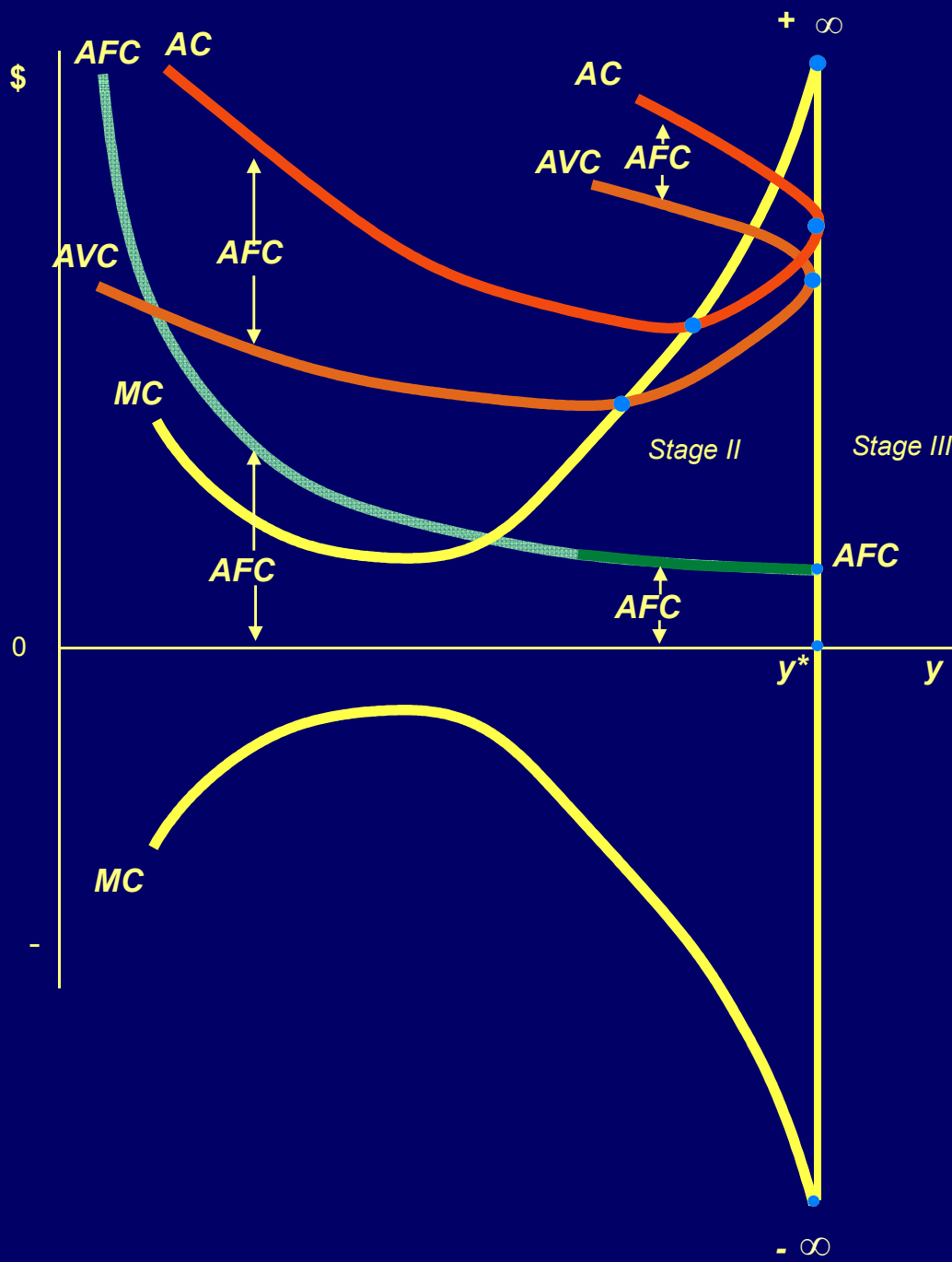


Figure 4.3 Behavior of Cost Curves as Output Approaches a Technical Maximum y^*

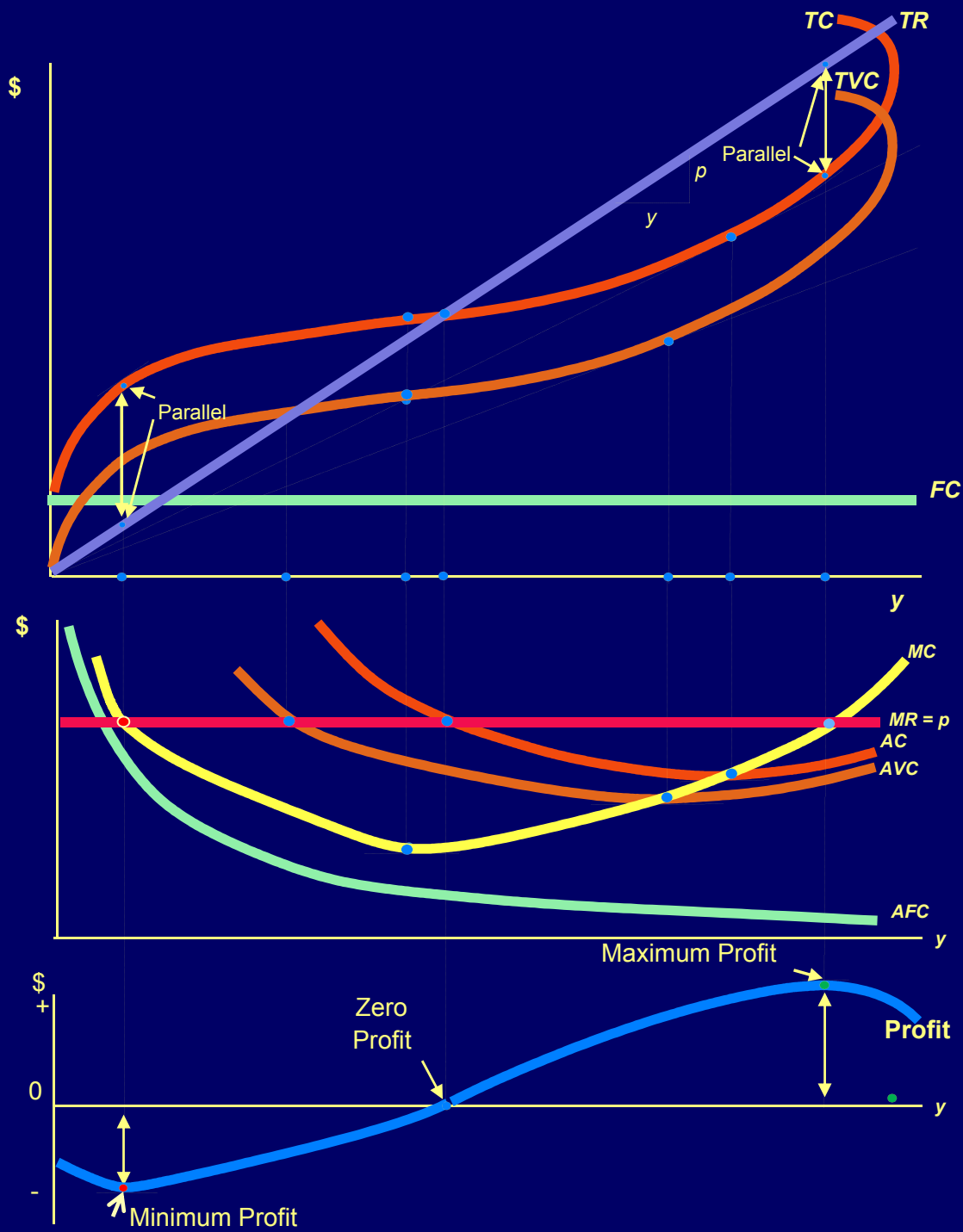


Figure 4.4 Cost Functions and Profit Functions

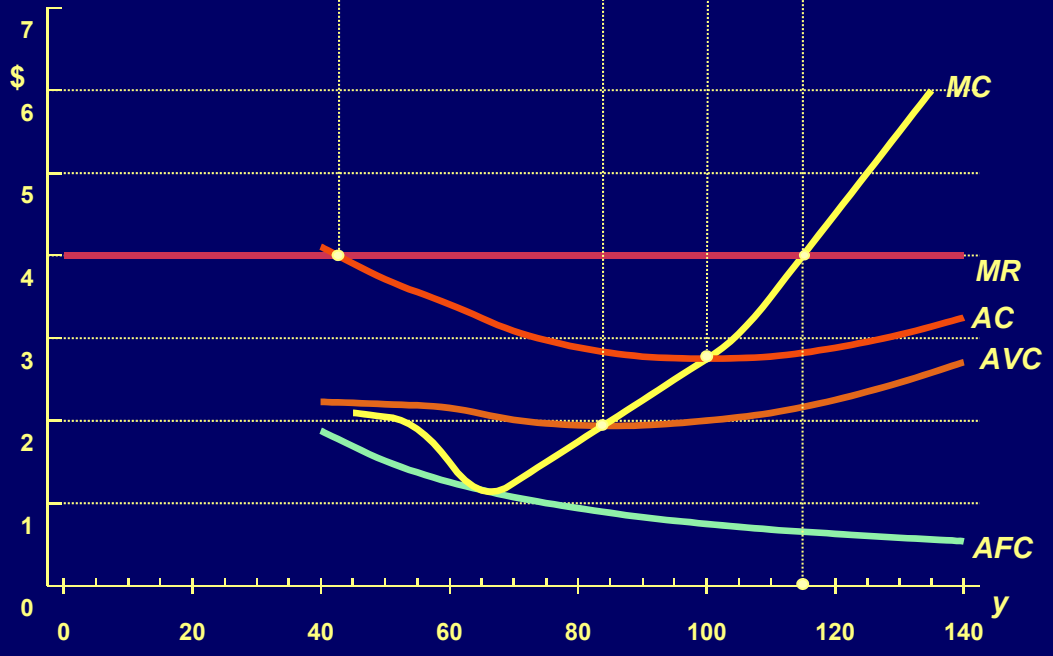
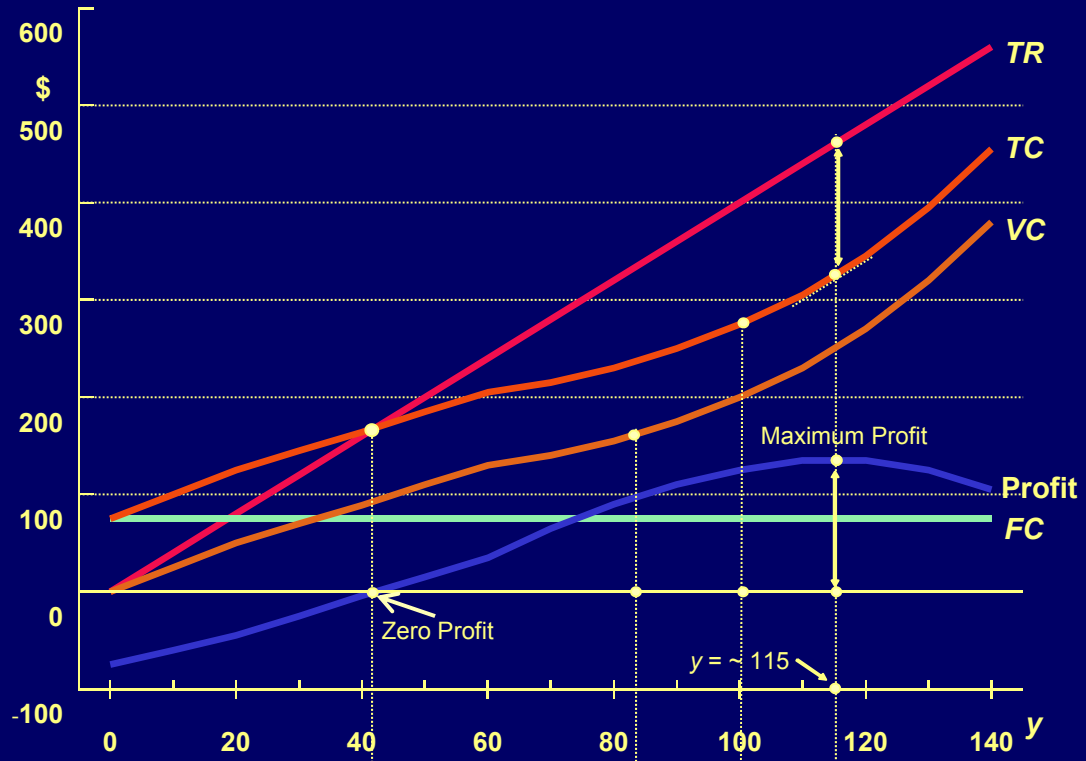


Figure 4.5 The Profit-Maximizing Output Level
Based on Data Contained in Table 4.1

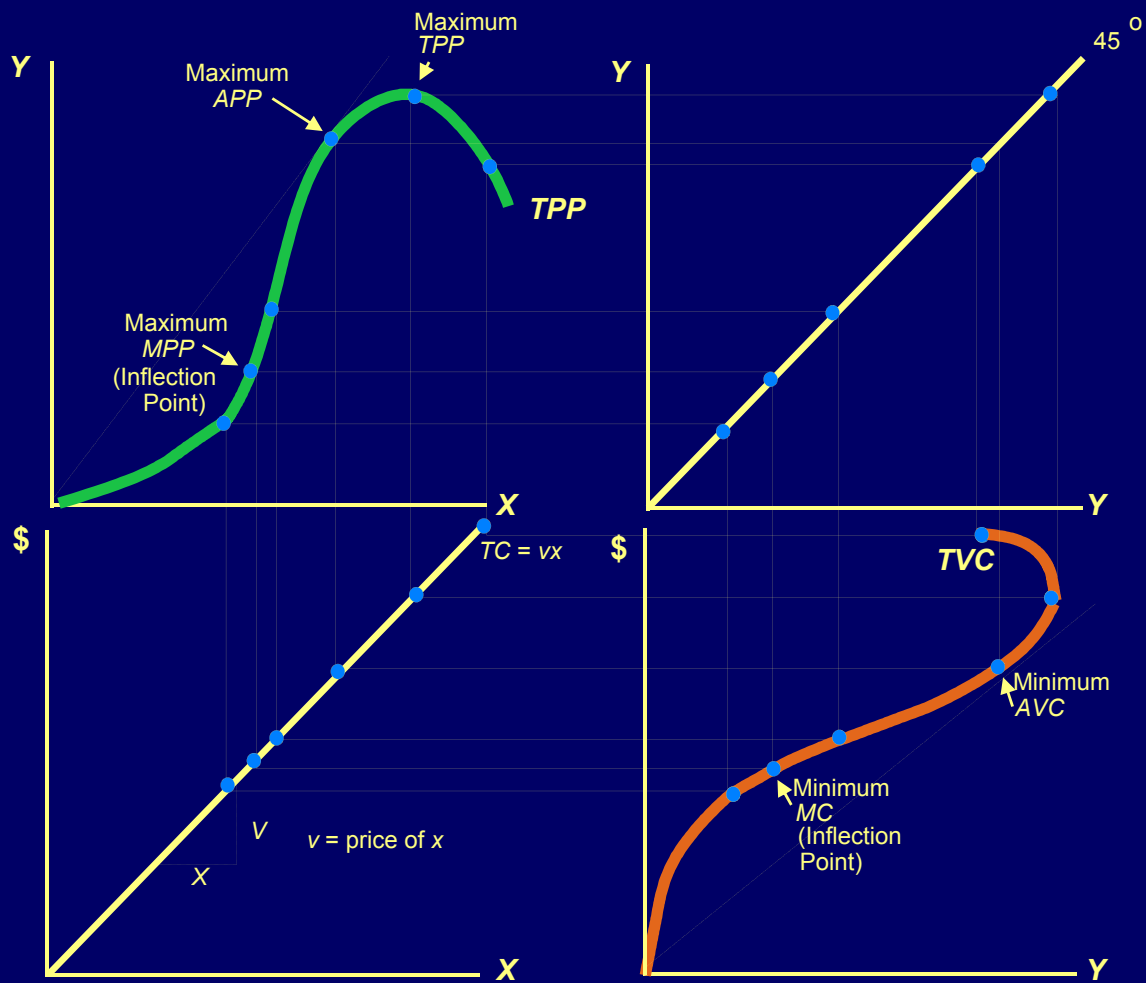


Figure 4.6 A Cost Function as an Inverse Production Function

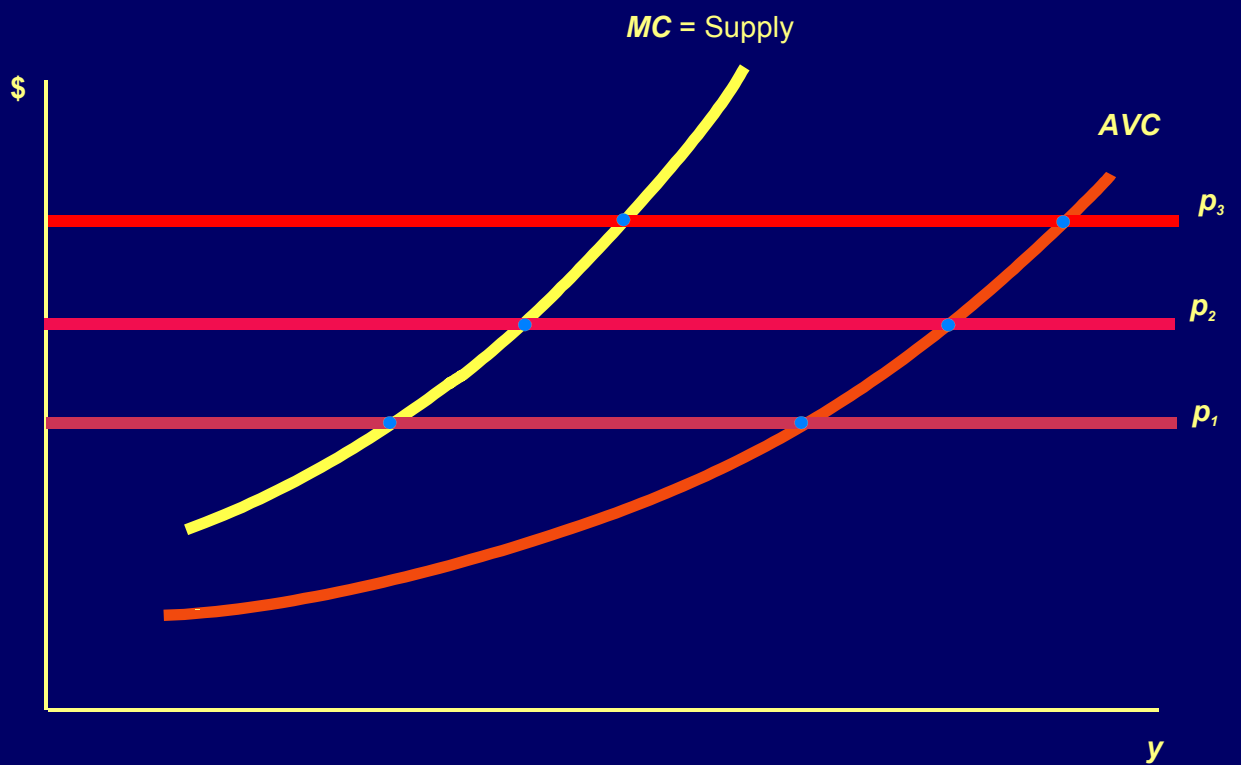


Figure 4.7 Aggregate Supply When the Ratio $MC/AC = 1/b$ and b is less than 1

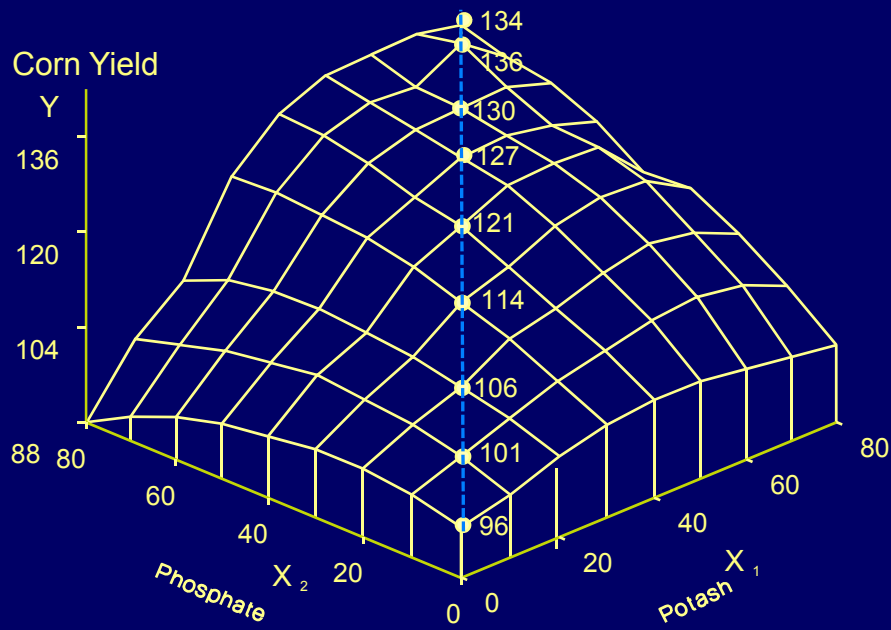


Figure 5.1 Production Response Surface Based on Data Contained in Table 5.1

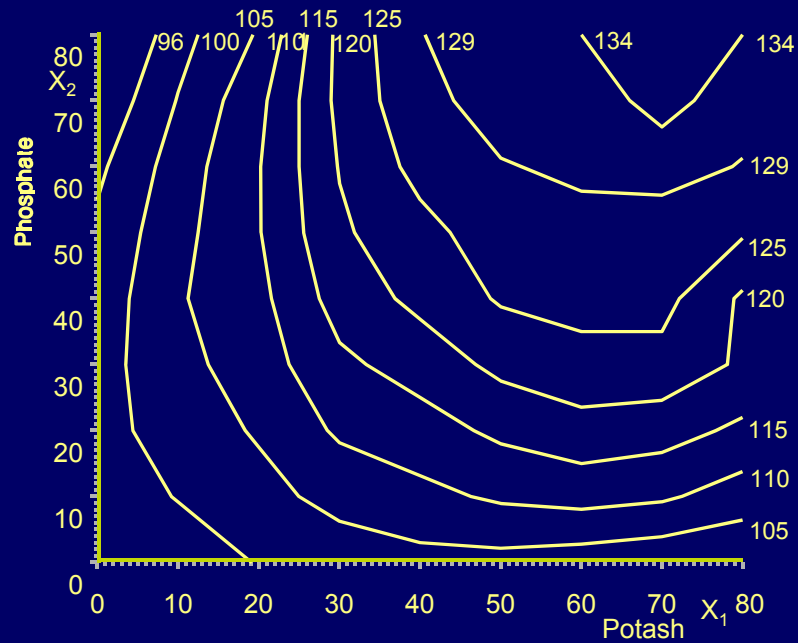


Figure 5.2 Isoquants for the Production Surface in Figure 5.1 Based on Data Contained in Table 5.1

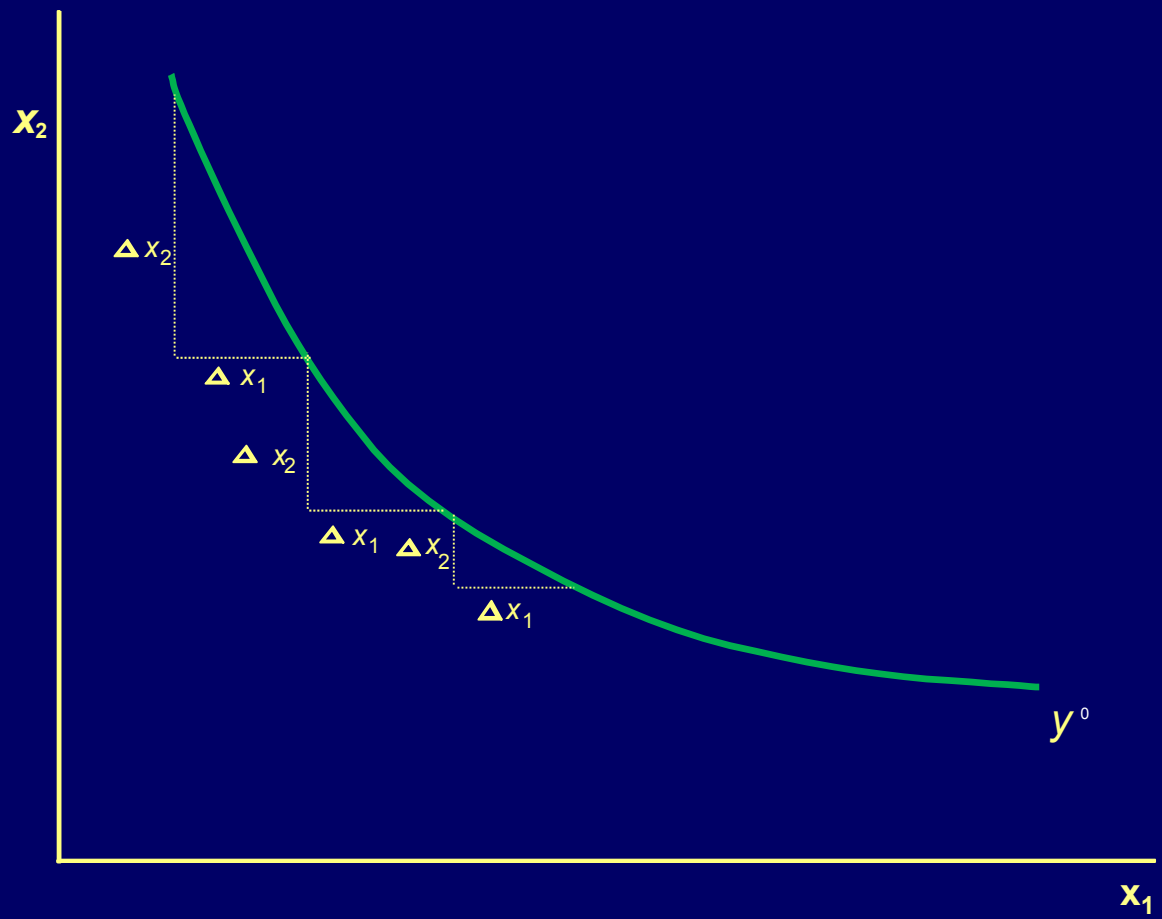


Figure 5.3 Illustration of Diminishing $MRS_{x_1x_2}$

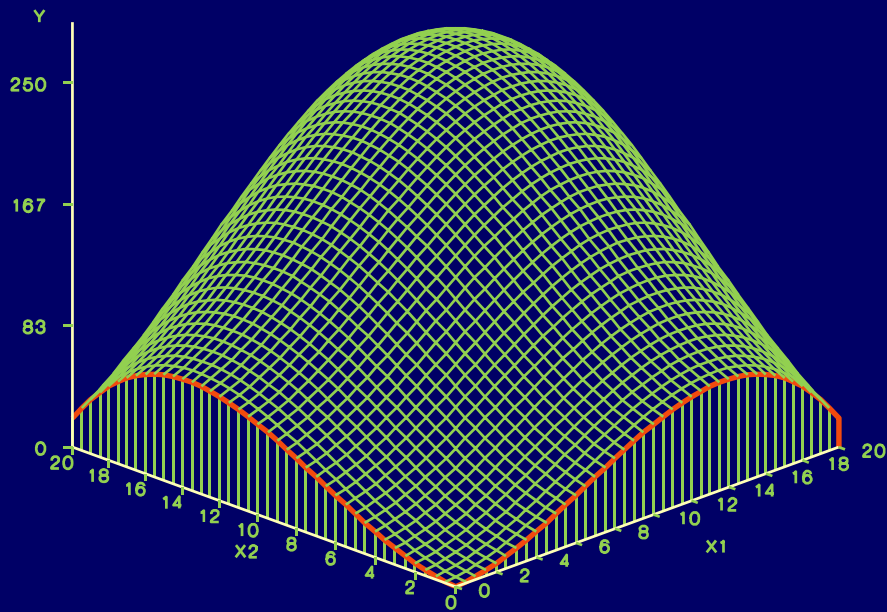


Figure 5.4 Isoquants and a Production Surface (Panel A)

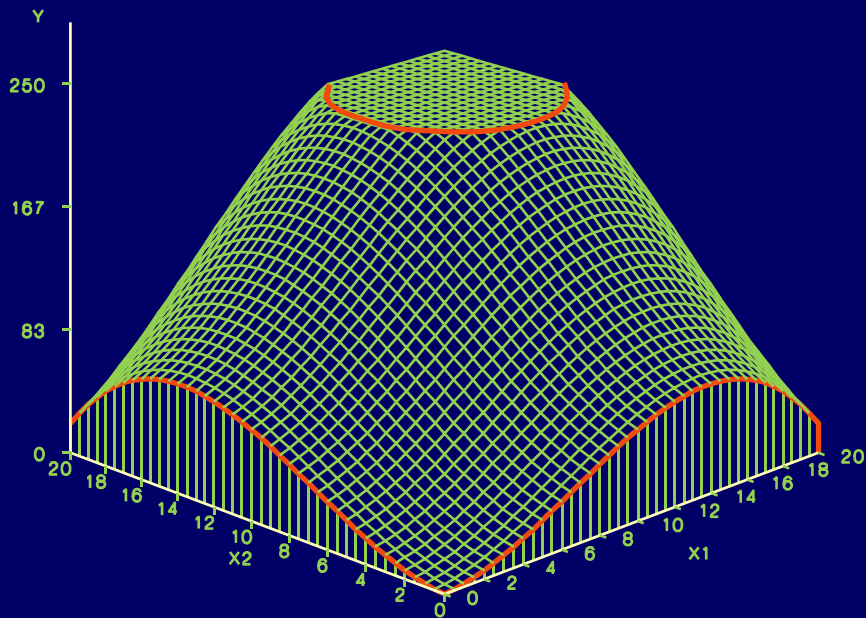


Figure 5.4 Isoquants and a Production Surface (Panel B)

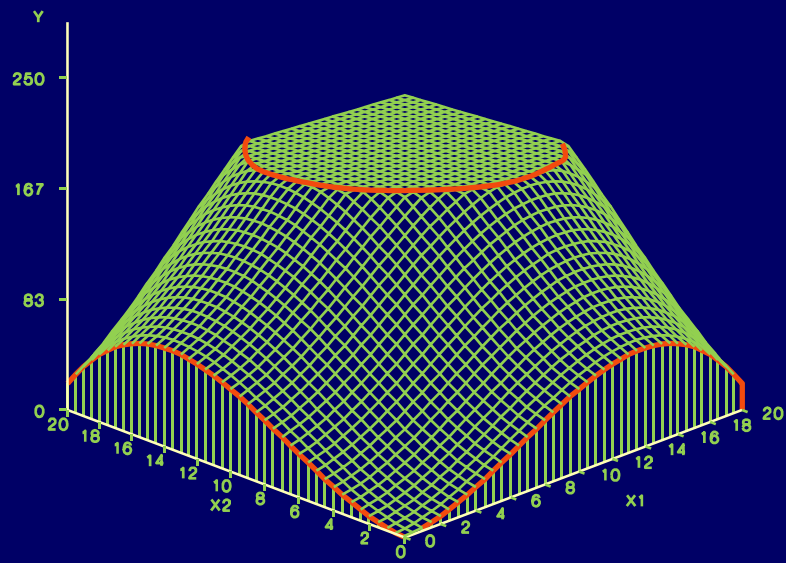


Figure 5.4 Isoquants and a Production Surface (Panel C)

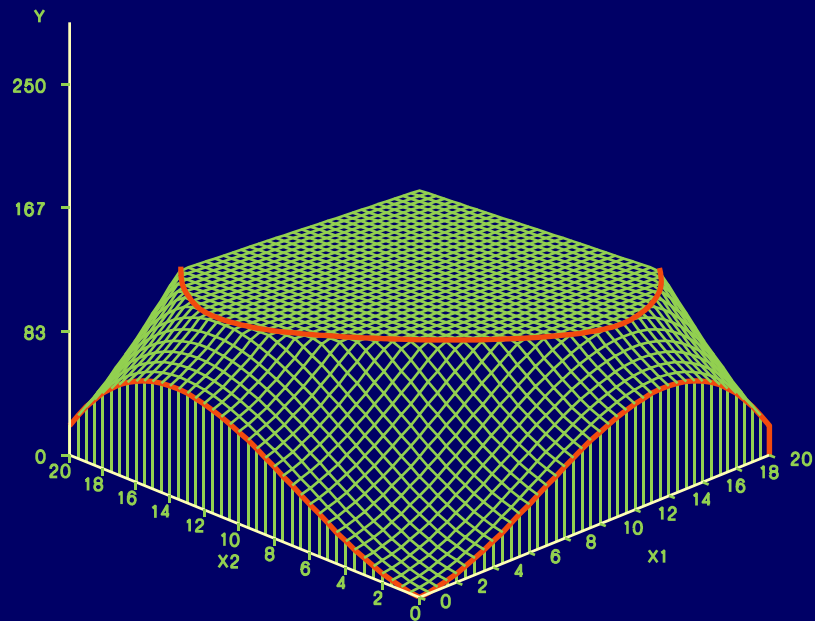


Figure 5.4 Isoquants and a Production Surface (Panel D)

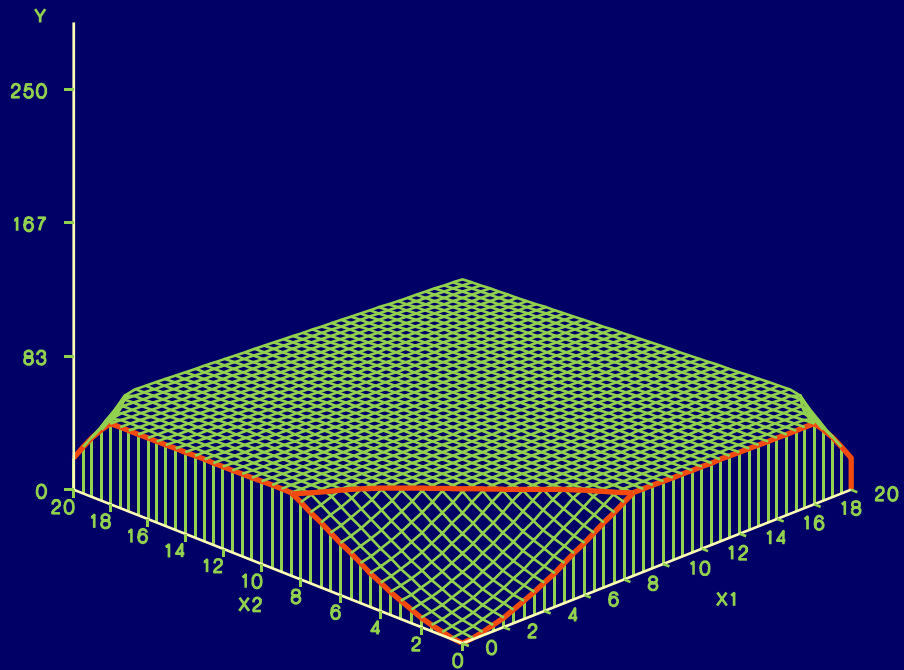


Figure 5.4 Isoquants and a Production Surface (Panel E)

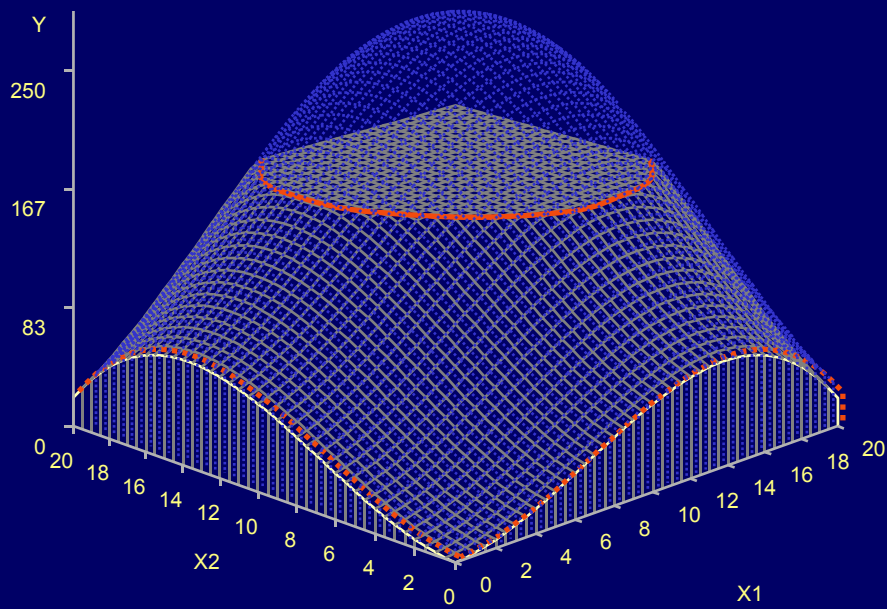


Figure 5.4 Isoquants and a Production Surface (Panel F)

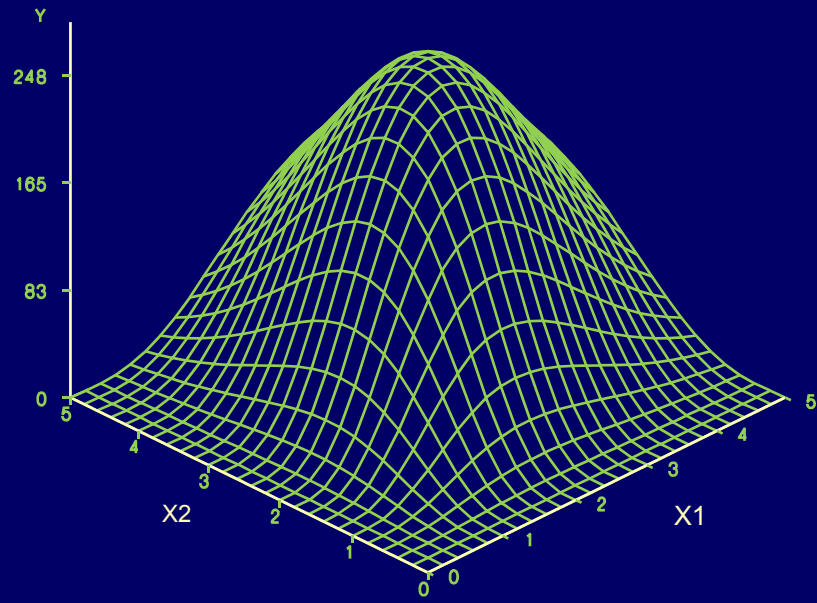


Figure 5.5 Some Possible Production Surfaces and Isoquant Map A. The Production Surface

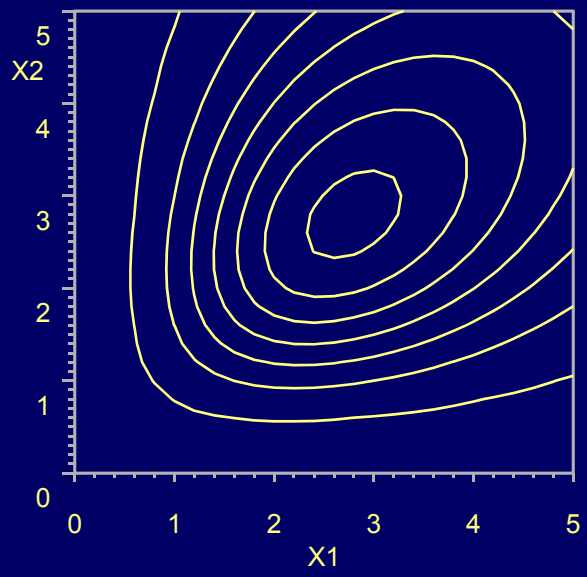


Figure 5.5 Some Possible Production Surfaces and Isoquant Map B. The Isoquant Map

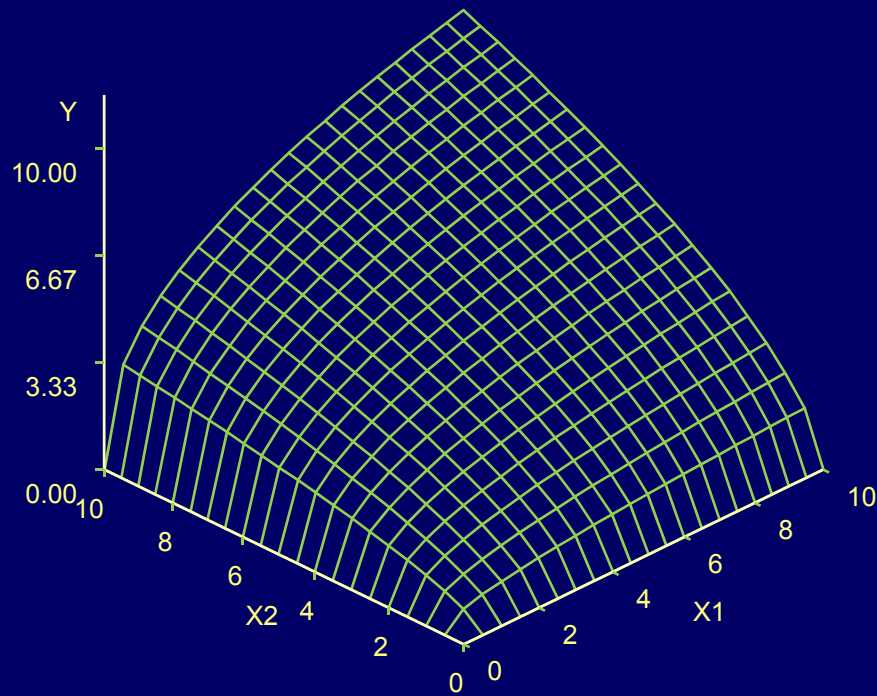


Figure 5.5 Some Possible Production Surfaces and Isoquant Map C . The Production Surface

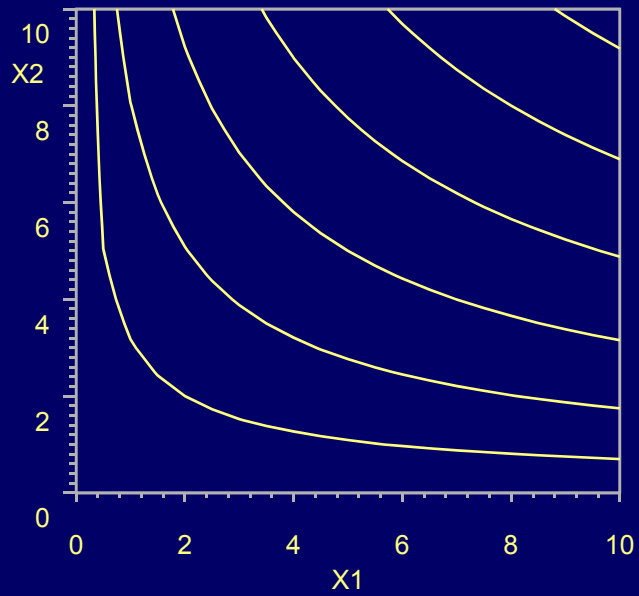


Figure 5.5 Some Possible Production Surfaces and Isoquant Map D . The Isoquants

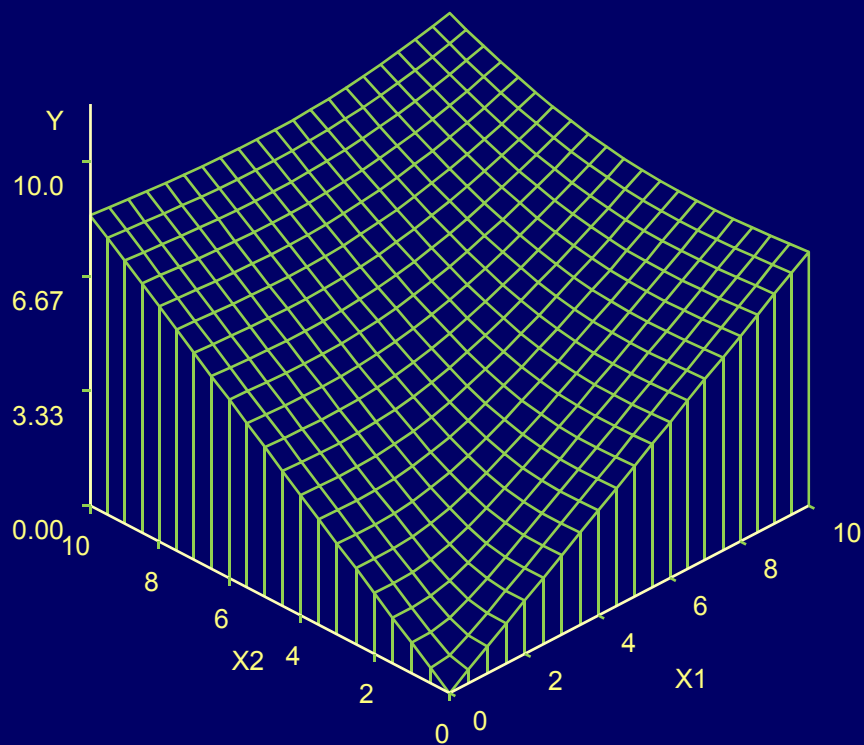


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
E. The Production Surface

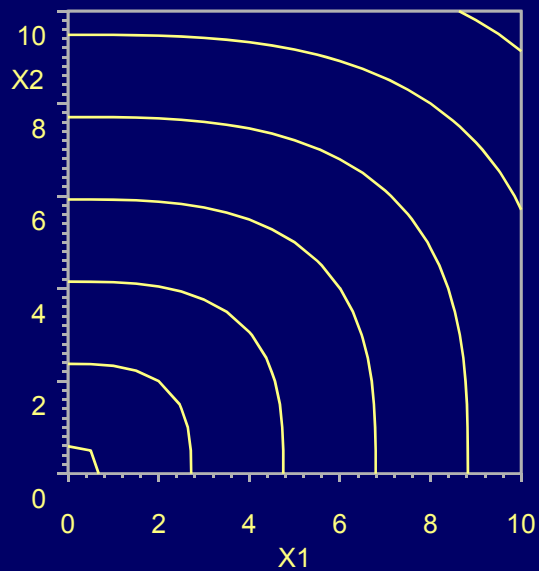


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
F. The Isoquants

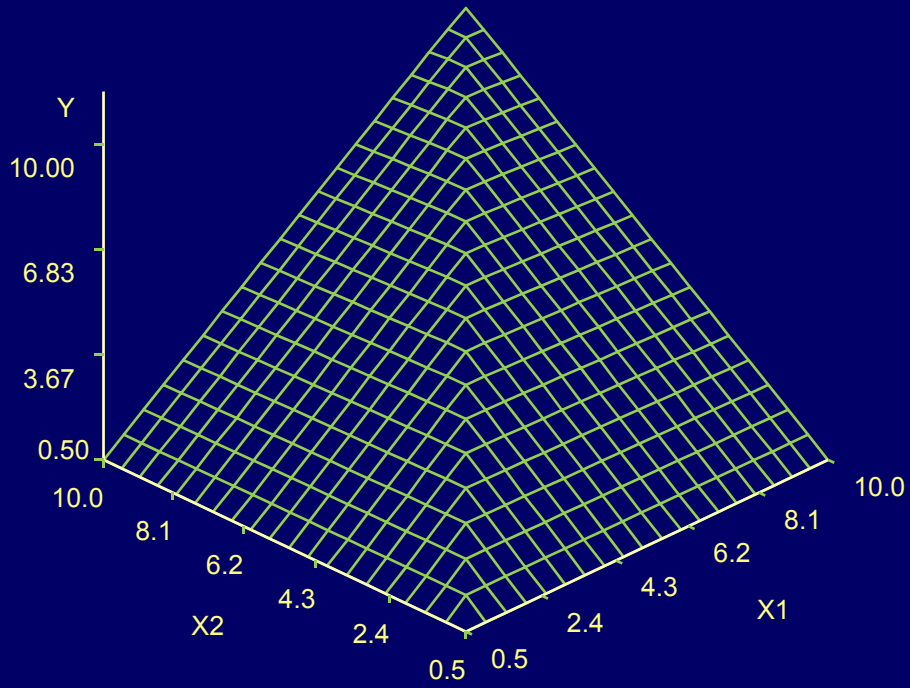


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
 K. The Production Surface

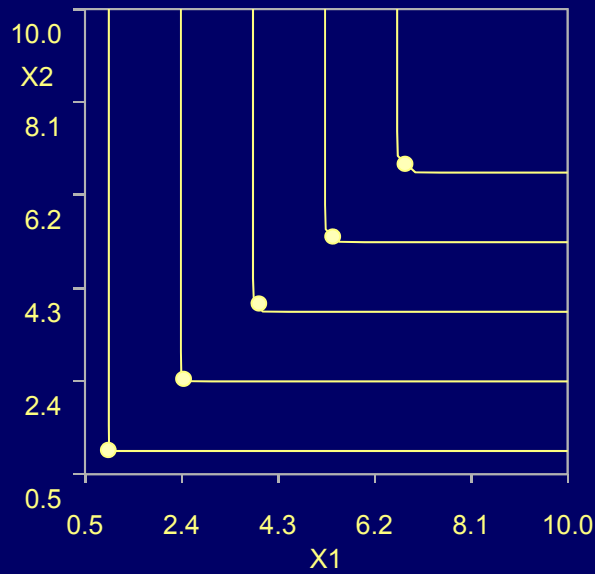


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
 L. The Isoquants

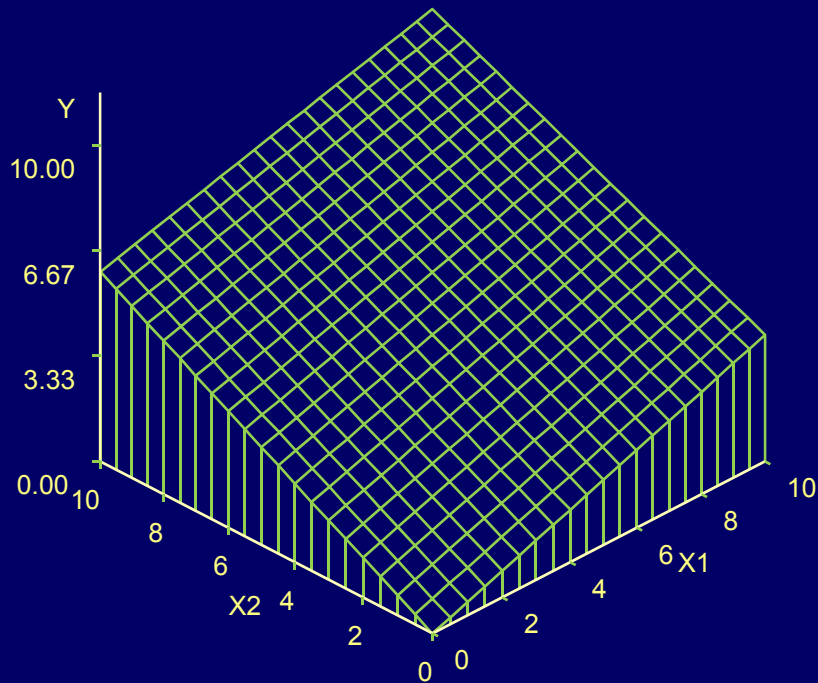


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
 G. The Production Surface

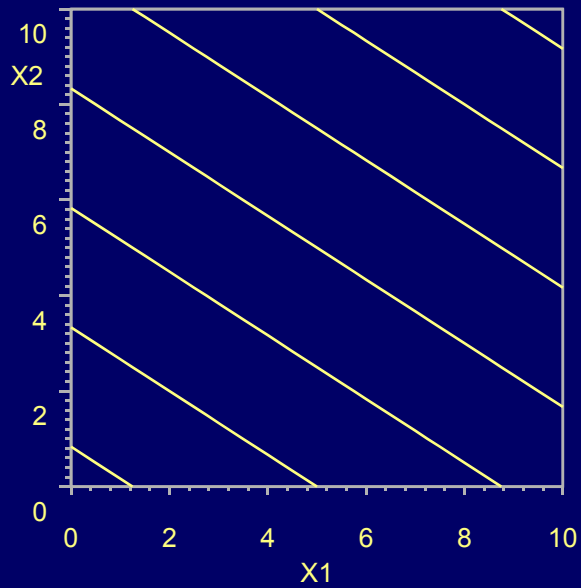


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
 H. The Isoquants

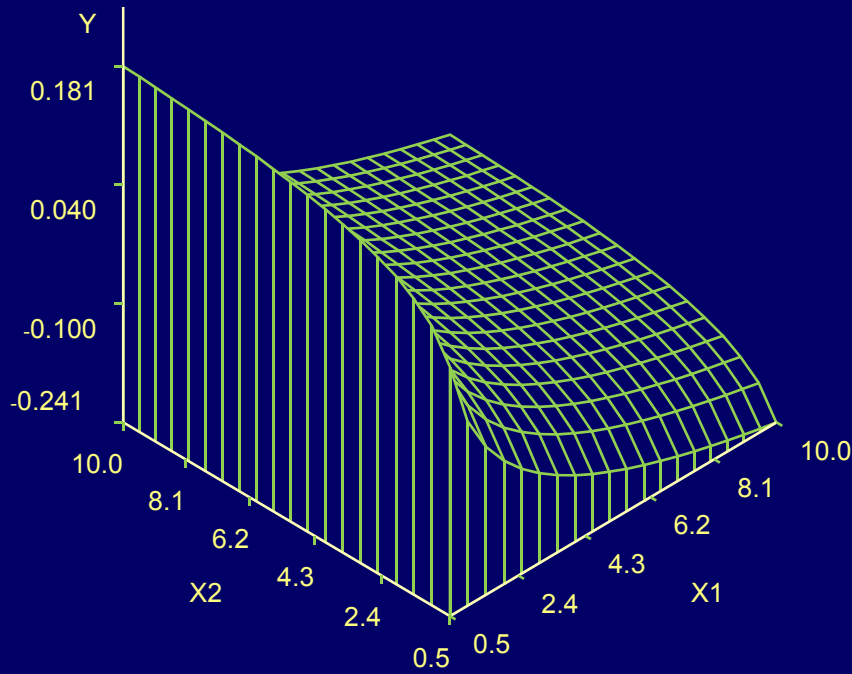


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
I. The Production Surface

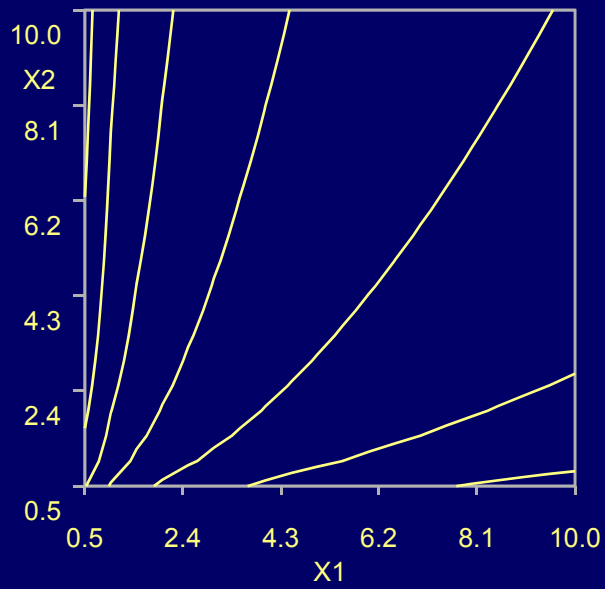


Figure 5.5 Some Possible Production Surfaces and Isoquant Maps
J. The Isoquants

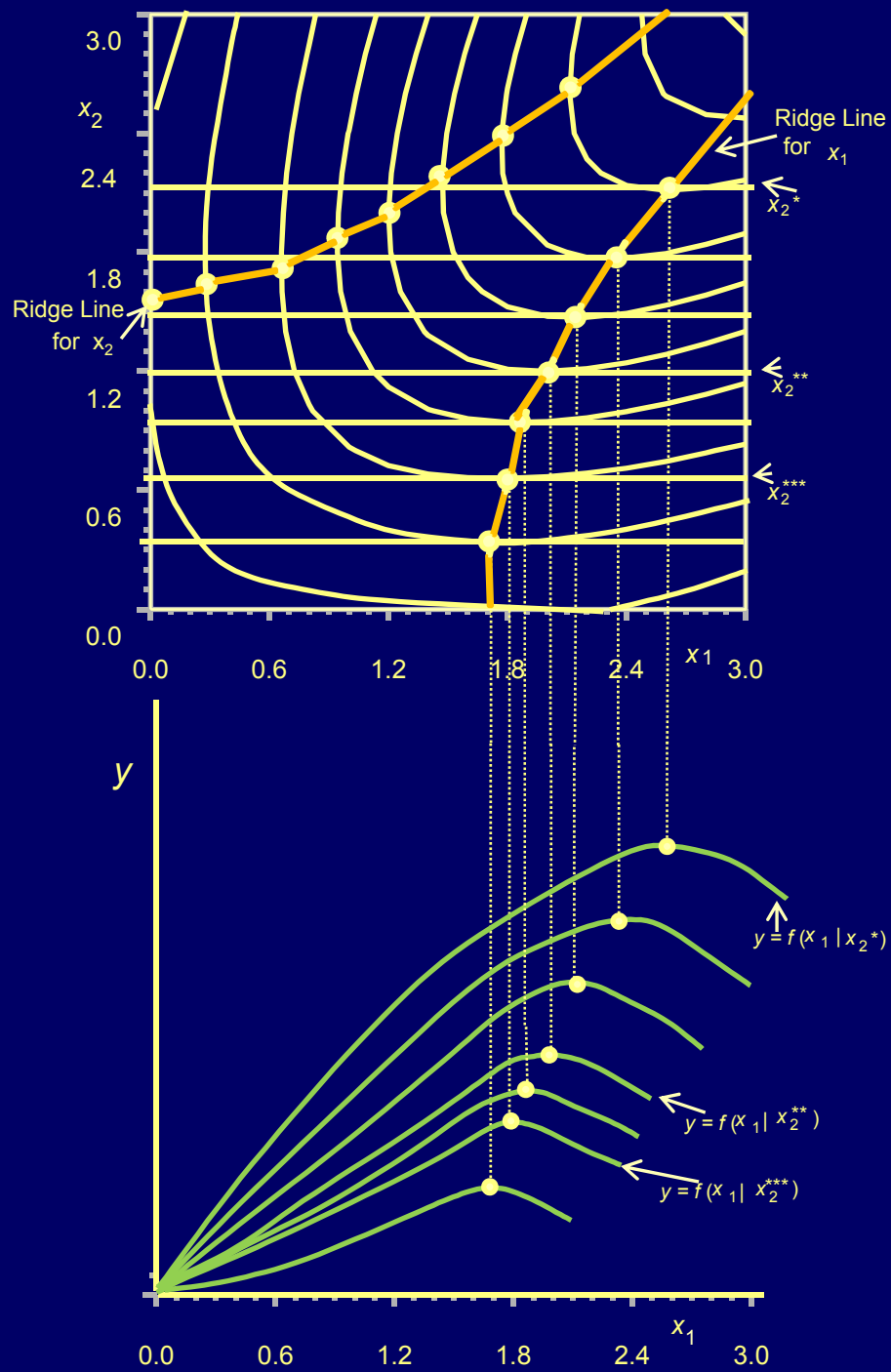


Figure 5.6 Ridge Lines and a Family of Production Functions For Input x_1

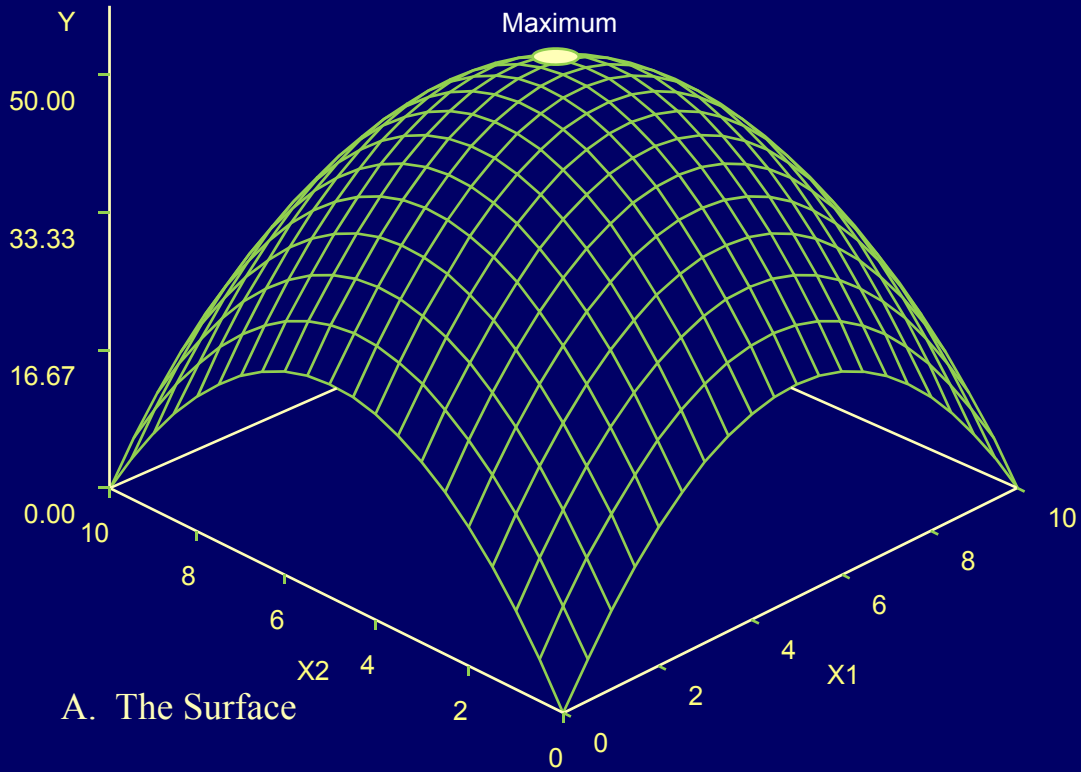


Figure 6.1 Alternative Surfaces and Contours Illustrating Second Order Conditions

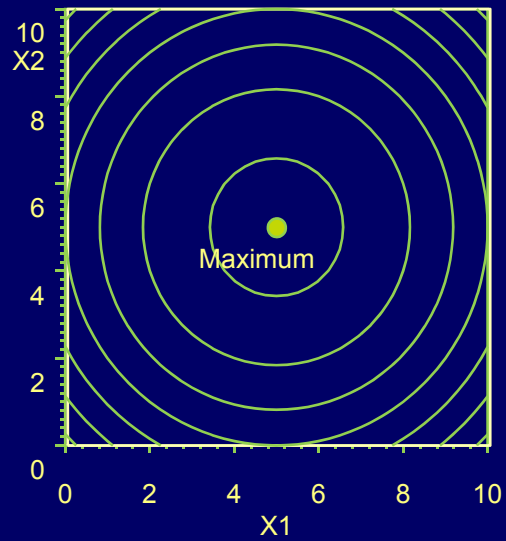
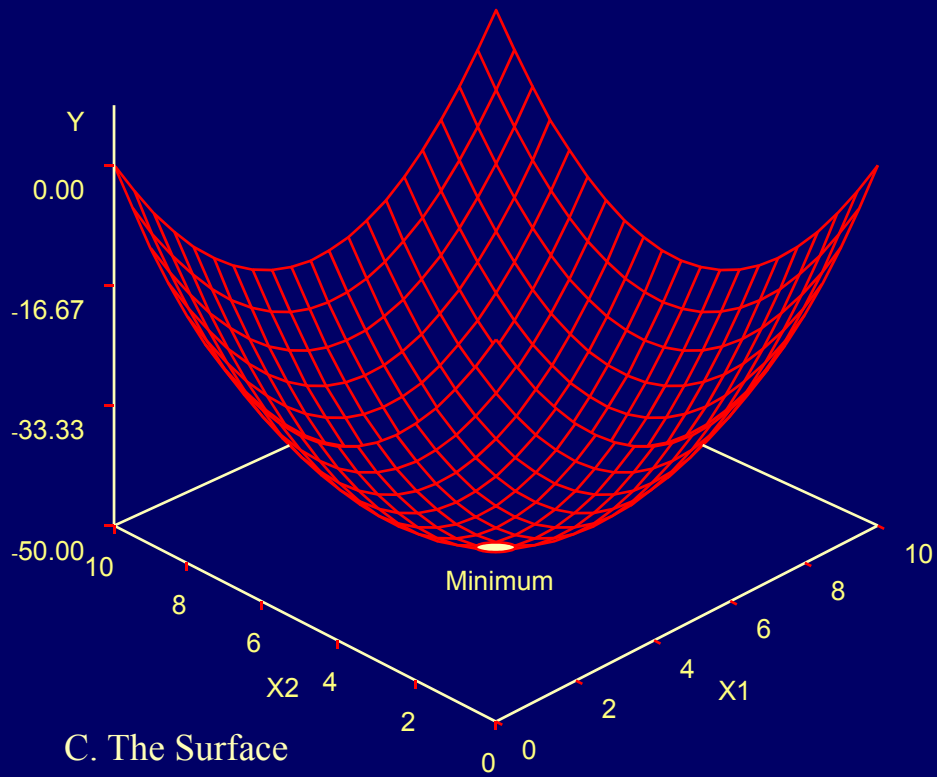
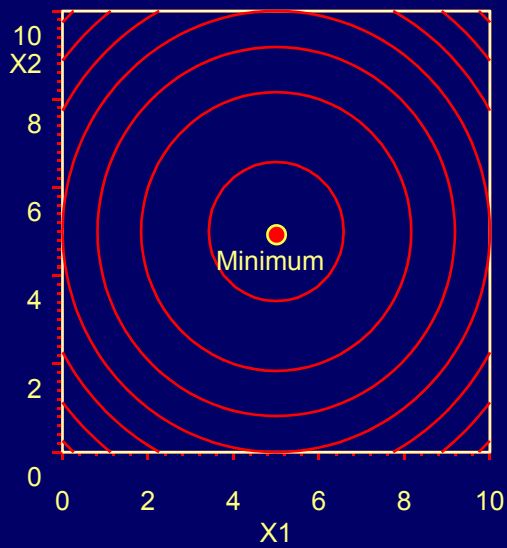


Figure 6.1 Alternative Surfaces and Contours Illustrating Second Order Conditions



C. The Surface

Figure 6.1 Alternative Surfaces and Contours Illustrating Second Order Conditions



D. The Contour Lines

Figure 6.1 Alternative Surfaces and Contours Illustrating Second Order Conditions

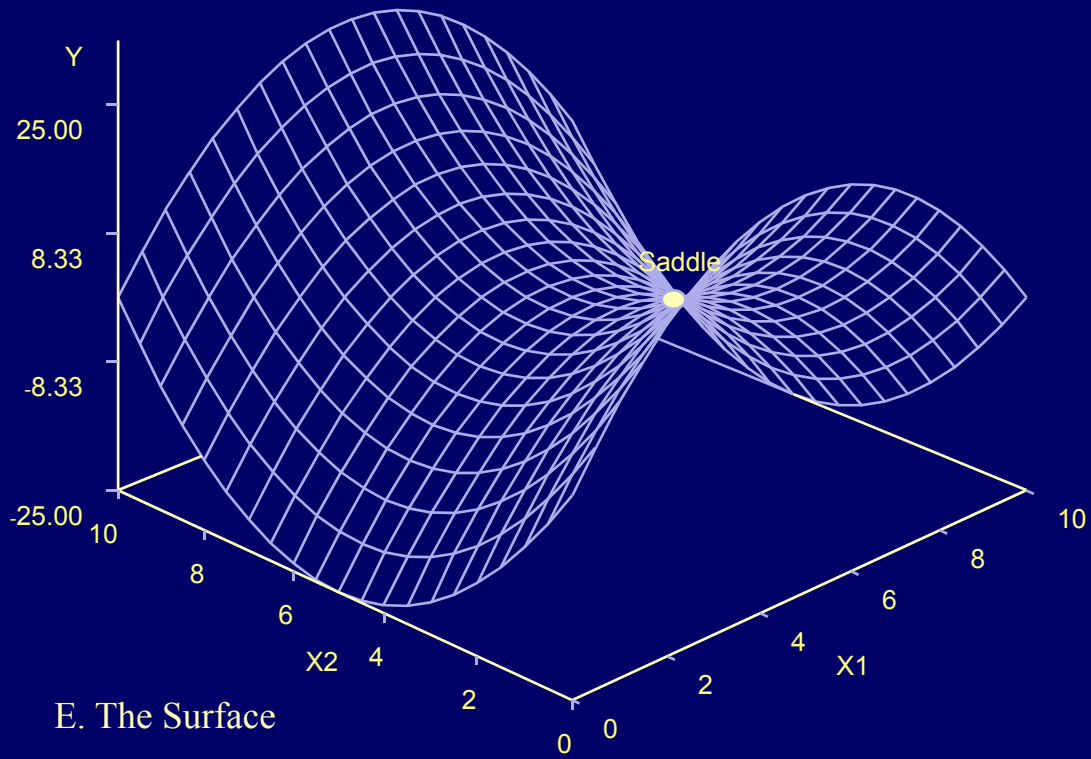


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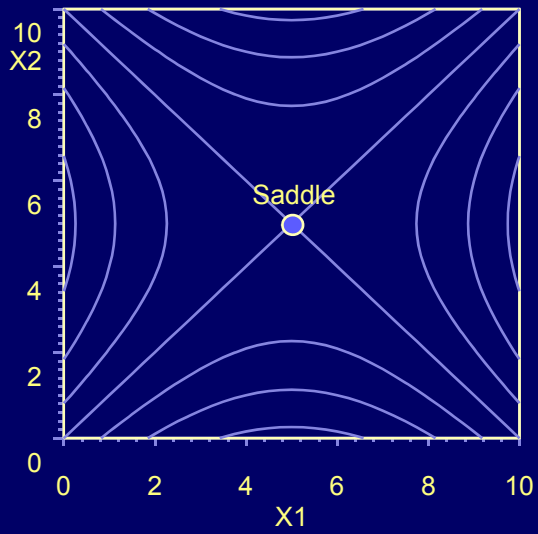
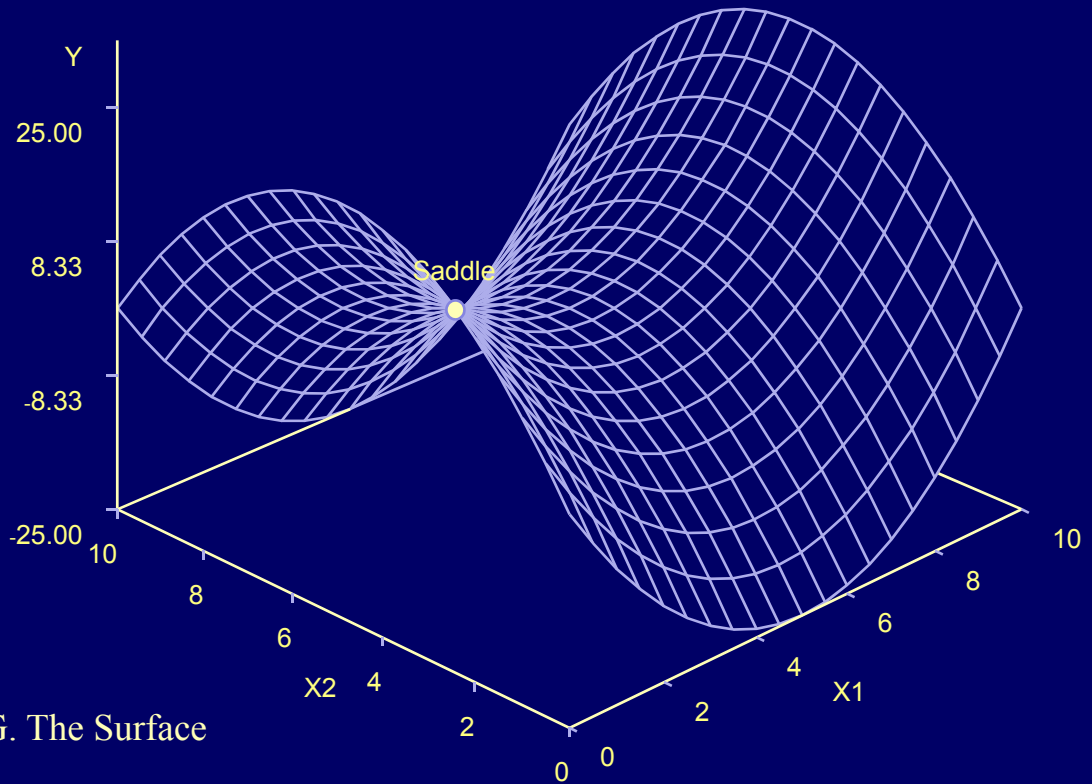
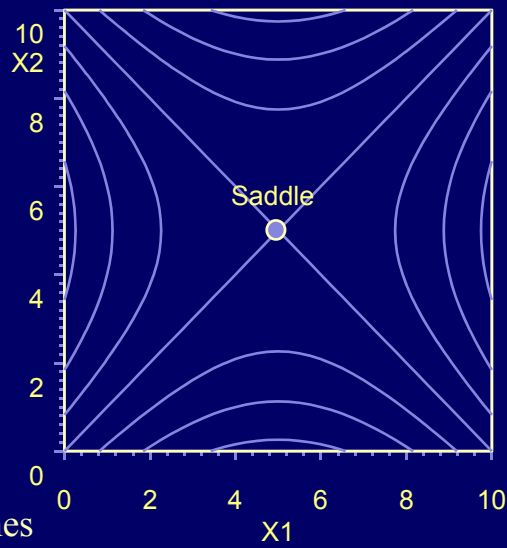


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H. The Contour Lines

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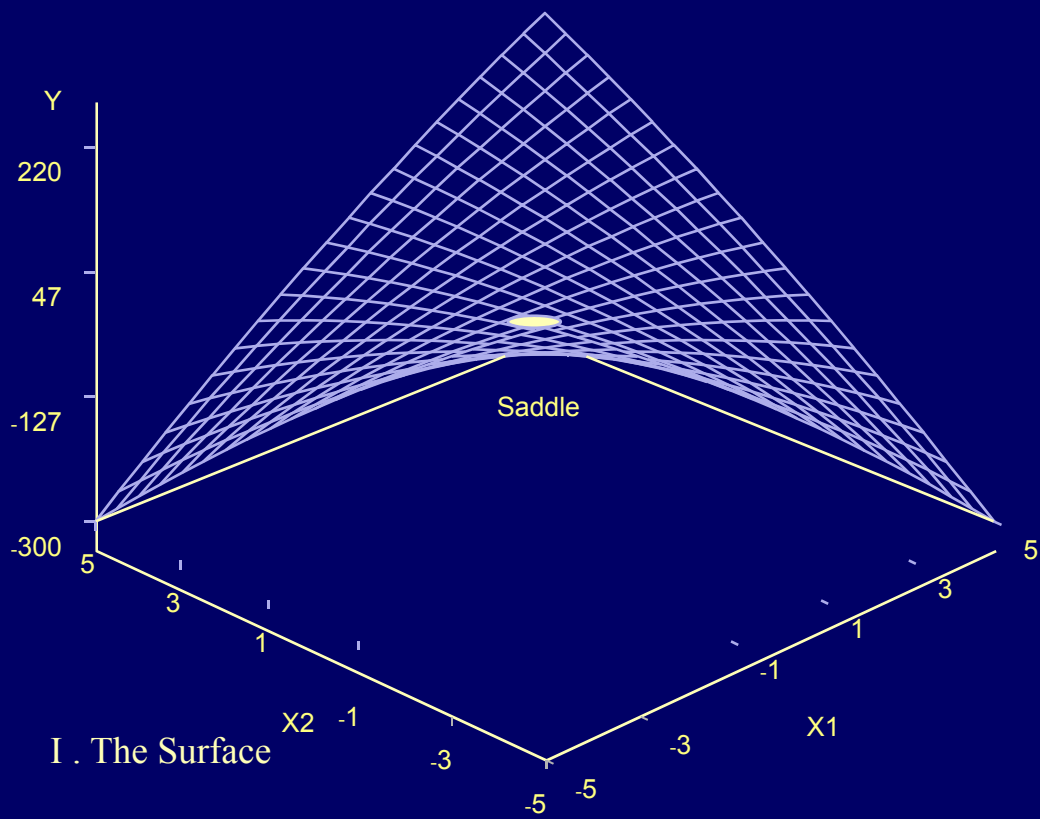


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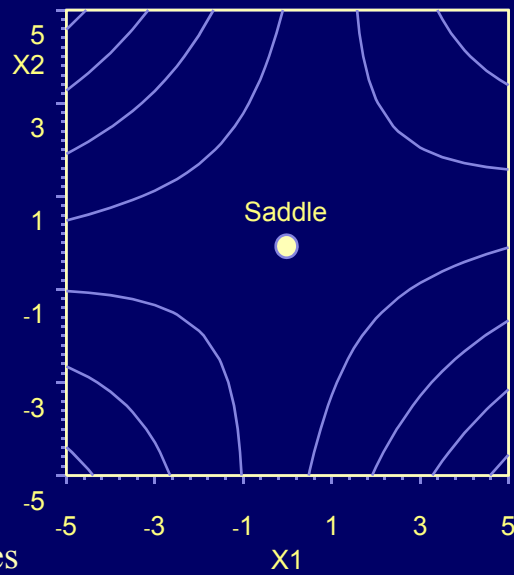


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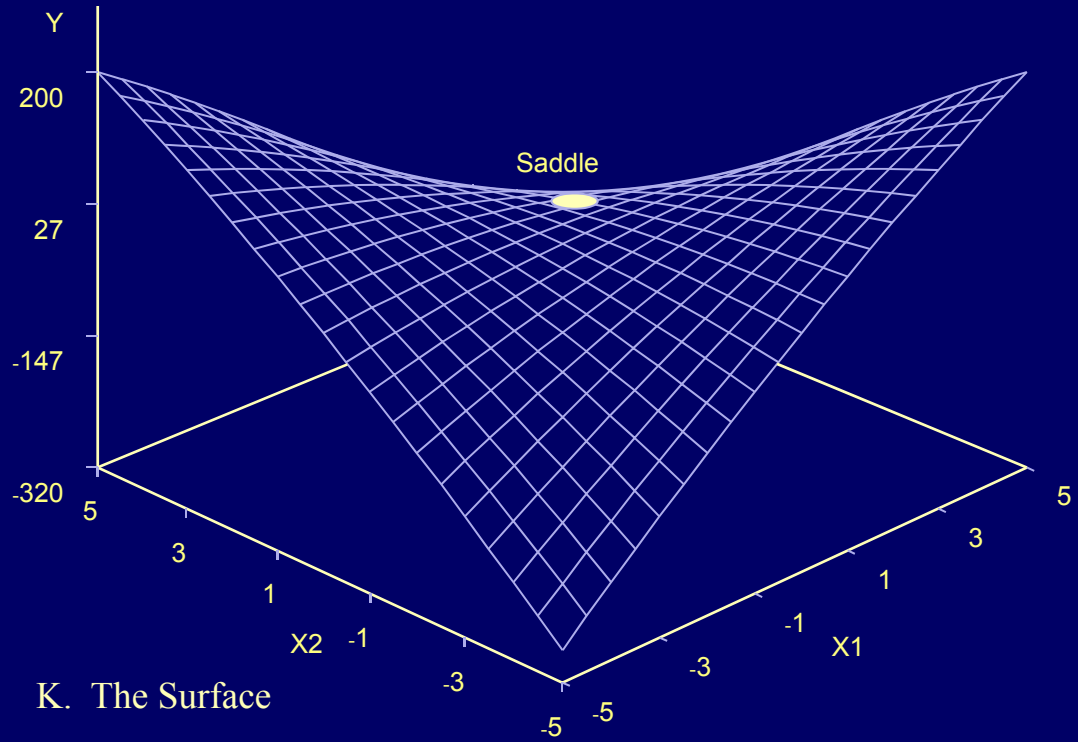


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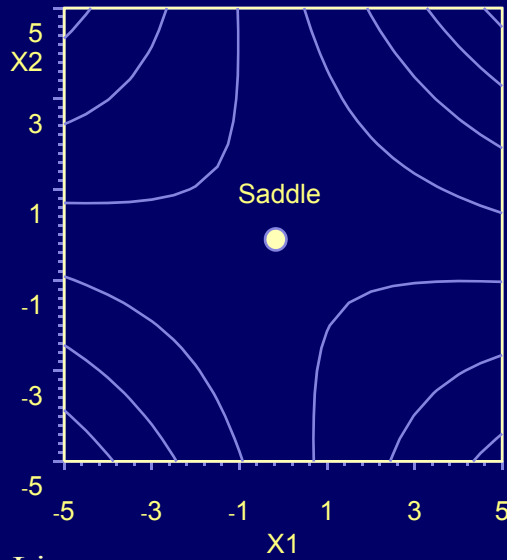


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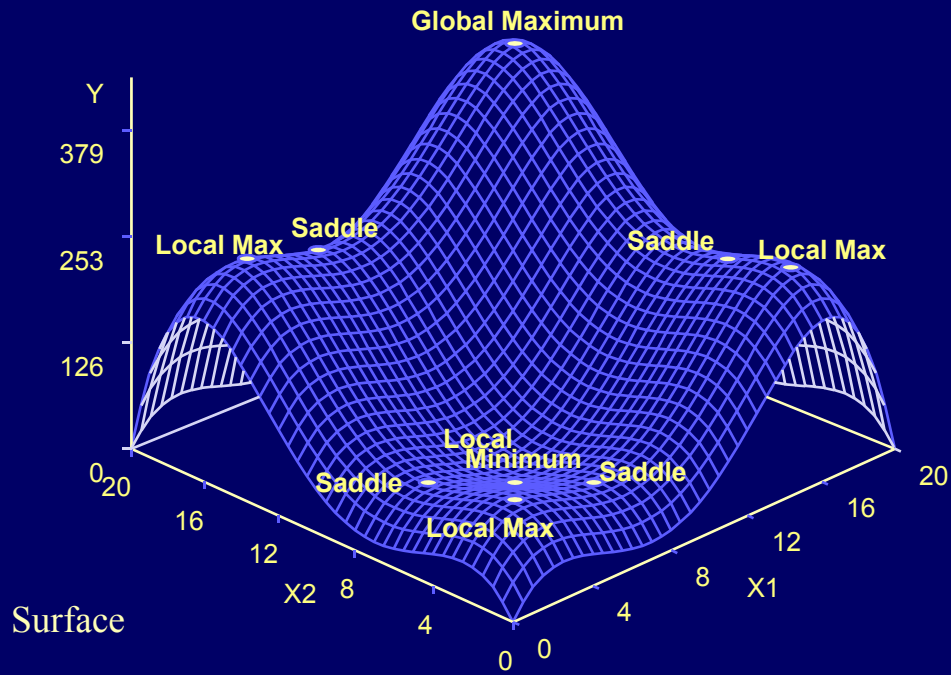


Figure 6.2 Critical Values for the Polynomial $y = 40x_1 - 12x_1^2 + 1.2x_1^3 - 0.035x_1^4 + 40x_2 - 12x_2^2 + 1.2x_2^3 - 0.035x_2^4$

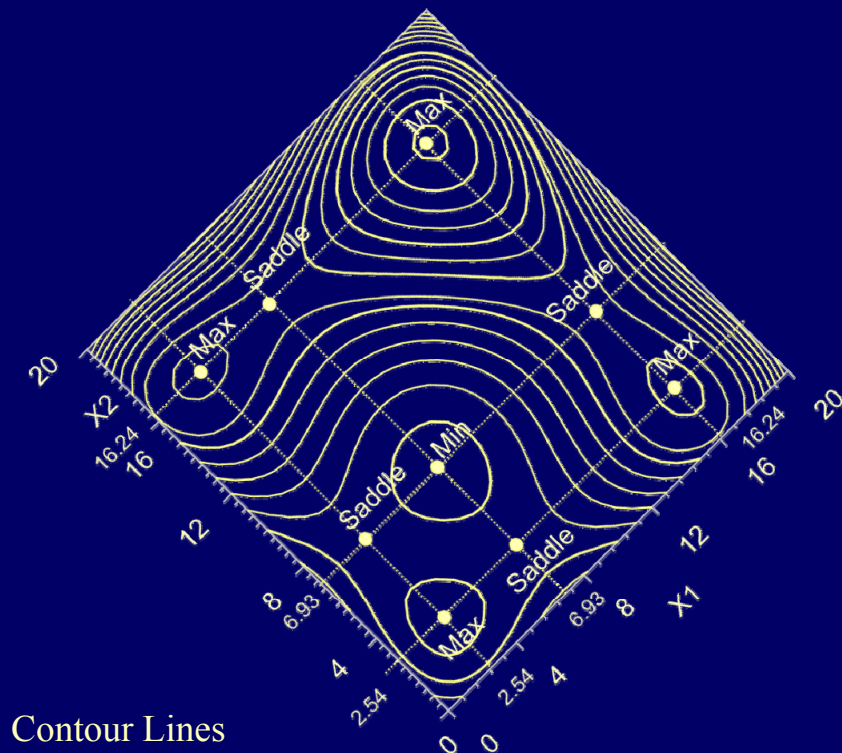


Figure 6.2 Critical Values for the Polynomial $y = 40x_1 - 12x_1^2 + 1.2x_1^3 - 0.035x_1^4 + 40x_2 - 12x_2^2 + 1.2x_2^3 - 0.035x_2^4$

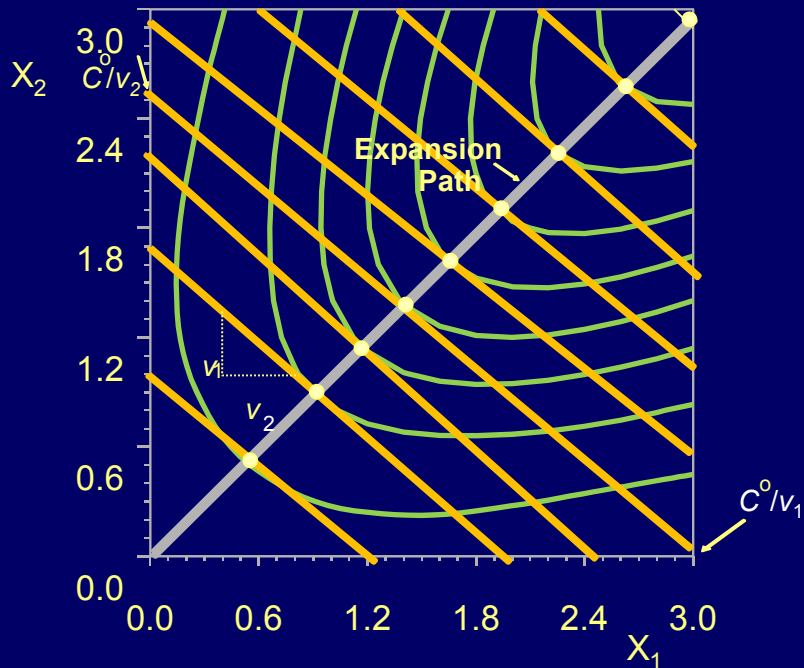
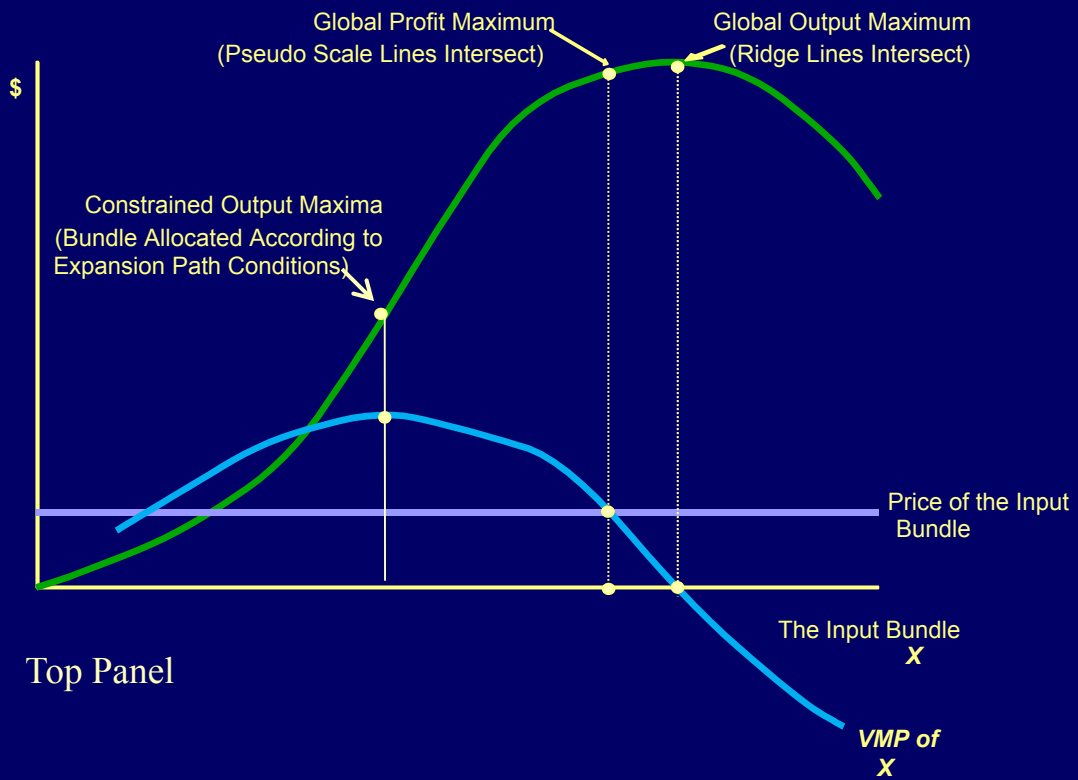


Figure 7.1 Iso-outlay Lines and the Isoquant Map



Top Panel

Figure 7.2 Global Output and Profit Maximization for the Bundle 39

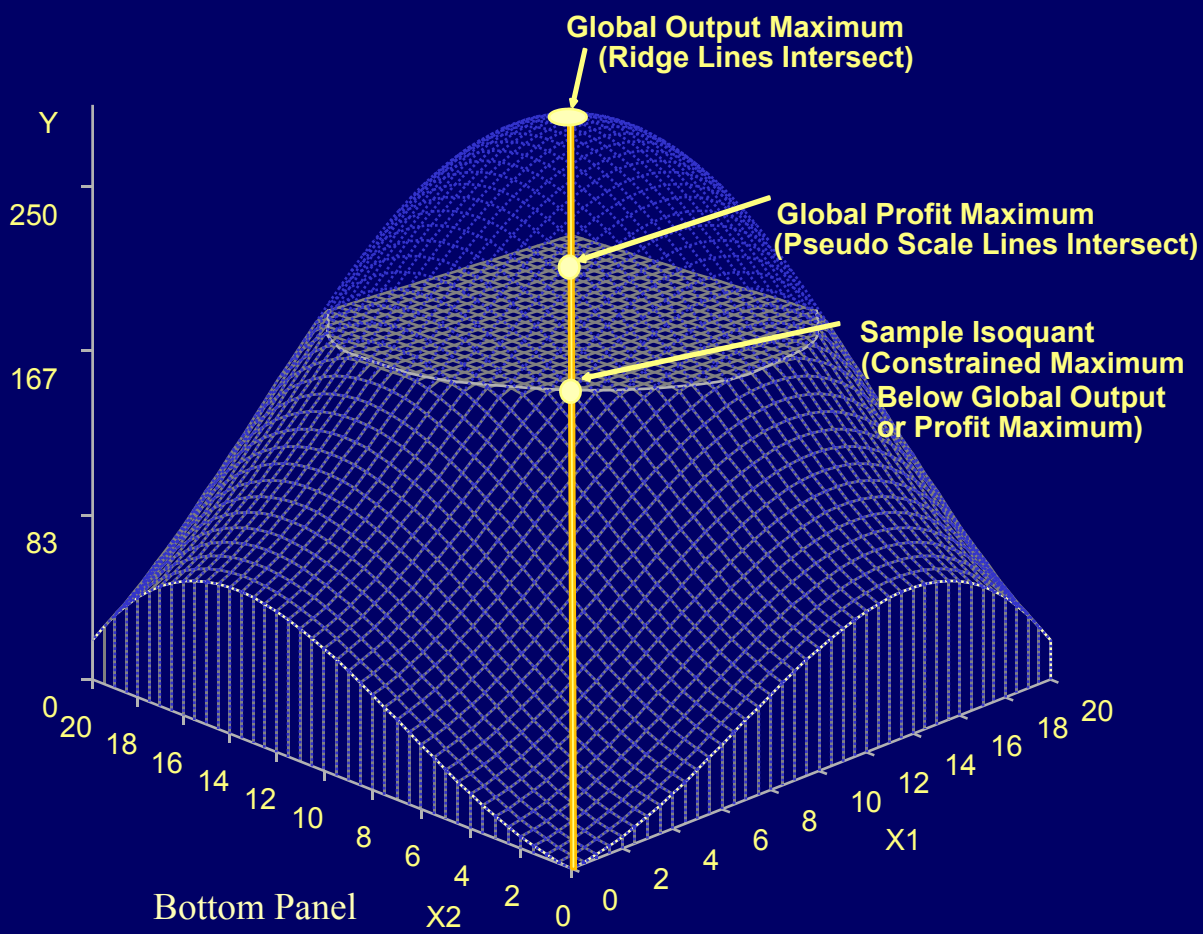


Figure 7.2 Global Output and Profit Maximization for the Bundle

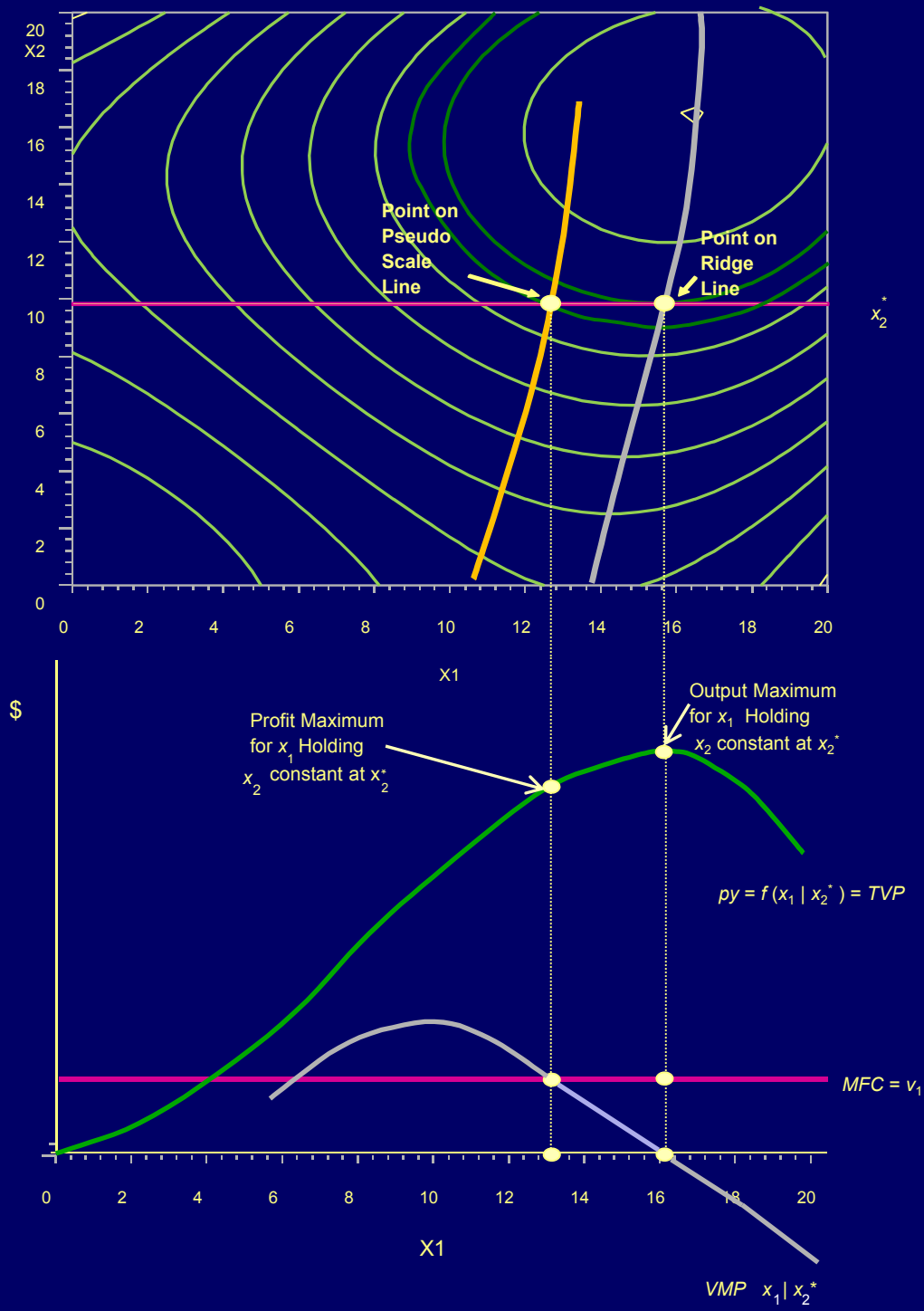


Figure 7.3 Deriving a Point on a Pseudo Scale Line

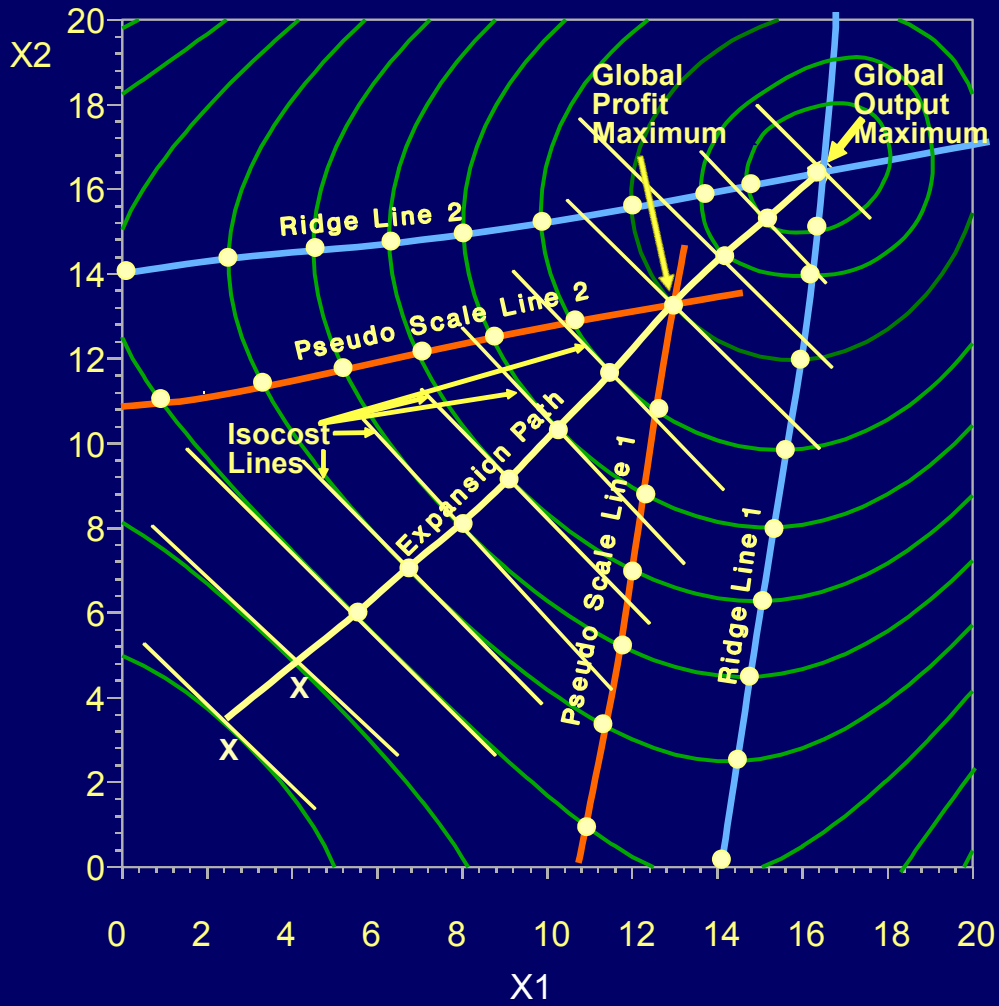


Figure 7.4 The Complete Factor-Factor Model

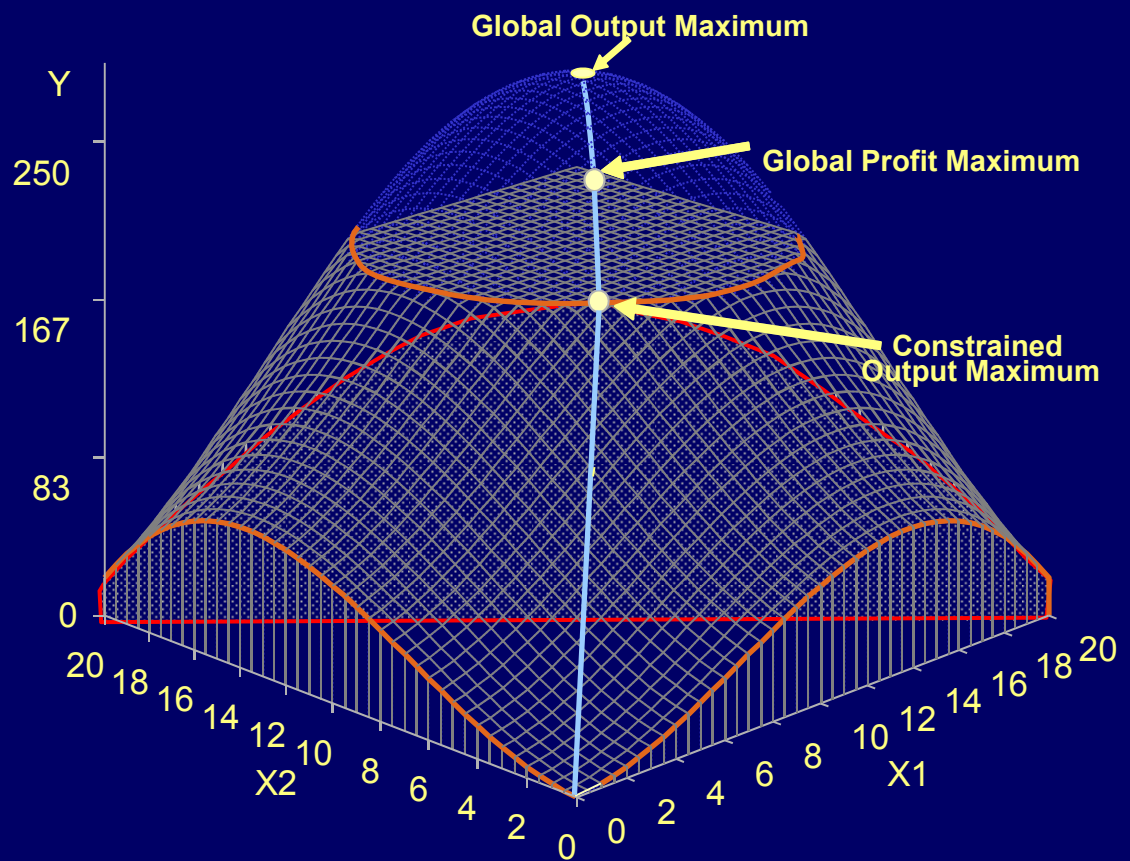


Figure 7.5 Constrained and Global Profit and Output Maxima along the Expansion Path

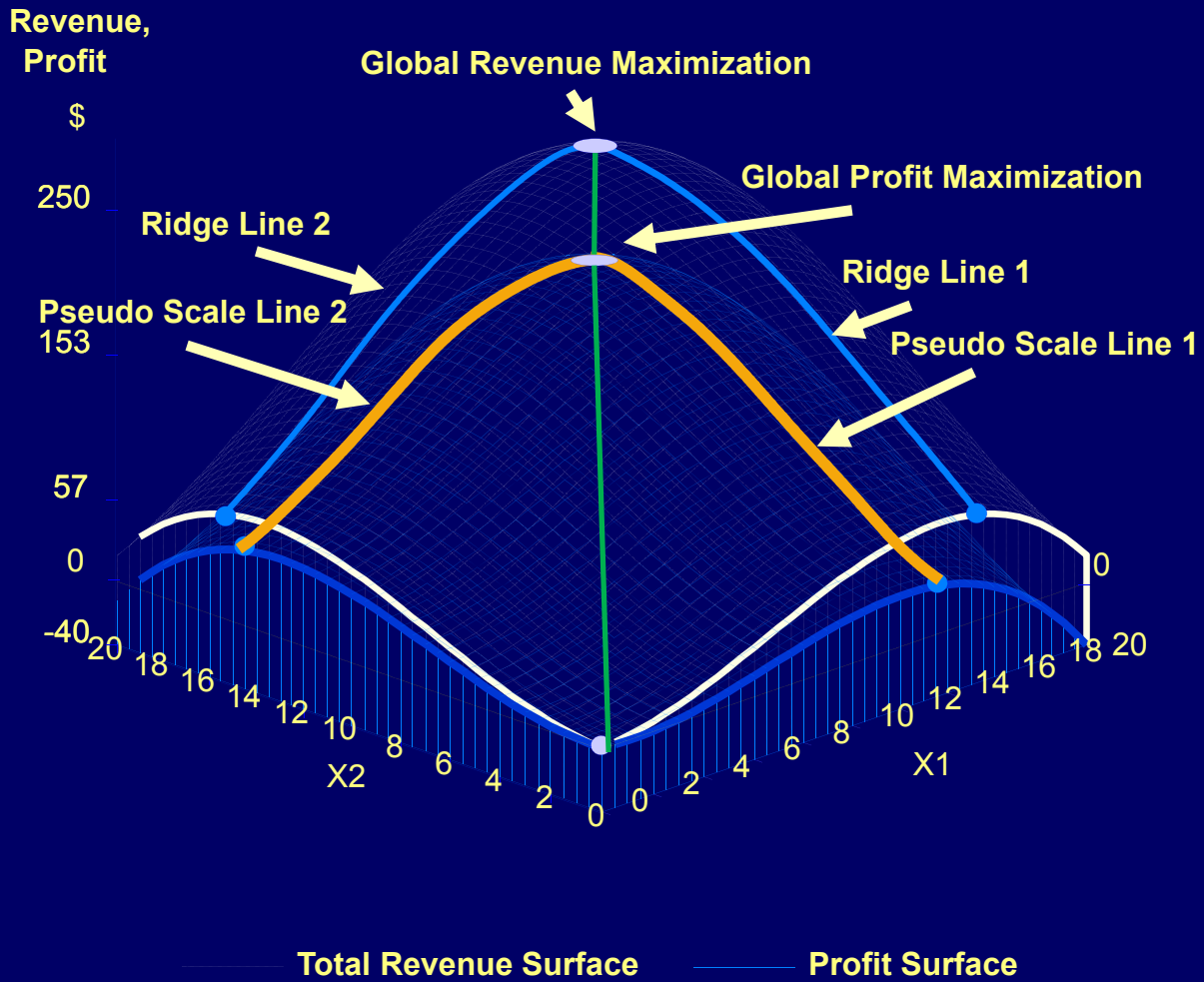


Figure 8.1 *TVP*- and Profit-Maximizing Surfaces

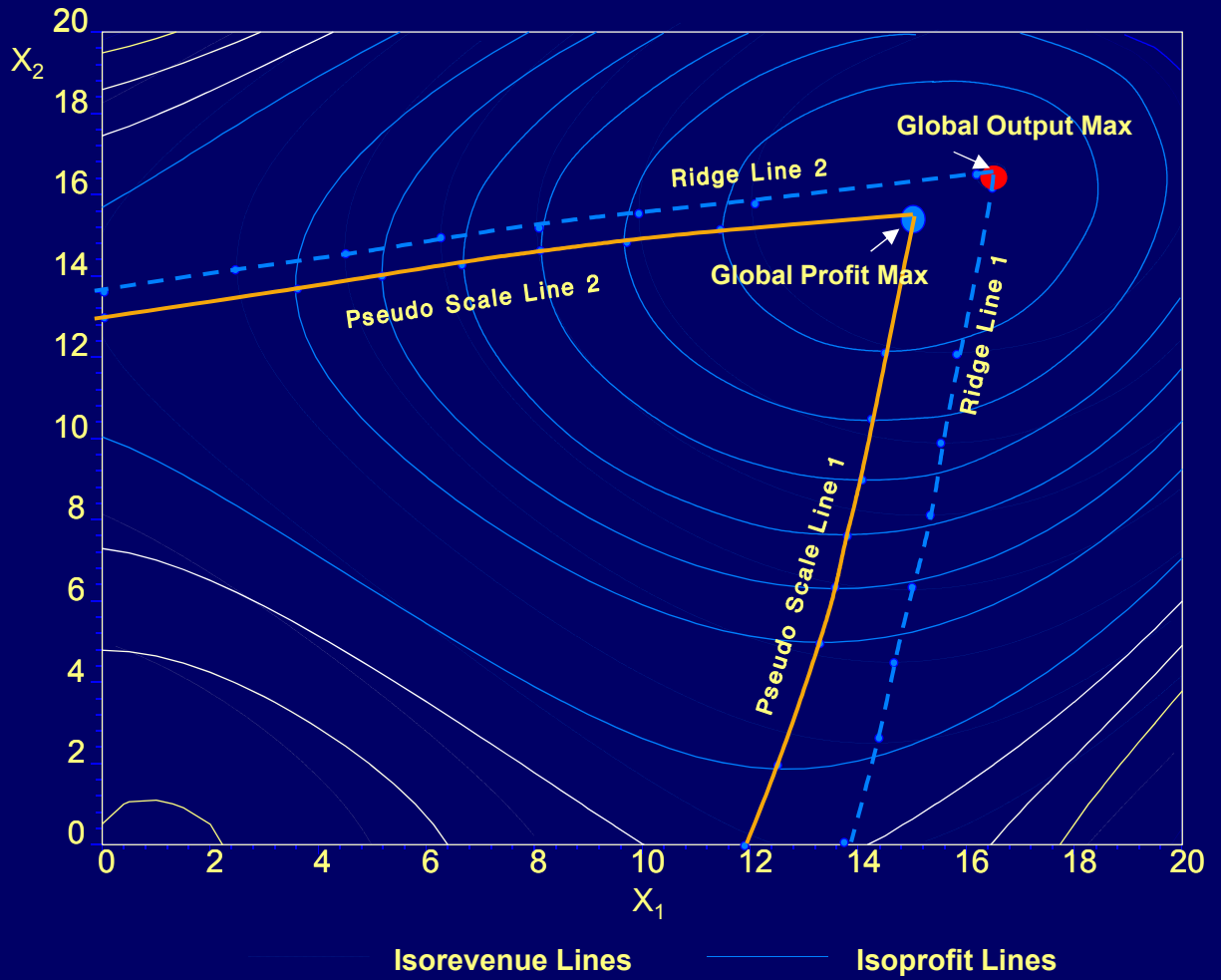


Figure 8.2 Isorevenue and Isoprofit Contours

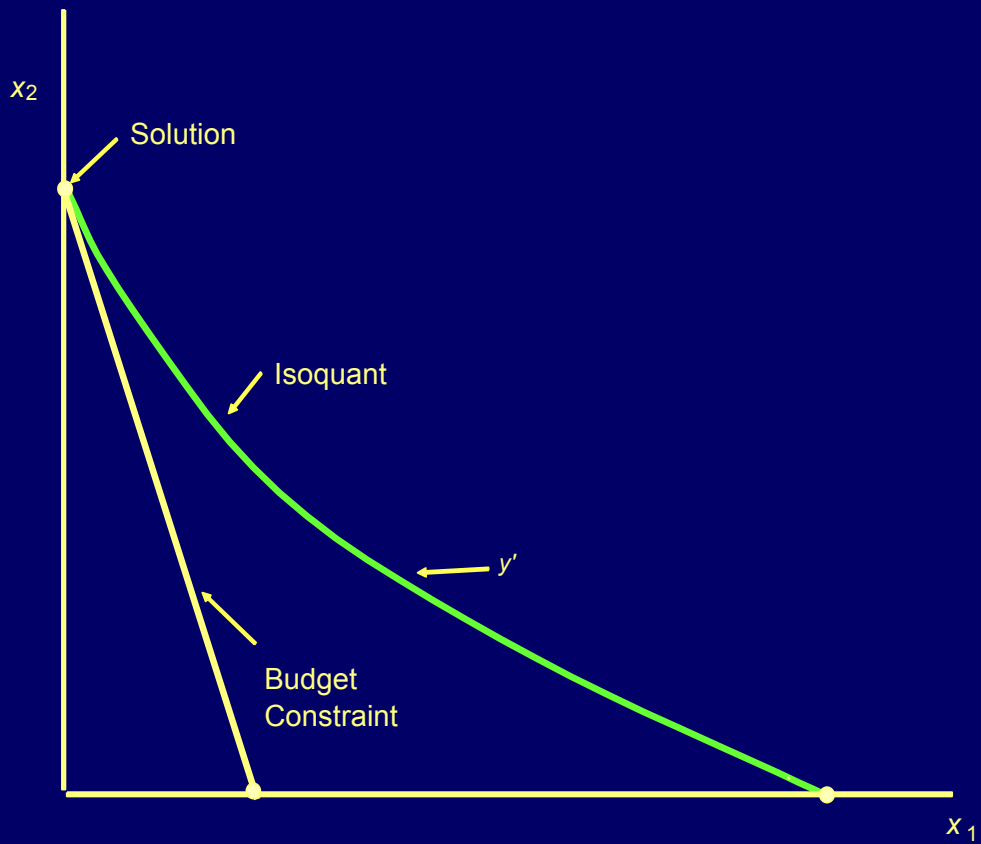


Figure 8.3 A Corner Solution

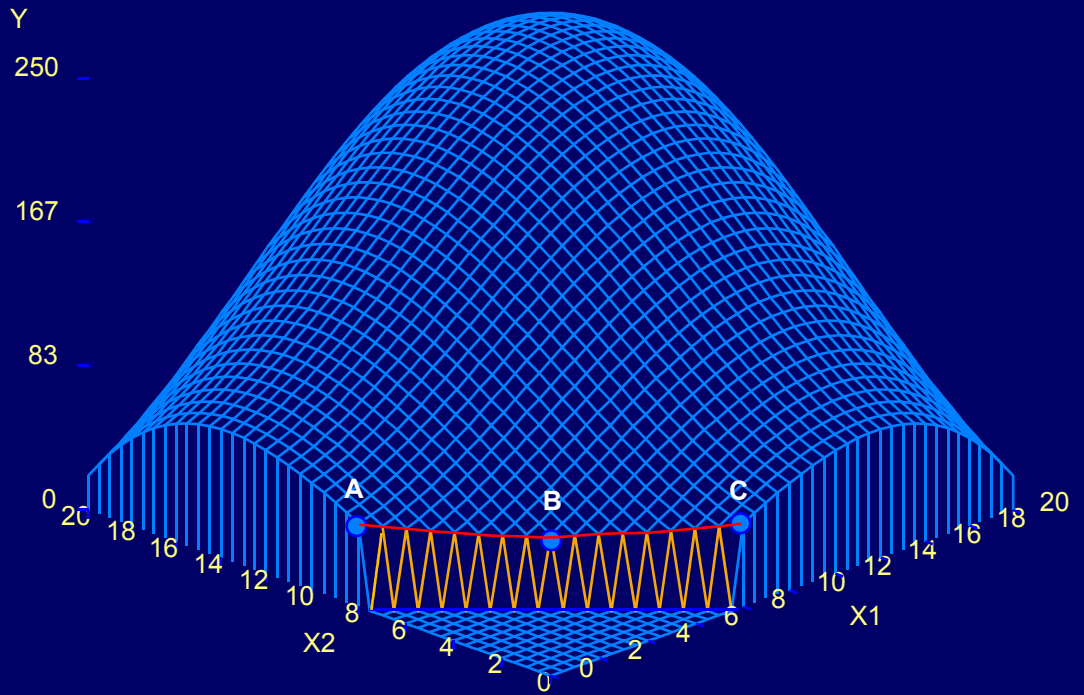


Figure 8.4 A. Point B Less than A and C

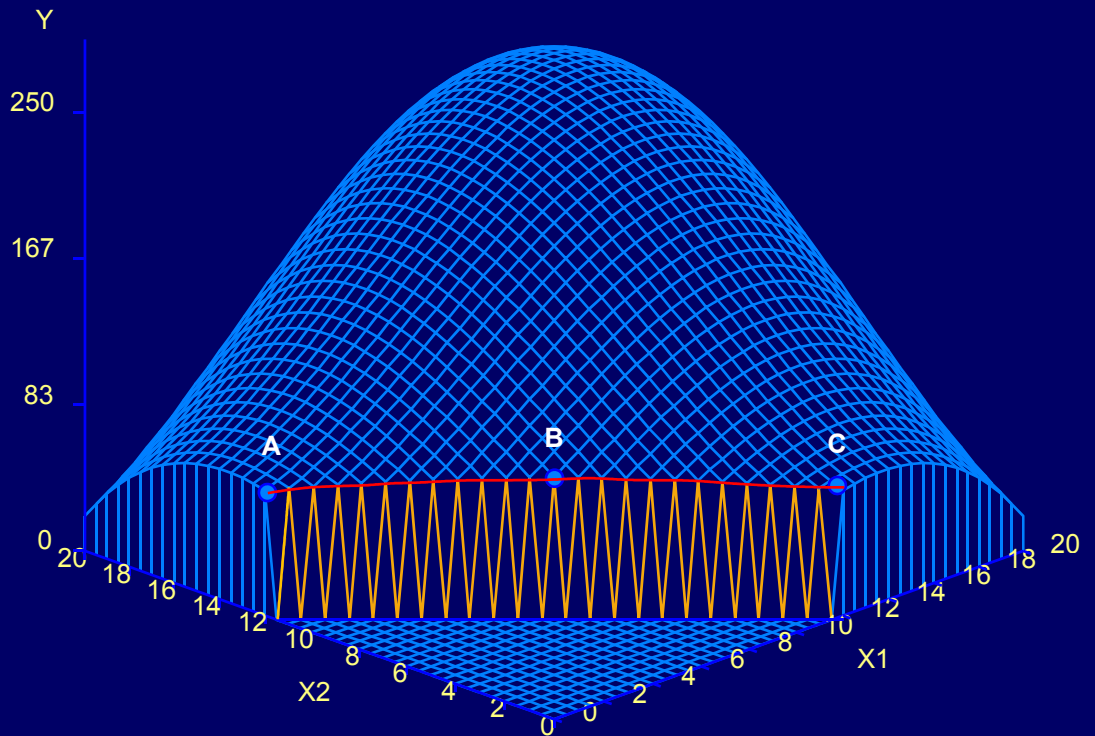


Figure 8.4 B. Point B Equal to A and C

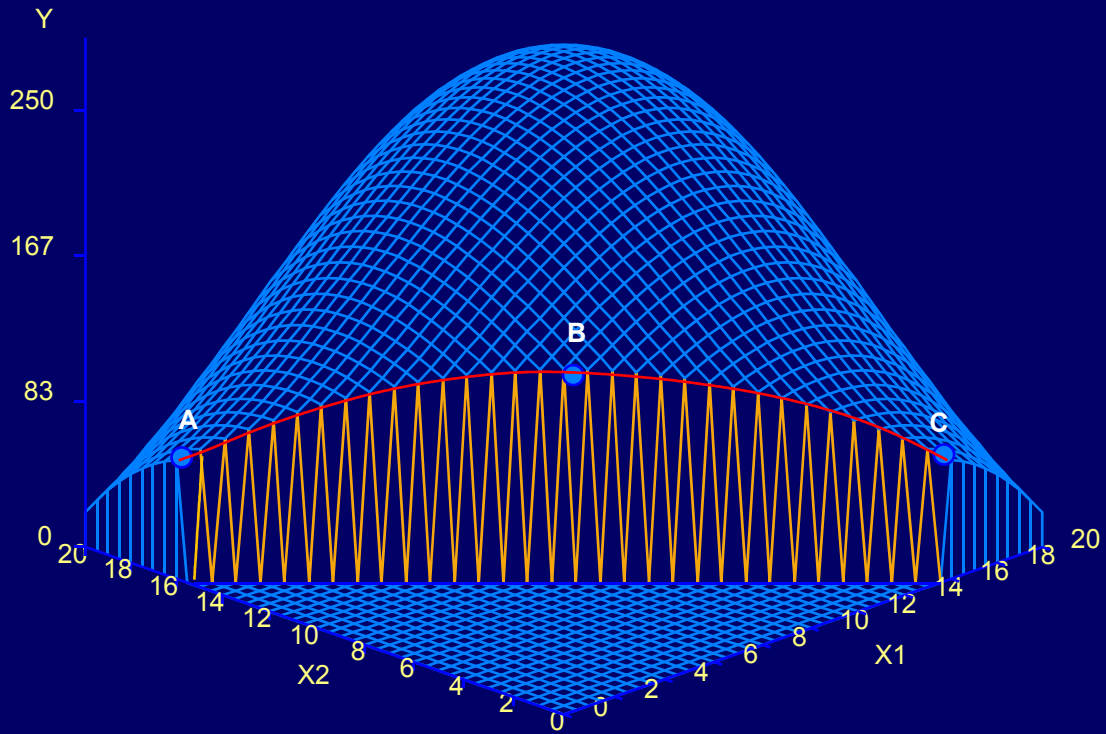


Figure 8.4 C . Point B Greater than A and C

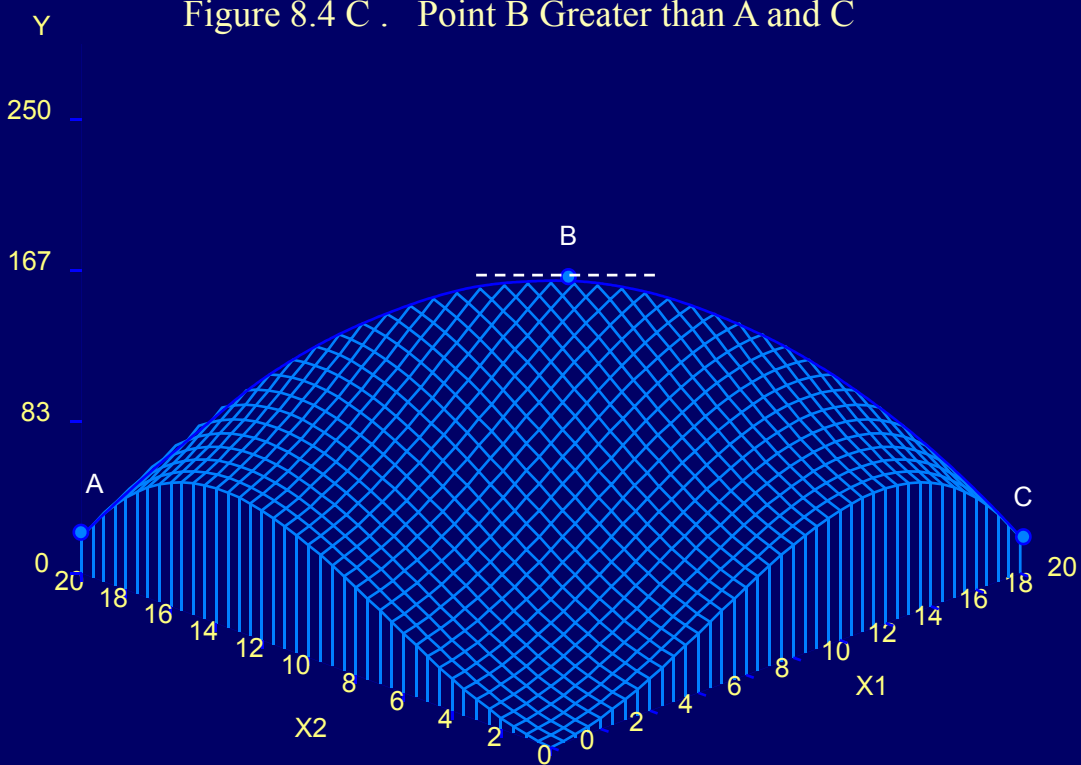


Figure 8.4 D. Point B Greater than A and C

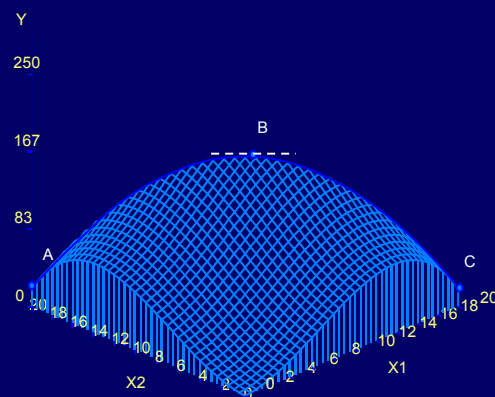
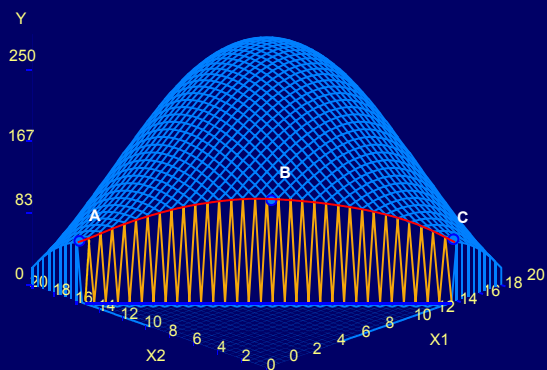
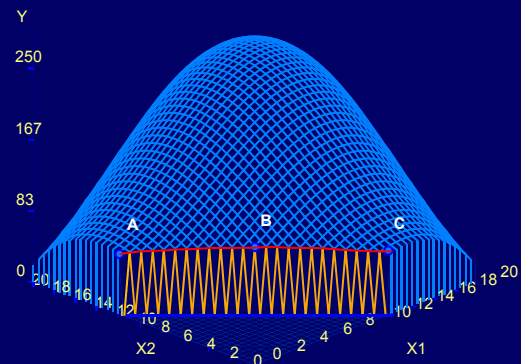
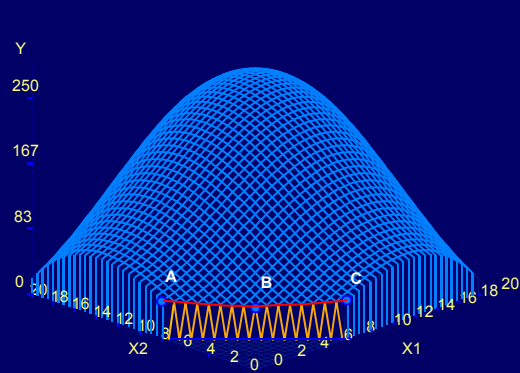


Figure 8.4 Constrained Maximization under Alternative Isoquant Convexity or Concavity Conditions

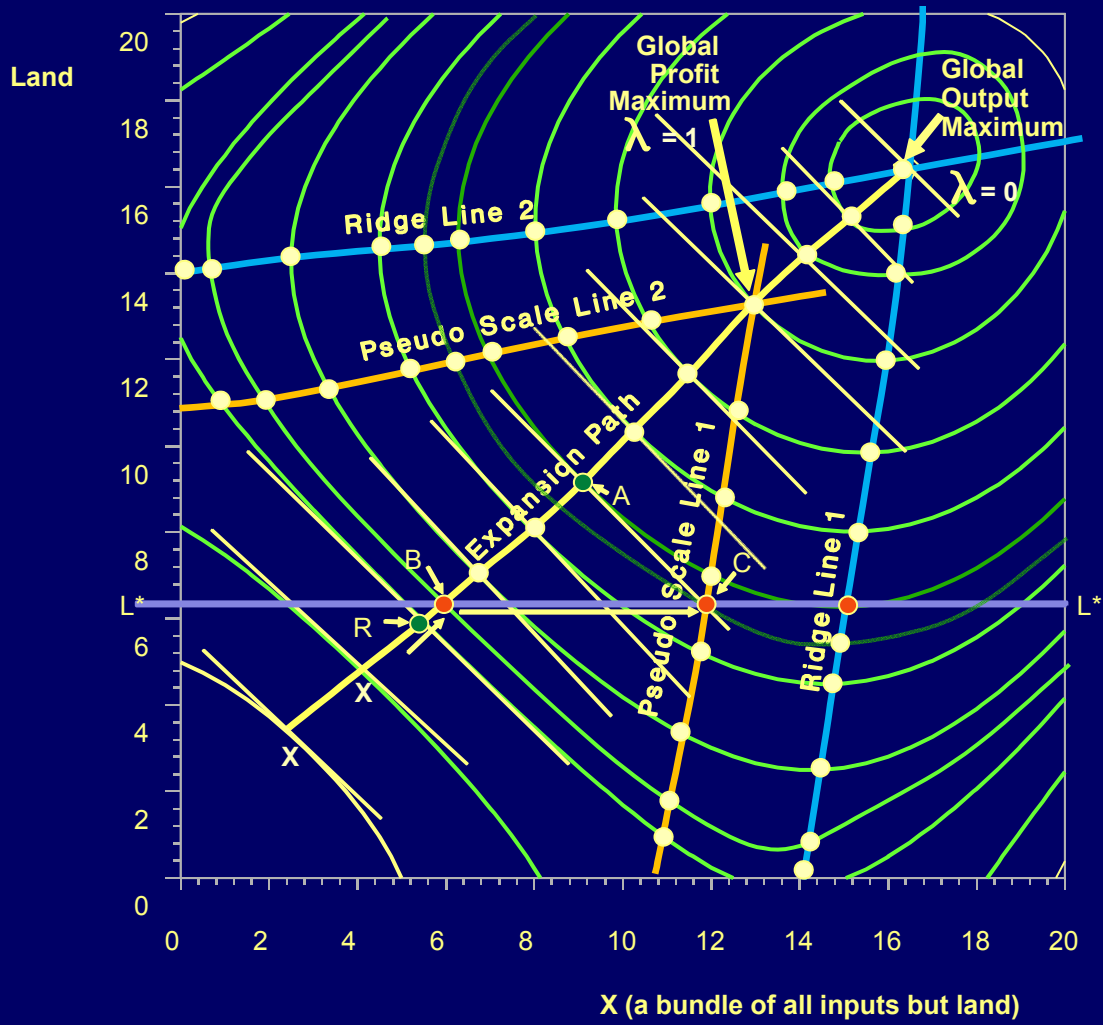


Figure 8.5 The Acreage Allotment Problem

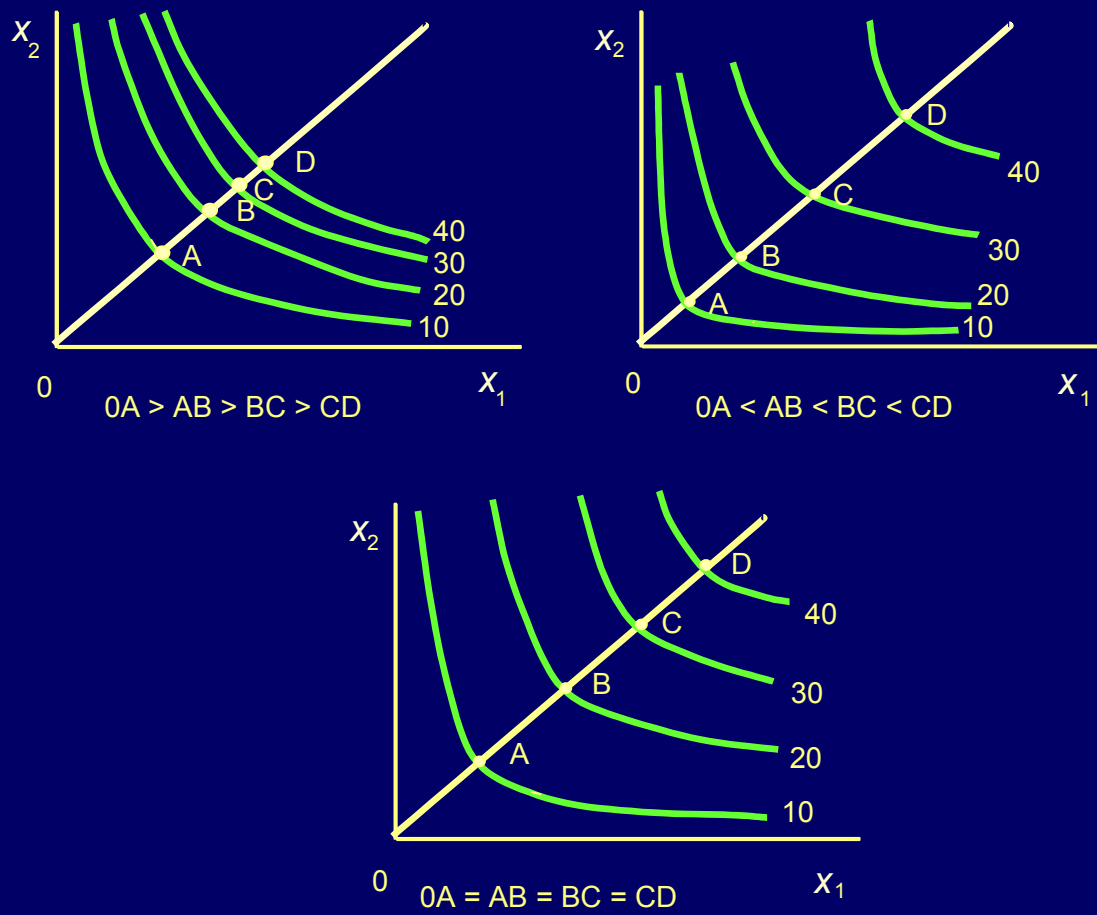


Figure 9.1 Economies, Diseconomies and Constant Returns to Scale For a Production Function with Two Inputs

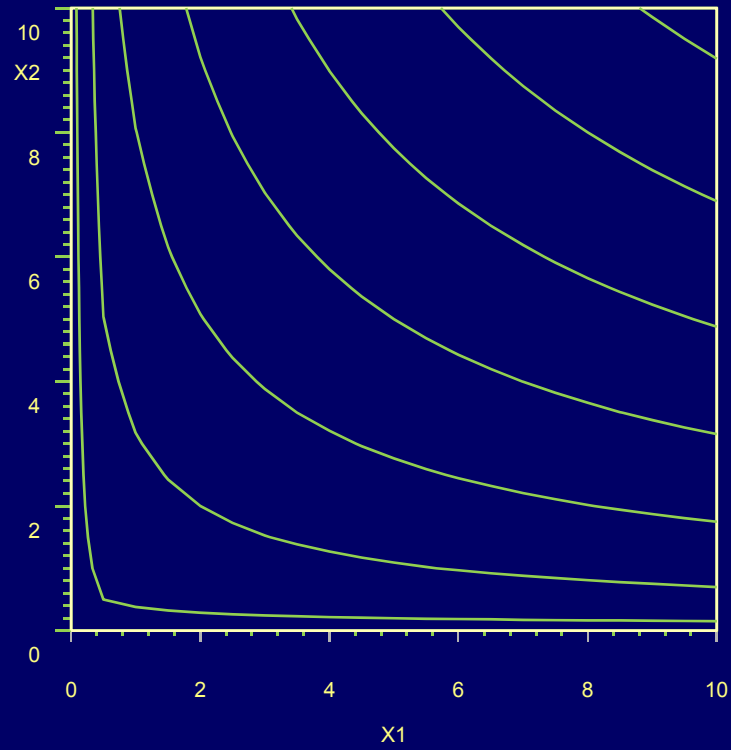


Figure 10.1 Isoquants for the Cobb-Douglas Production Function

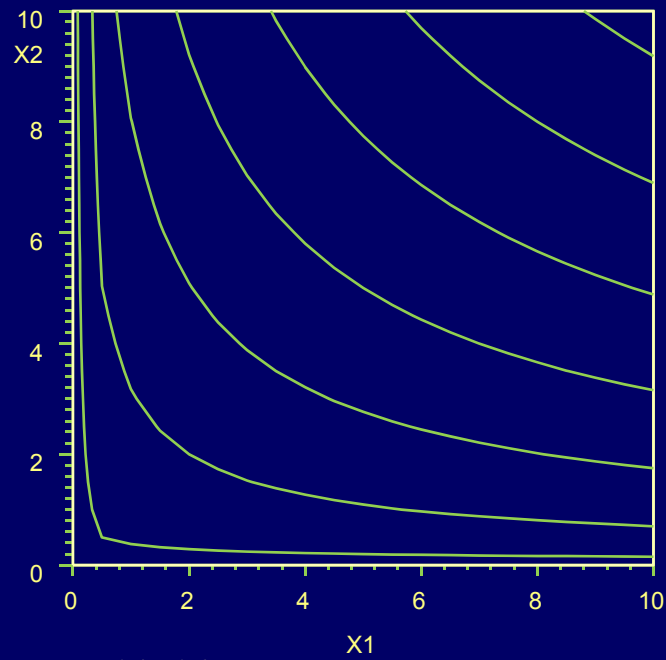
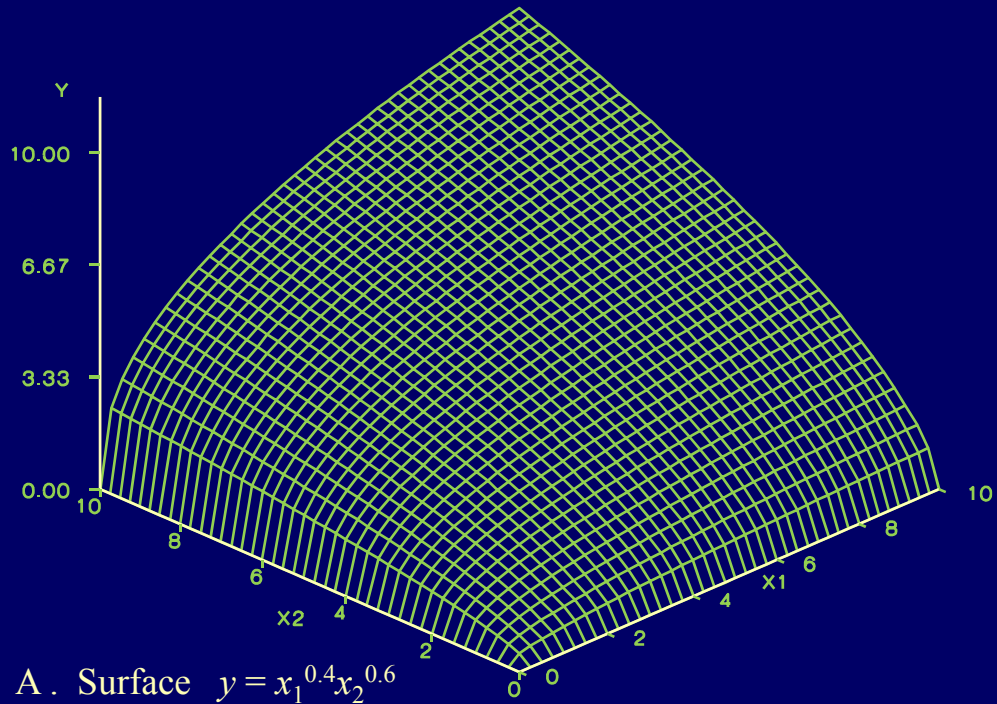


Figure 10.2 Surfaces and Isoquants for the Cobb-Douglas Type Production Function

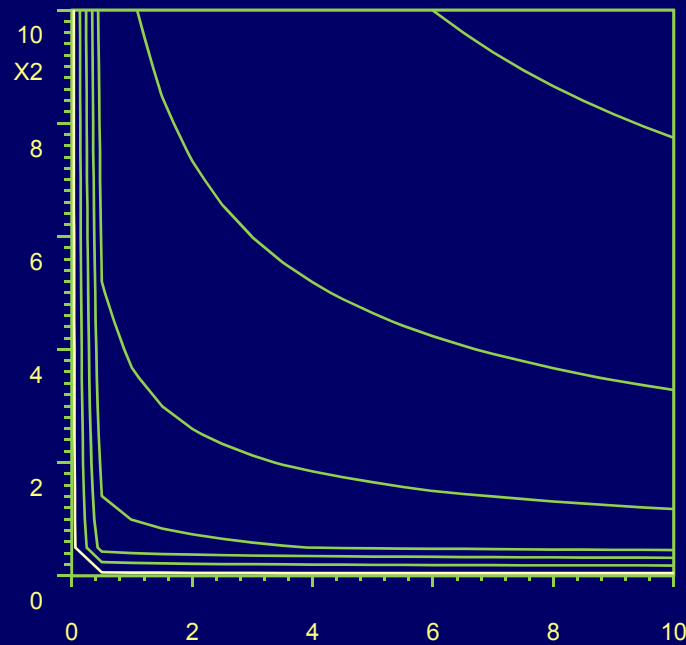
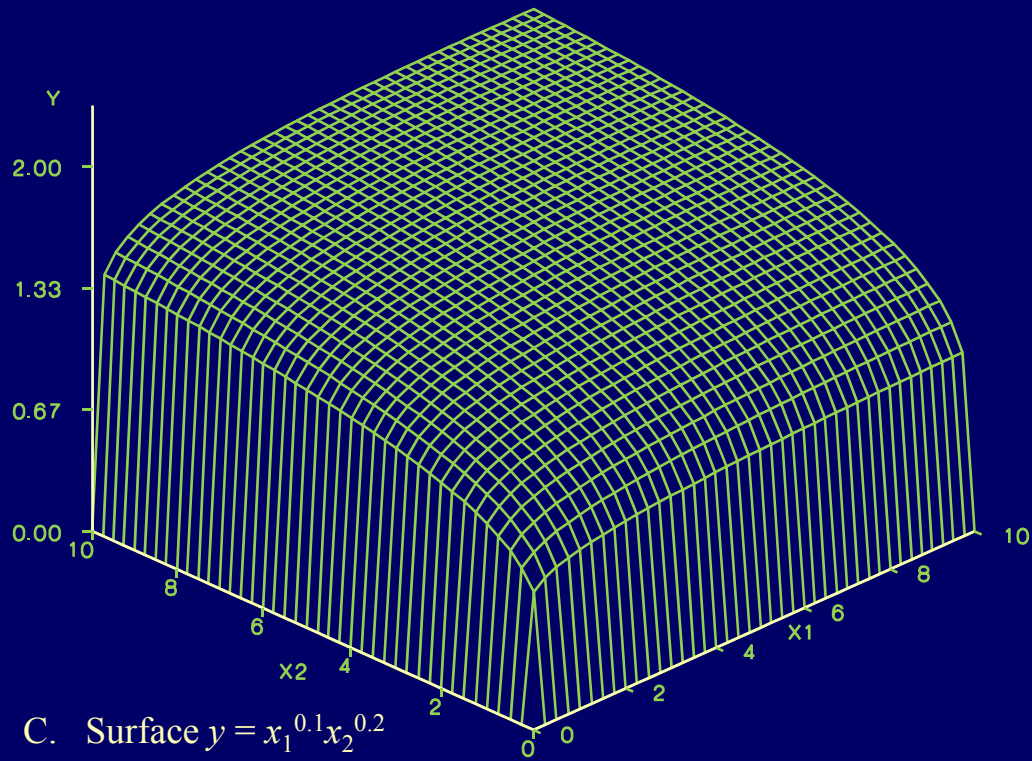
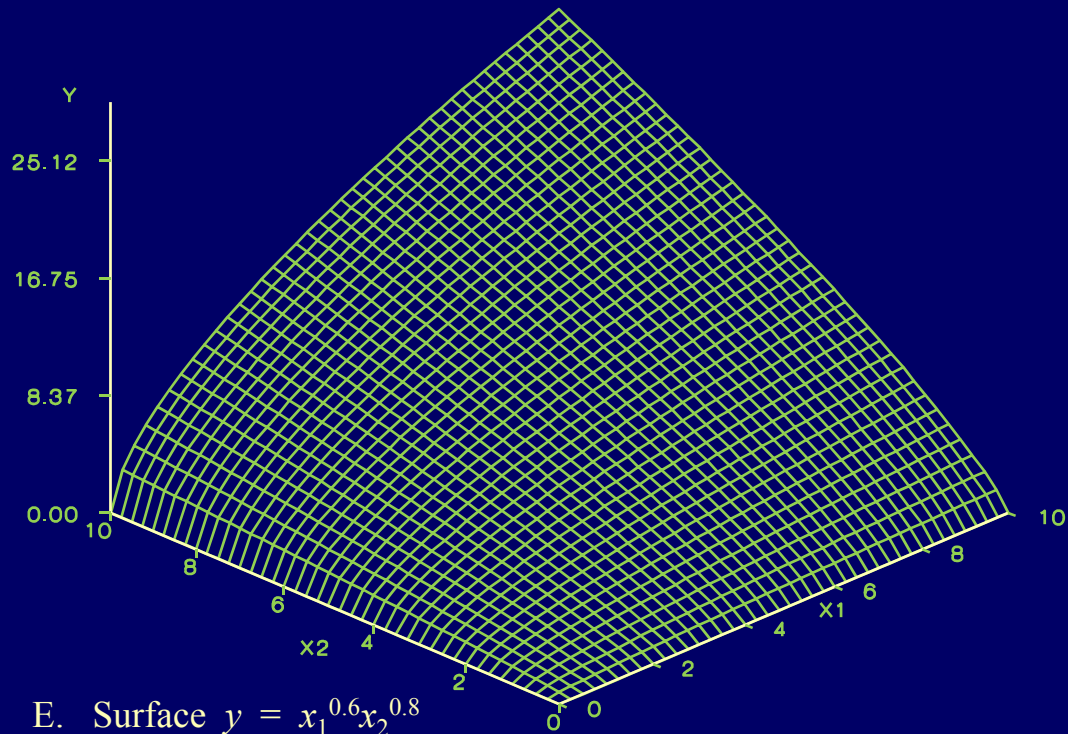
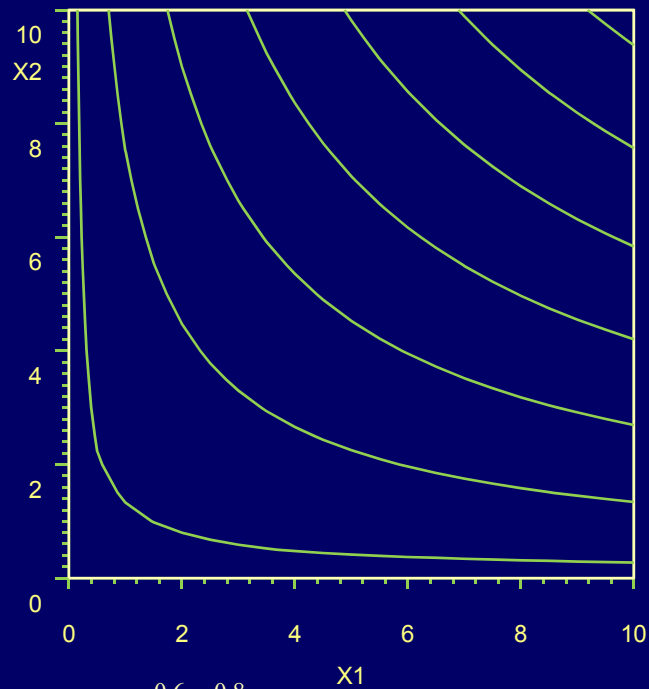


Figure 10.2 Surfaces and Isoquants for the Cobb-Douglas Type Production Function



E. Surface $y = x_1^{0.6}x_2^{0.8}$



F. Isoquants $y = x_1^{0.6}x_2^{0.8}$

Figure 10.2 Surfaces and Isoquants for the Cobb-Douglas Type Production Function

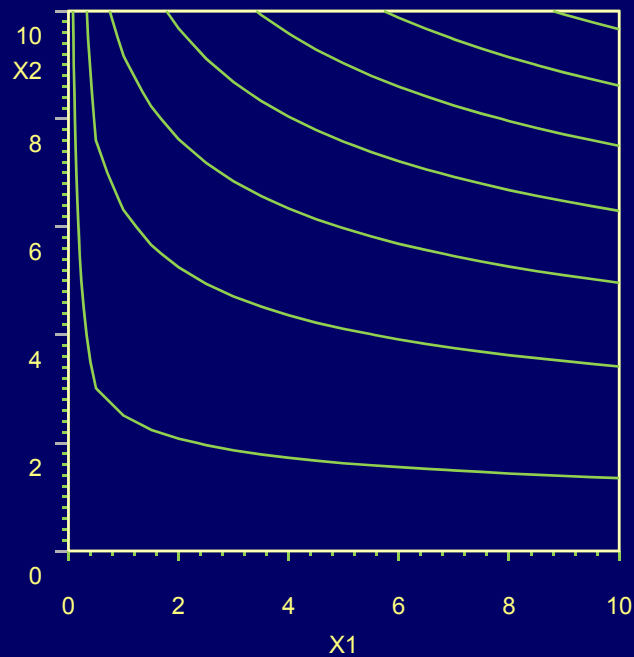
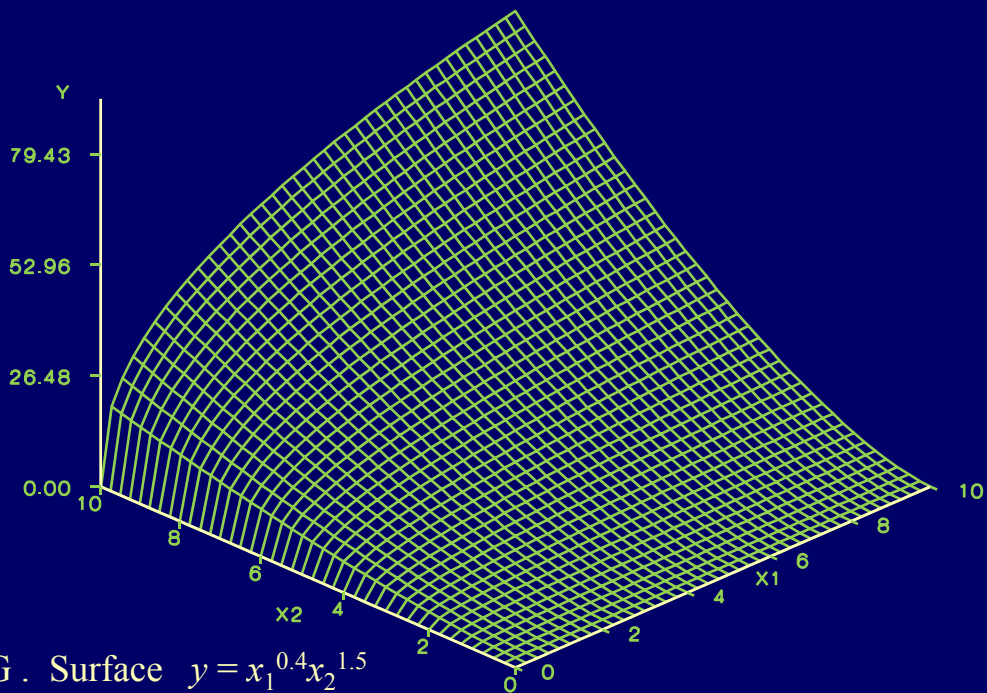
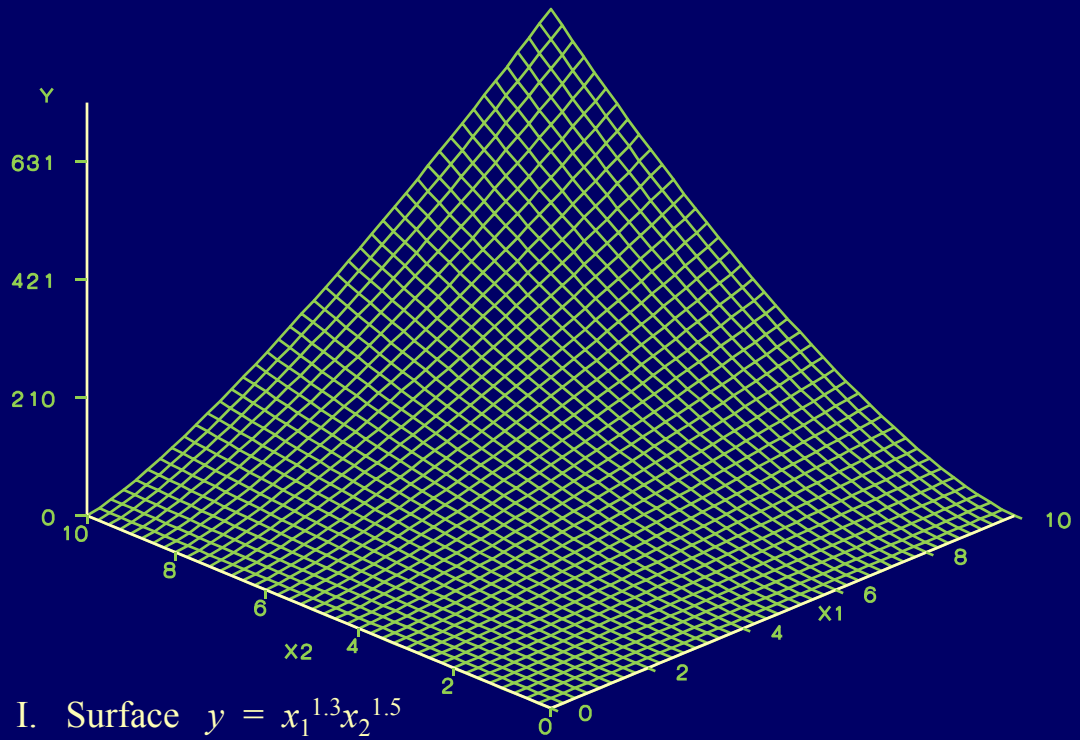
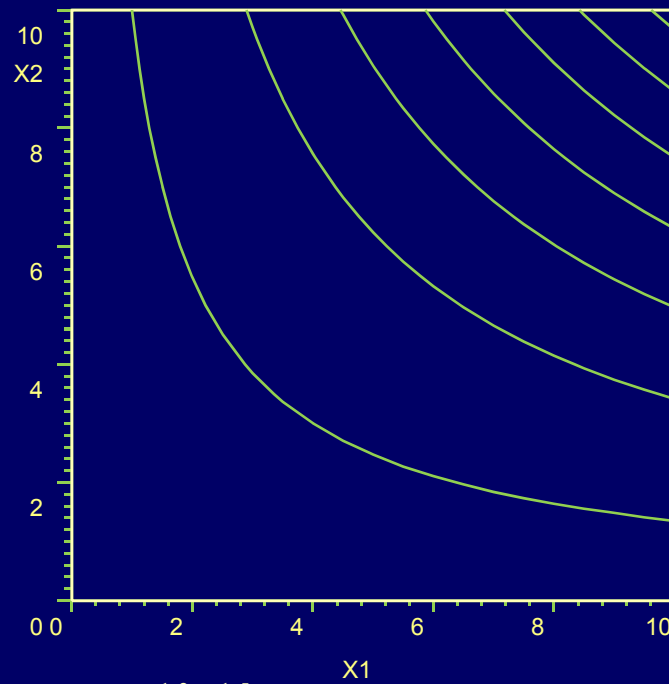


Figure 10.2 Surfaces and Isoquants for the Cobb-Douglas Type Production Function

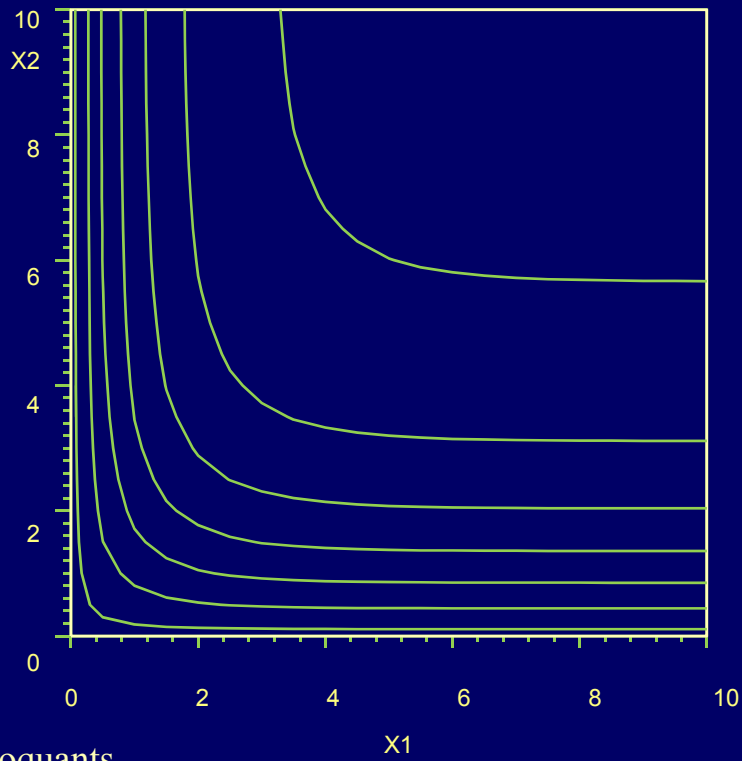
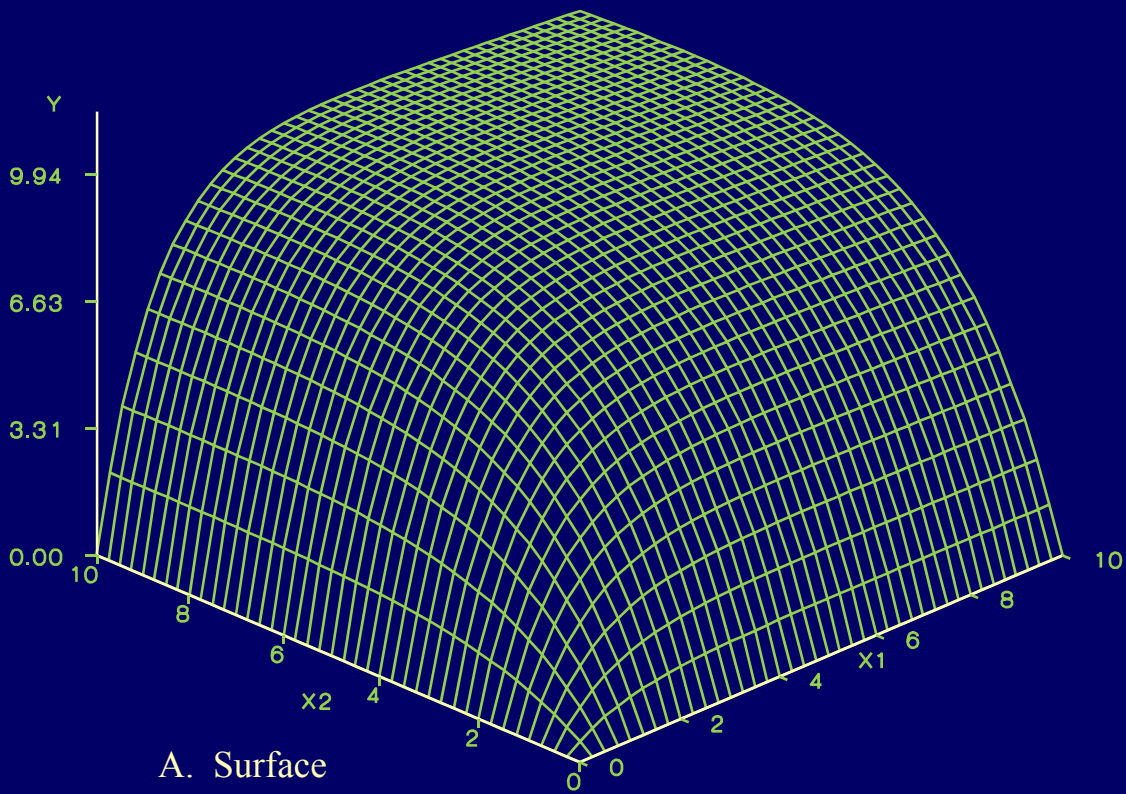


I. Surface $y = x_1^{1.3}x_2^{1.5}$



J. Isoquants $y = x_1^{1.3}x_2^{1.5}$

Figure 10.2 Surfaces and Isoquants for a Cobb-Douglas Type Production Function



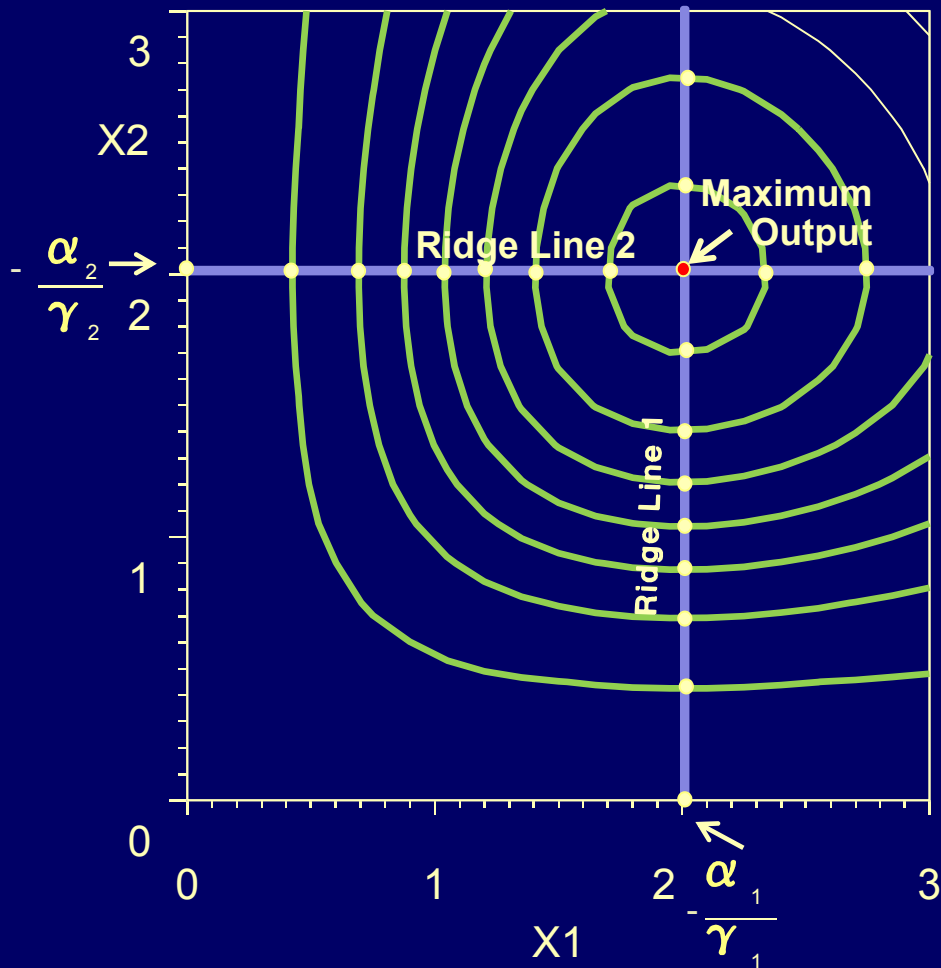
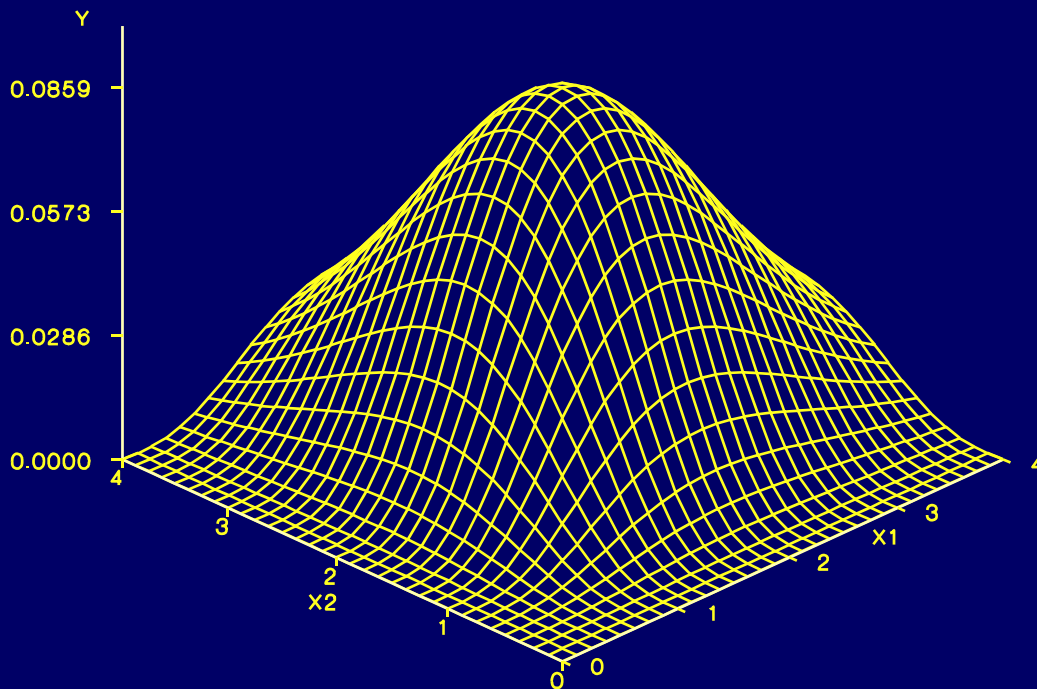
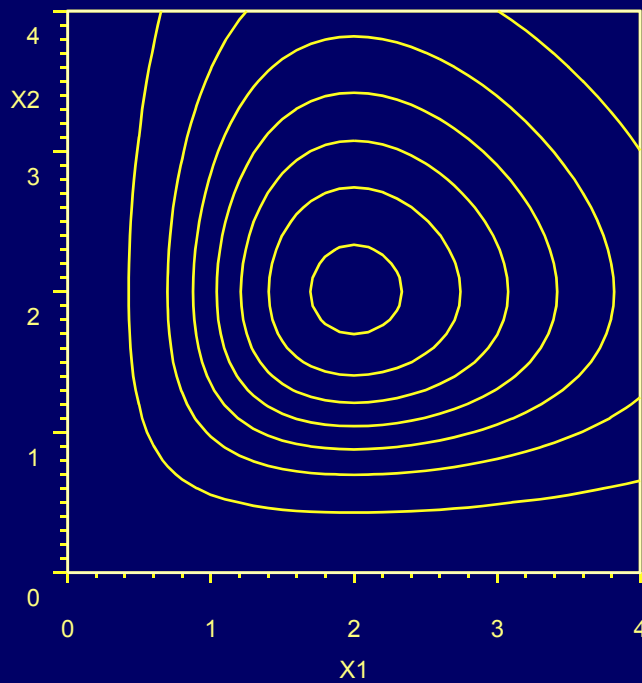


Figure 11.2 Isoquants and Ridge Lines for the Transcendental,
 $\gamma_1 = \gamma_2 - 2$; $\alpha_1 = \alpha_2 = 4$; $\gamma_3 = 0$

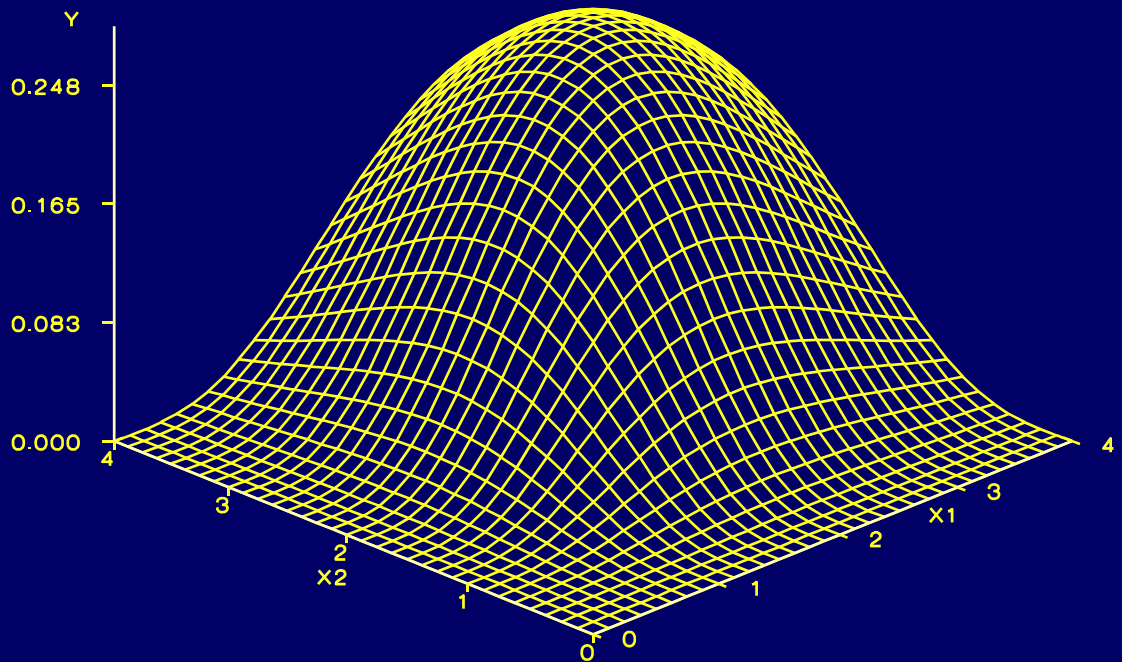


A. Surface $\gamma_1 = \gamma_2 = -2$; $\alpha_1 = \alpha_2 = 4$; $\gamma_3 = 0$

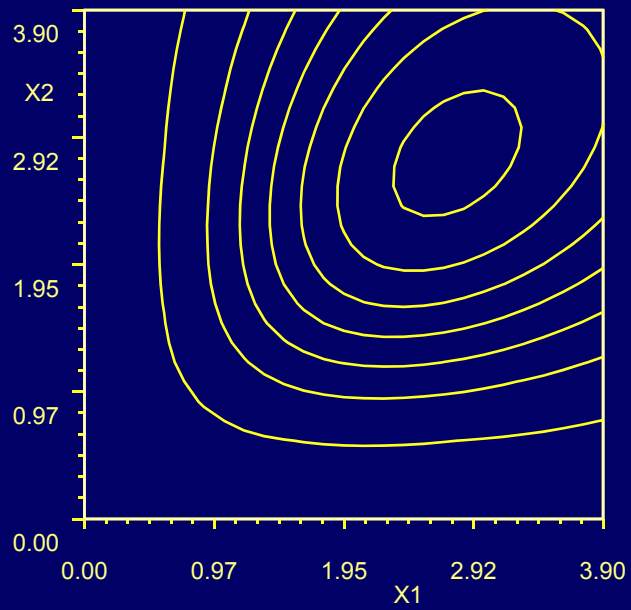


B. Isoquants $\gamma_1 = \gamma_2 = -2$; $\alpha_1 = \alpha_2 = 4$; $\gamma_3 = 0$

Figure 11.3 The Transcendental Production Function
Under Varying Parameter Assumptions

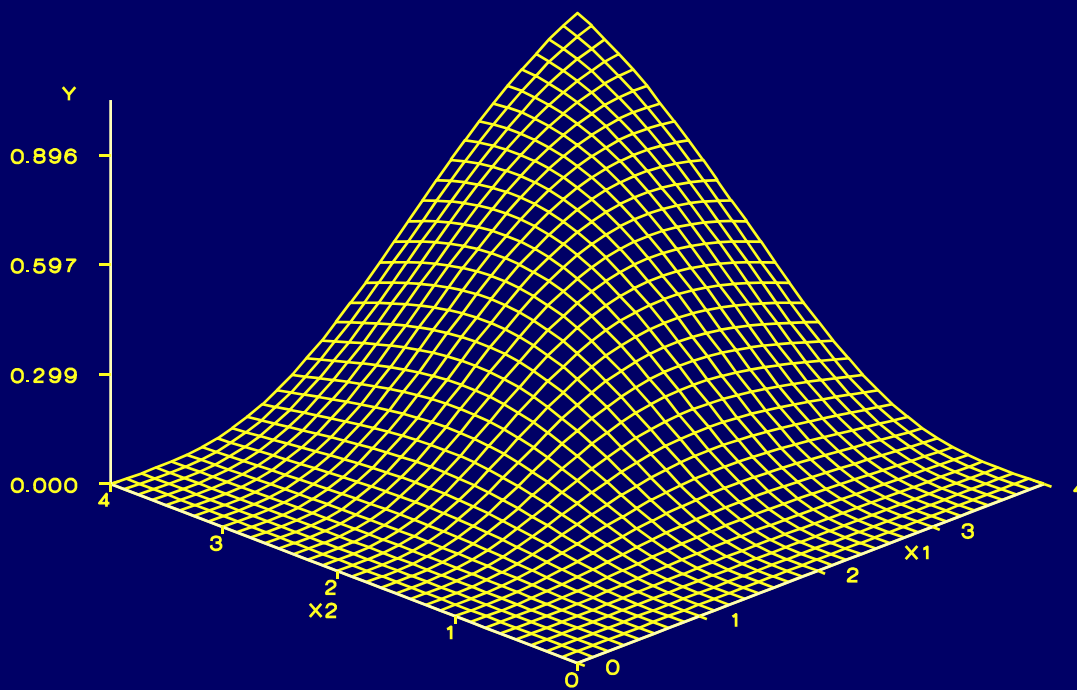


C. Surface $\gamma_1 = \gamma_2 = -2$; $\alpha_1 = \alpha_2 = 4$; $\gamma_3 = 0.2$

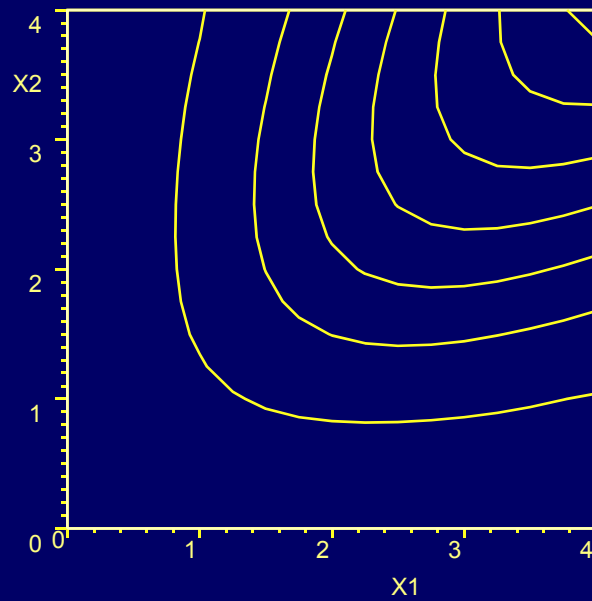


D. Isoquants $\gamma_1 = \gamma_2 = -2$; $\alpha_1 = \alpha_2 = 4$; $\gamma_3 = 0.2$

Figure 11.3 The Transcendent Production Function Under Varying Parameter Assumptions

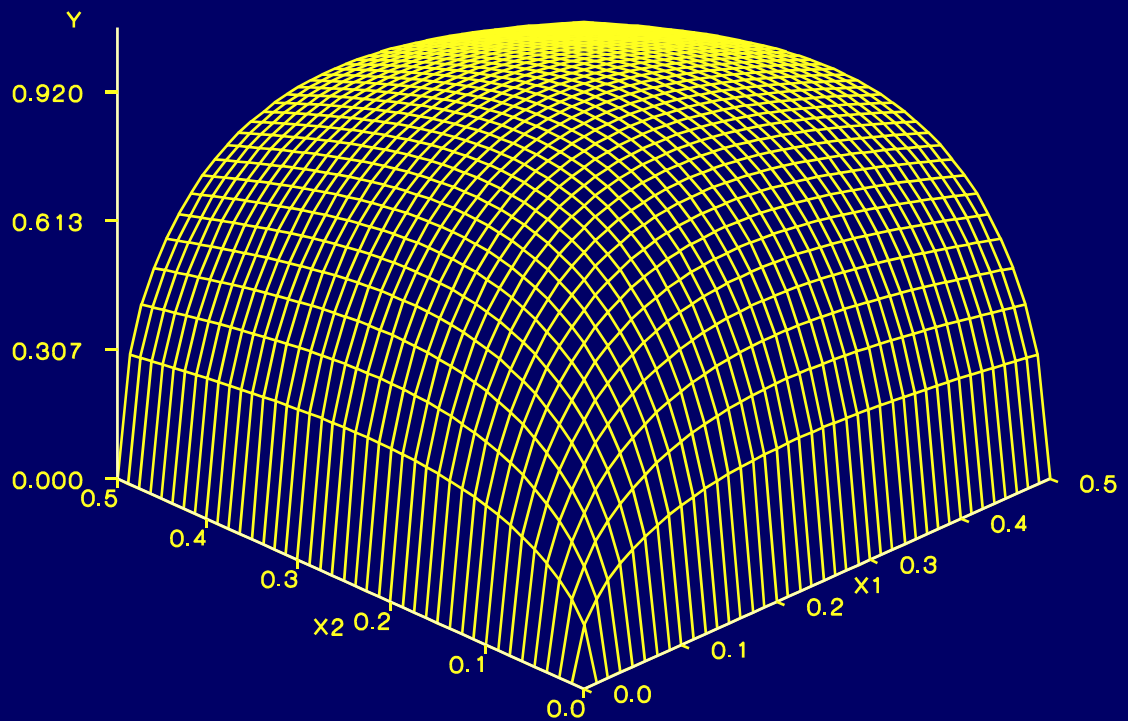


E. Surface $\gamma_1 = \gamma_2 = -2; \alpha_1 = \alpha_2 = 4; \gamma_3 = 0.3$

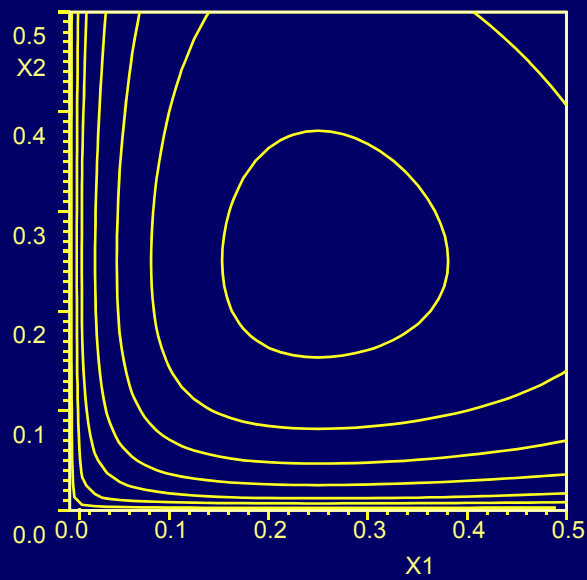


F. Isoquants $\gamma_1 = \gamma_2 = -2; \alpha_1 = \alpha_2 = 4; \gamma_3 = 0.3$

Figure 11.3 The Transcendental Production Function
Under Varying Parameter Assumptions

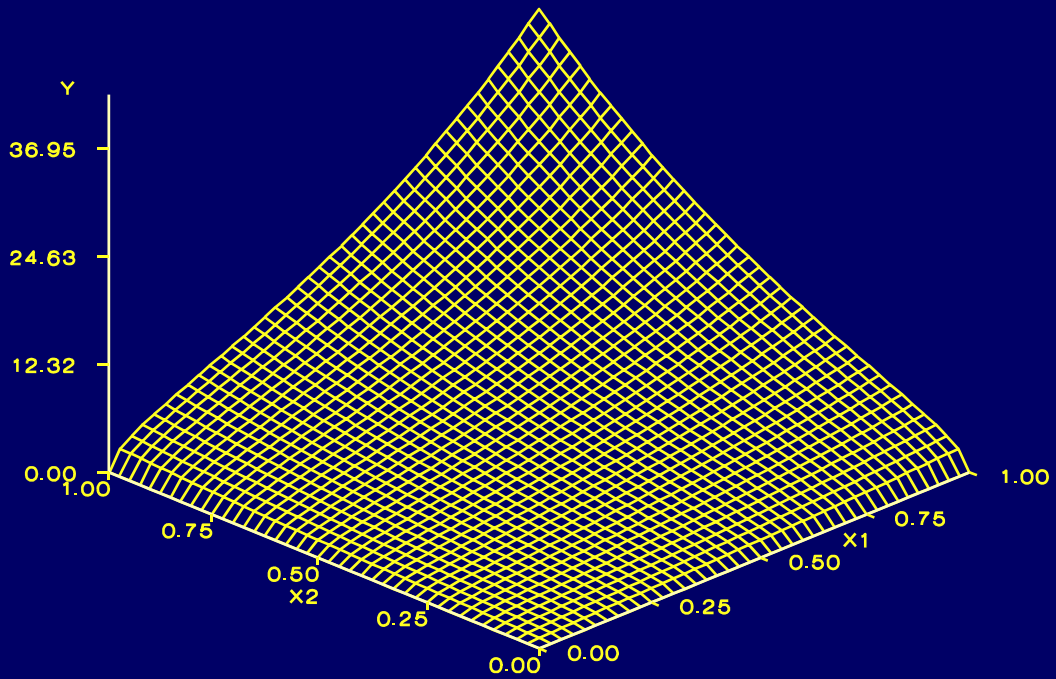


G. Surface $\gamma_1 = \gamma_2 = -2; \alpha_1 = \alpha_2 = 0.5; \gamma_3 = 0$

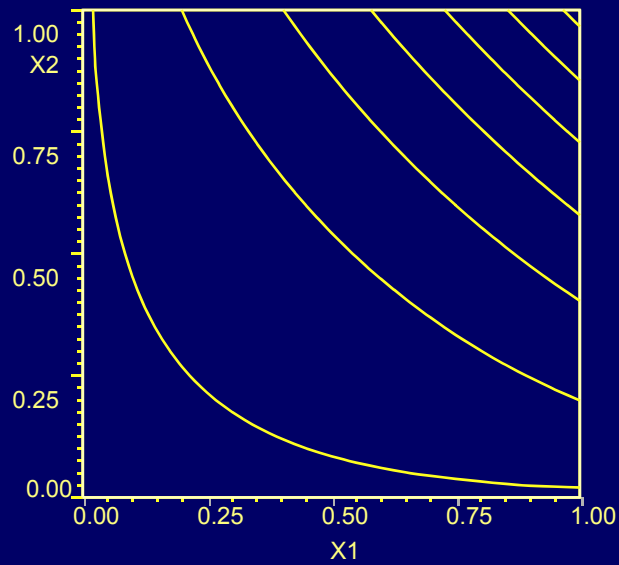


H. Isoquants $\gamma_1 = \gamma_2 = -2; \alpha_1 = \alpha_2 = 0.5; \gamma_3 = 0$

Figure 11.3 The Transcendental Production Function Under Varying Parameter Assumptions



I. Surface $\gamma_1 = \gamma_2 = 1; \alpha_1 = \alpha_2 = 0.5; \gamma_3 = 0$



J. Isoquants $\gamma_1 = \gamma_2 = 1; \alpha_1 = \alpha_2 = 0.5; \gamma_3 = 0$

Figure 11.3 The Transcendental Production Function Under Varying Parameter Assumptions

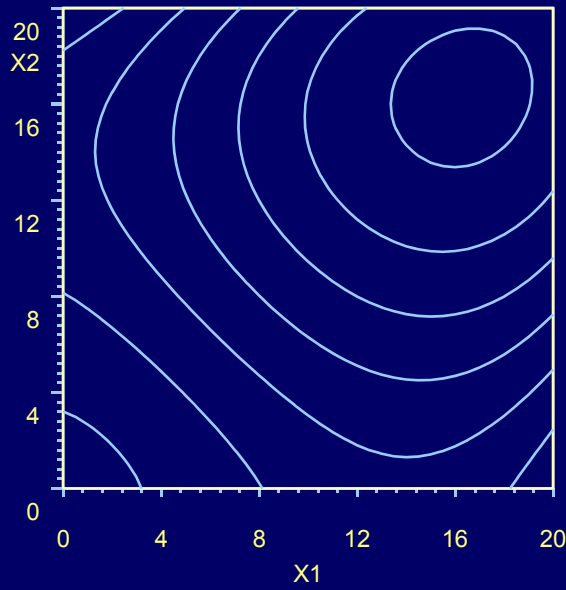
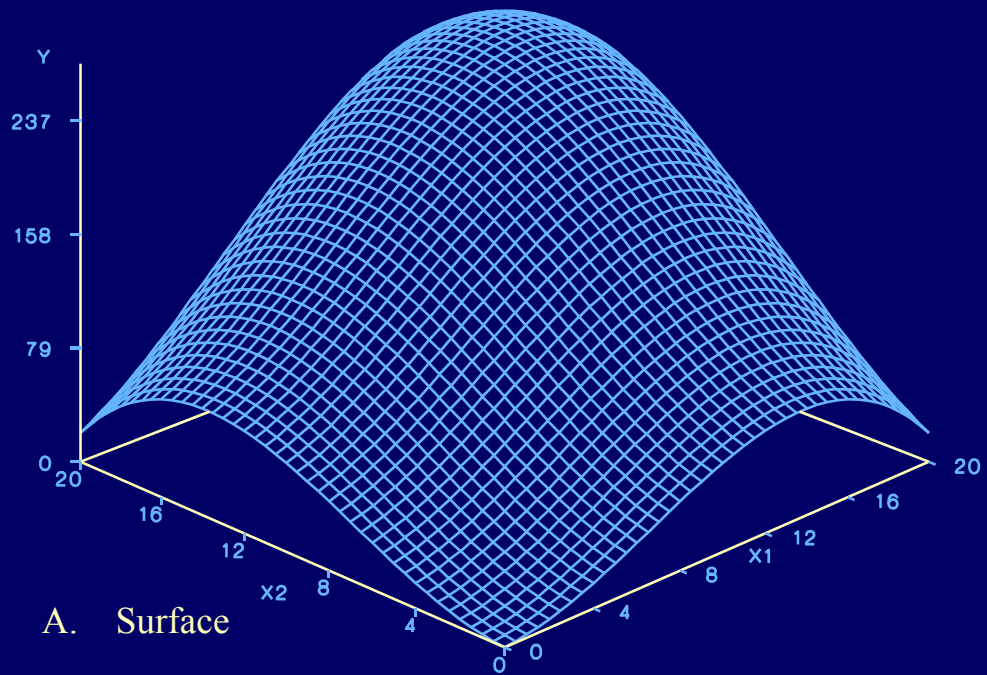


Figure 11.4 The Polynomial

$$y = x_1 + x_1^2 - 0.05 x_1^3 + x_2 + x_2^2 - 0.05 x_2^3 + 0.4 x_1 x_2$$

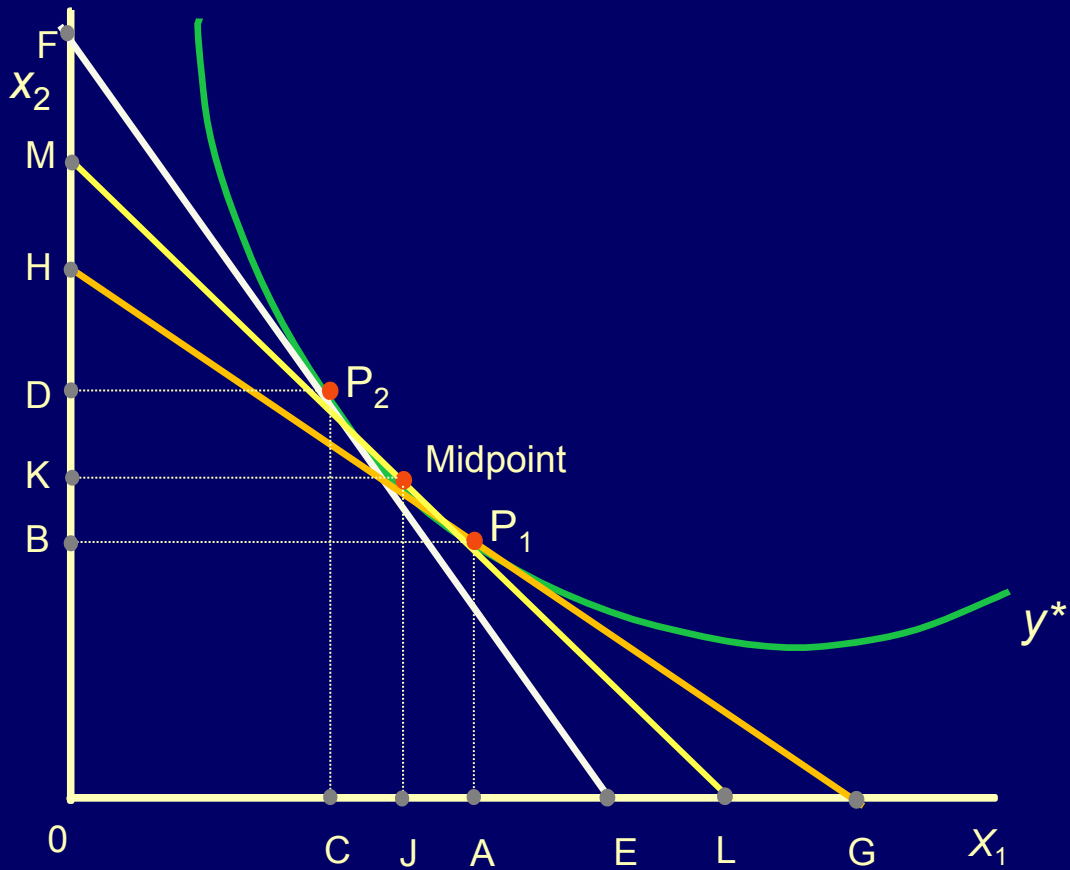


Figure 12.1 The Arc Elasticity of Substitution

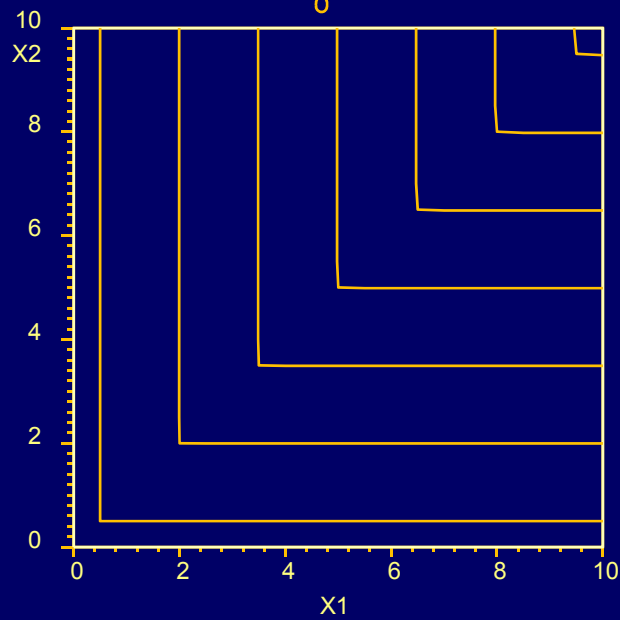
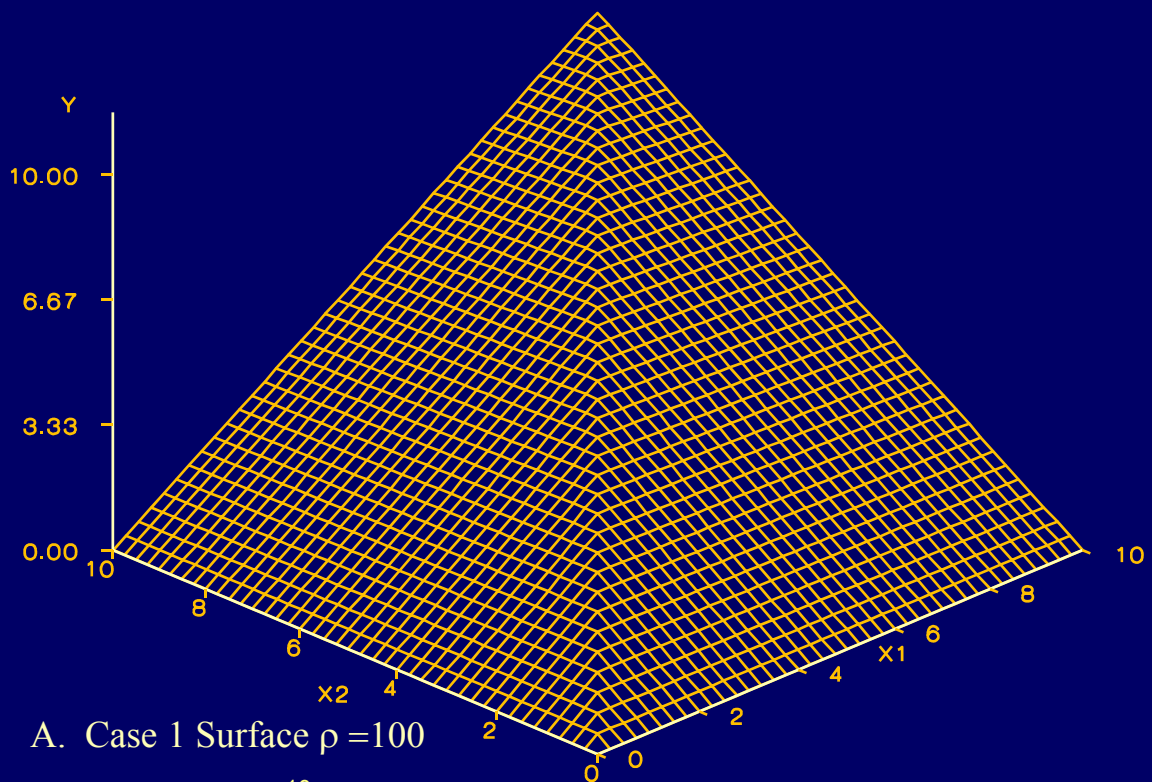
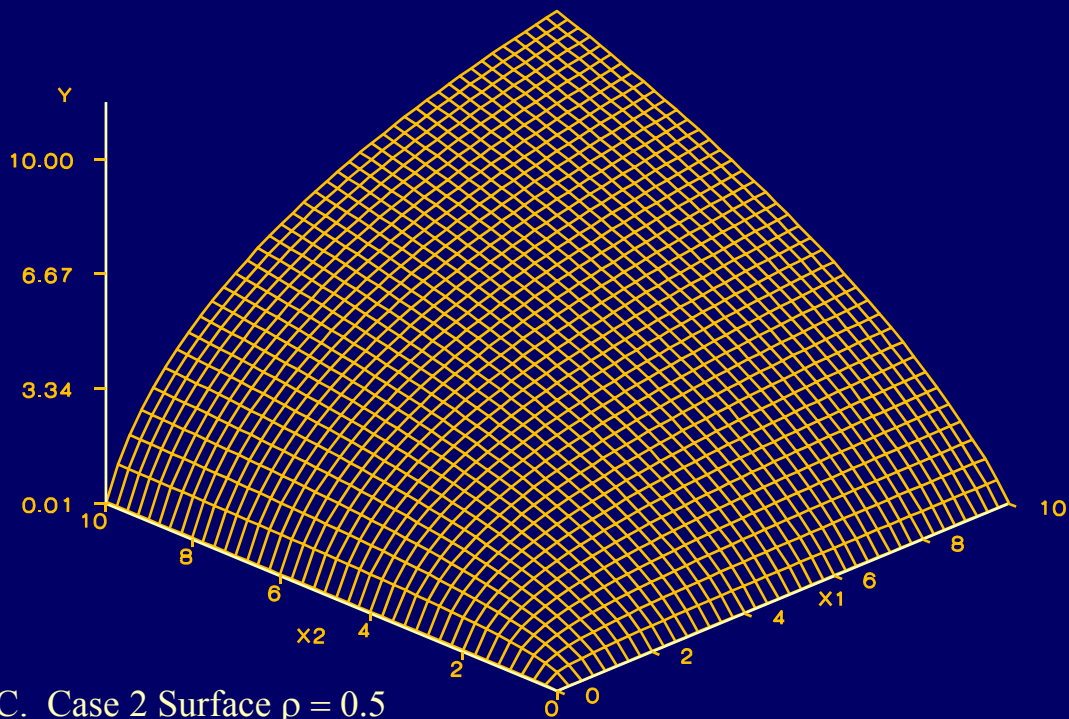
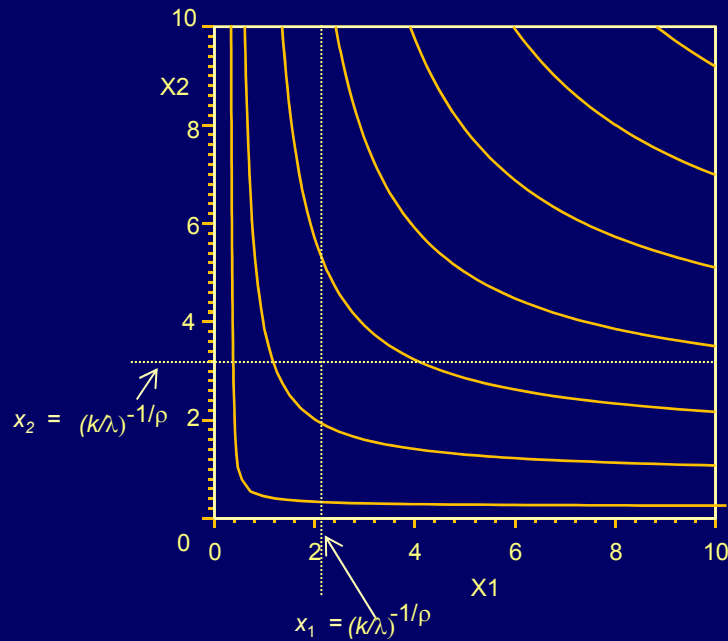


Figure 12.2 Production Surfaces and Isoquants for the *CES* Production Function under Varying Assumptions about ρ

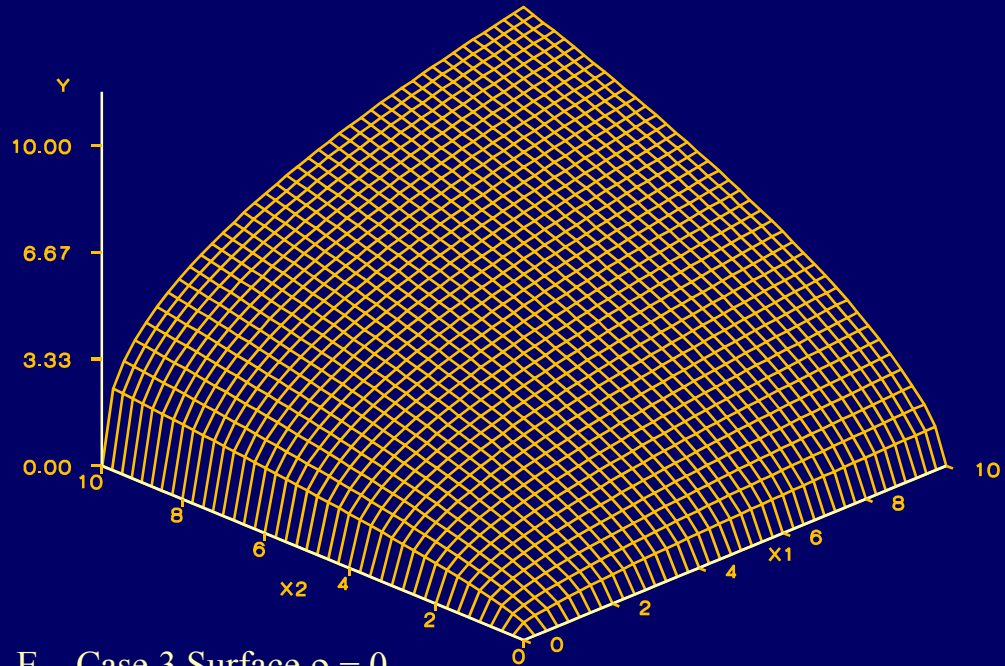


C. Case 2 Surface $\rho = 0.5$

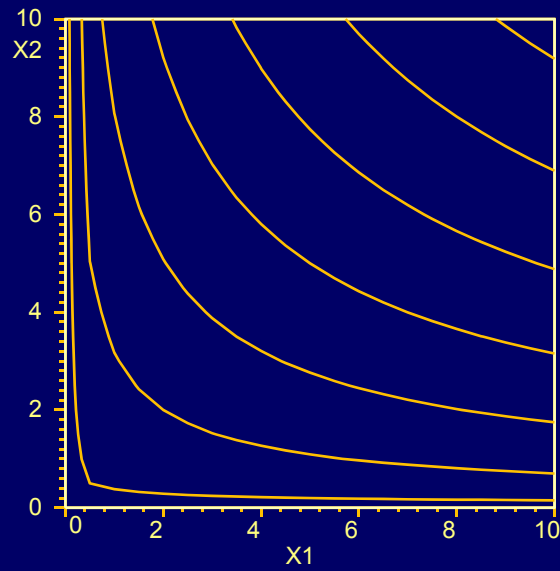


D. Case 2 Isoquants $\rho = 0.5$

Figure 12.2 Production Surfaces and Isoquants for the *CES* Production Function under Varying Assumptions about ρ

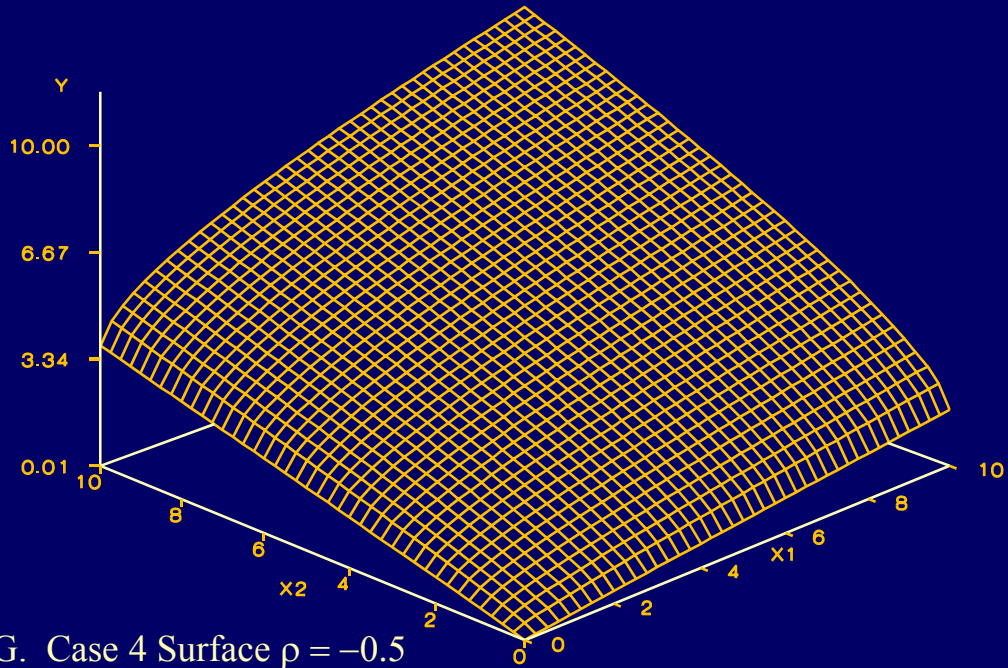


E. Case 3 Surface $\rho = 0$

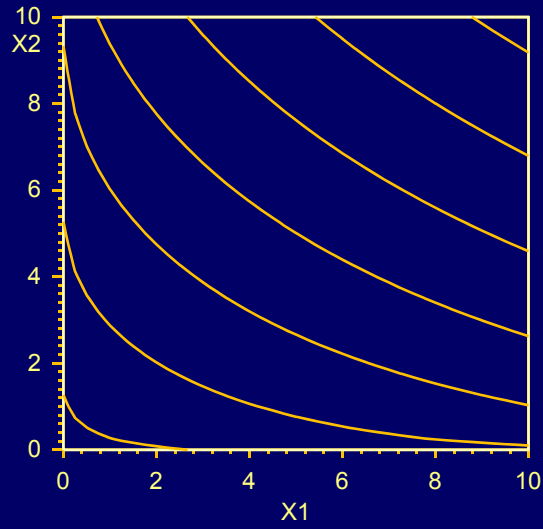


F. Case 3 Isoquants $\rho = 0$

Figure 12.2 Production Surfaces and Isoquants for the *CES* Production Function under Varying Assumptions about ρ

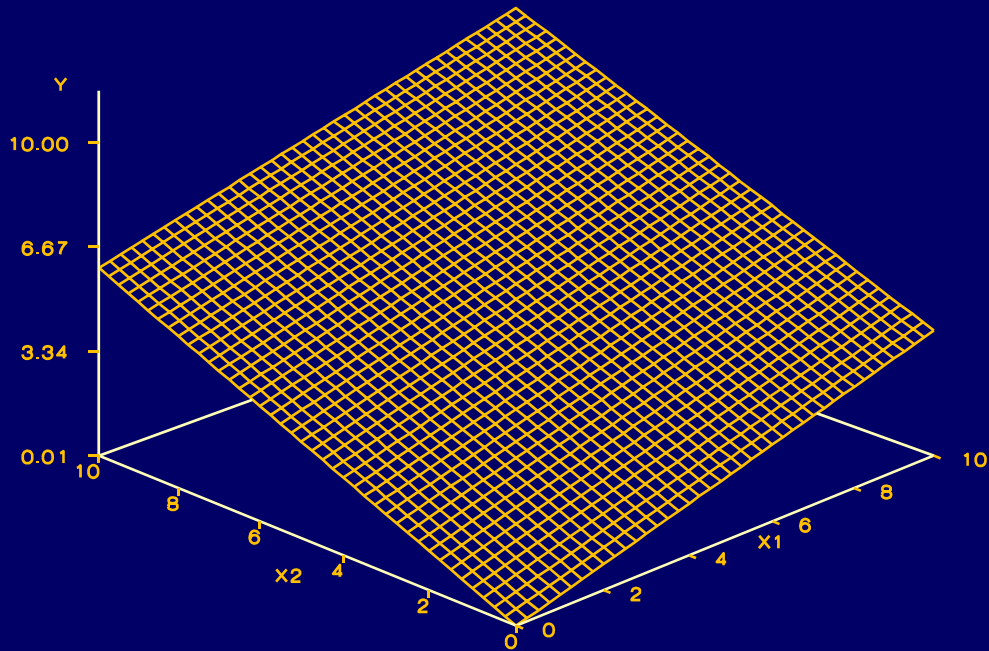


G. Case 4 Surface $\rho = -0.5$

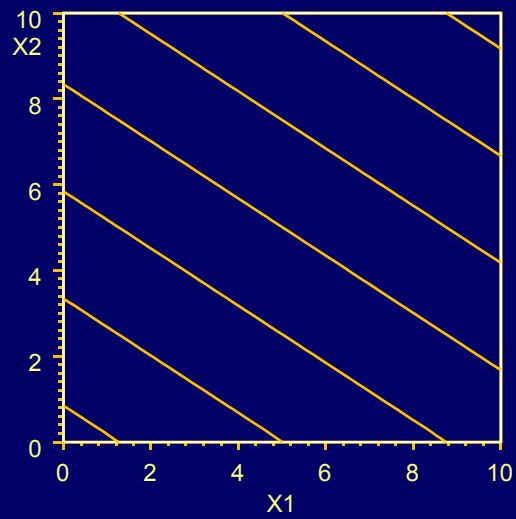


J Case 4 Isoquants $\rho = -0.5$

Figure 12.2 Production Surfaces and Isoquants for the *CES* Production Function under Varying Assumptions about ρ



I. Case 5 Surface ρ approaches -1



J. Case 5 Isoquants ρ approaches -1

Figure 12.2 Production Surfaces and Isoquants for the *CES* Production Function under Varying Assumptions about ρ

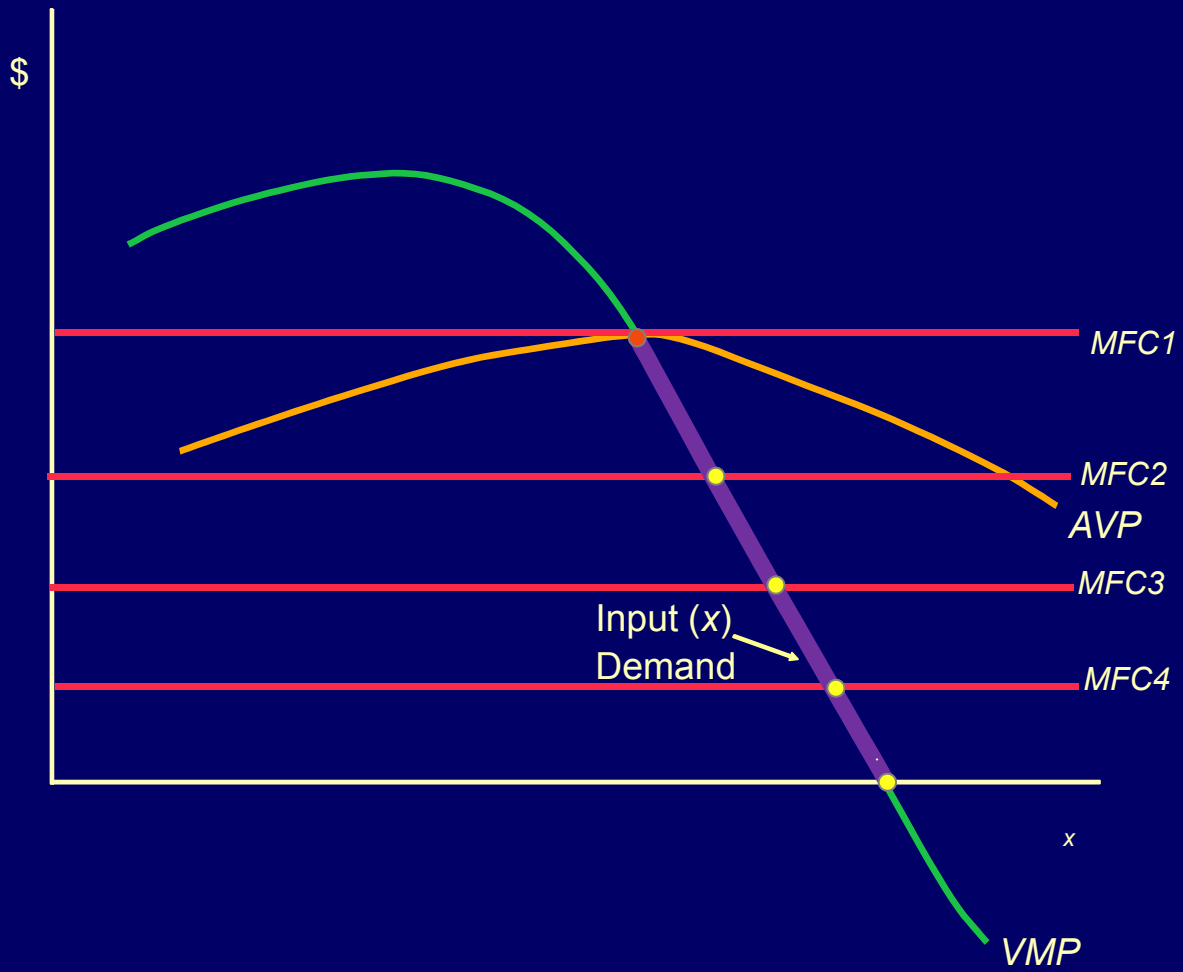


Figure 13.1 The Demand Function for Input x (No Other Inputs)

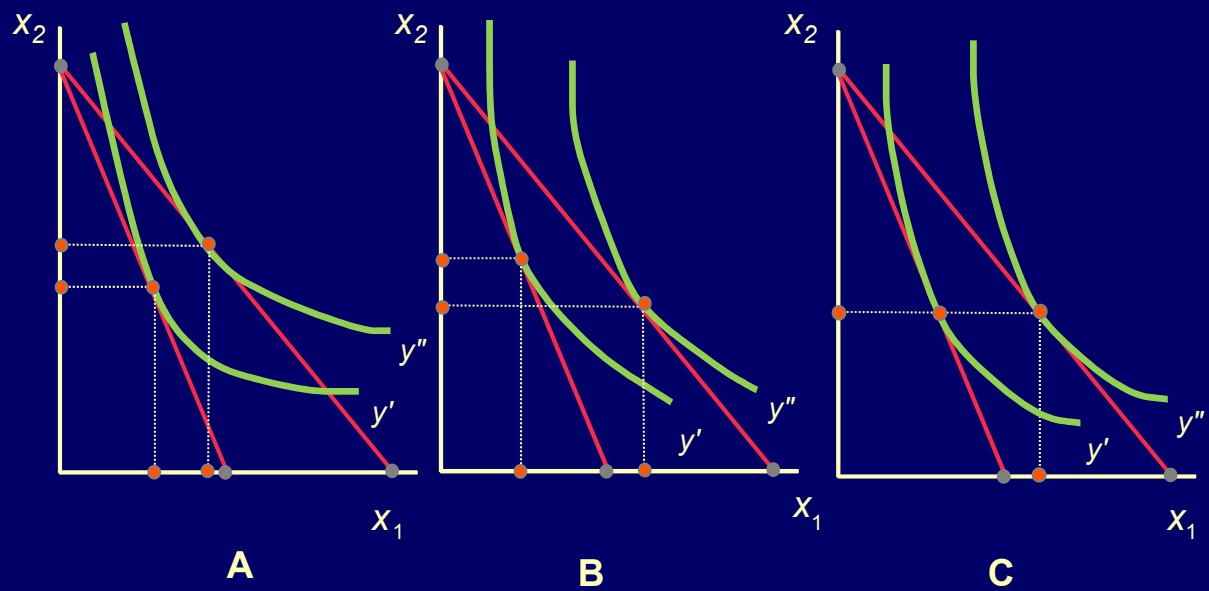


Figure 13.2 Possible Impacts of an Increase in the Price of x_1 on the use of x_2

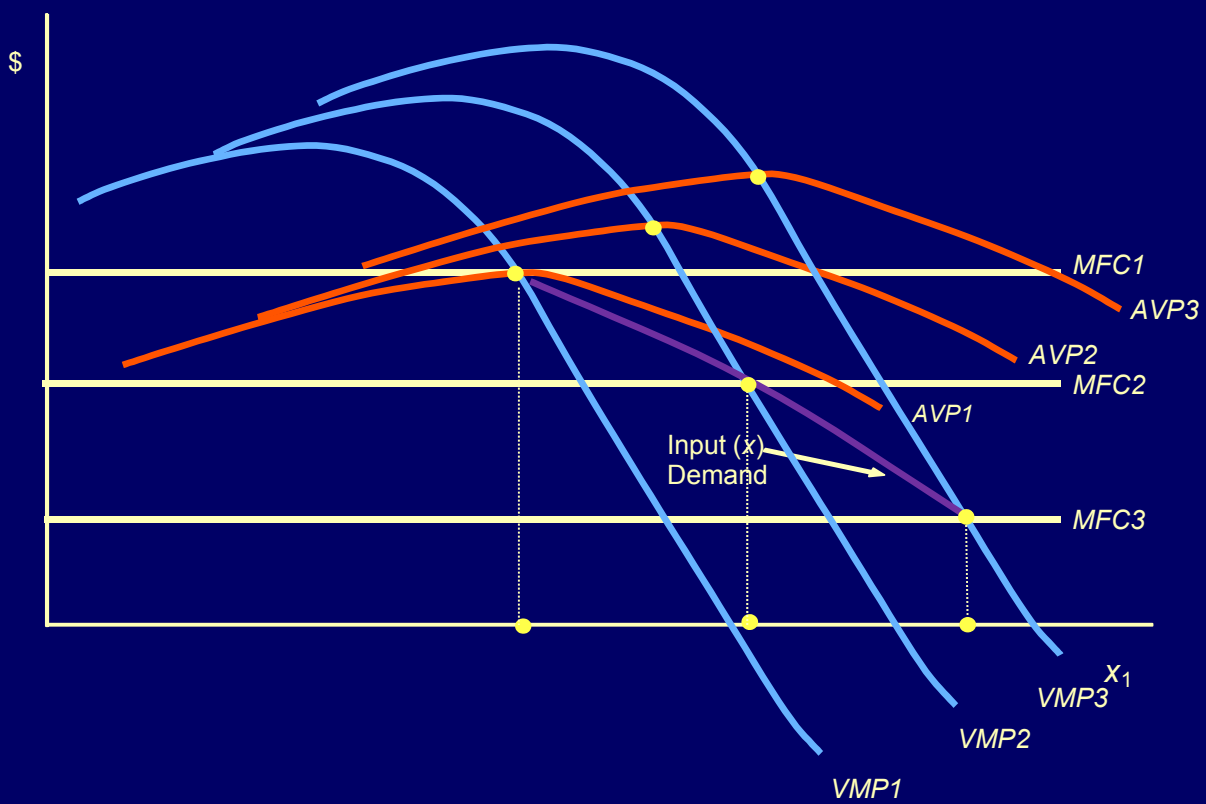


Figure 13.3 Demand for Input x_1 when a Decrease in the Price of x_1 Increases the Use of x_2

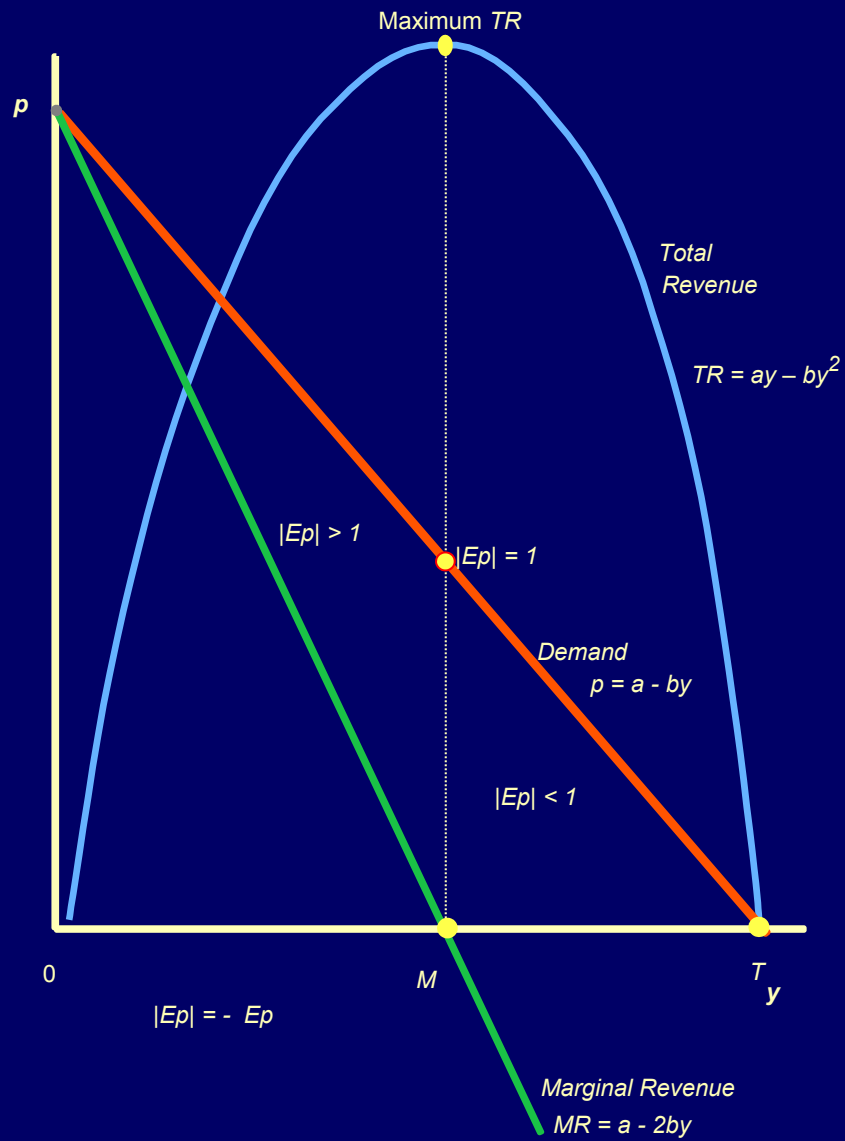


Figure 14.1 Total Revenue, Marginal Revenue, and the Elasticity of Demand

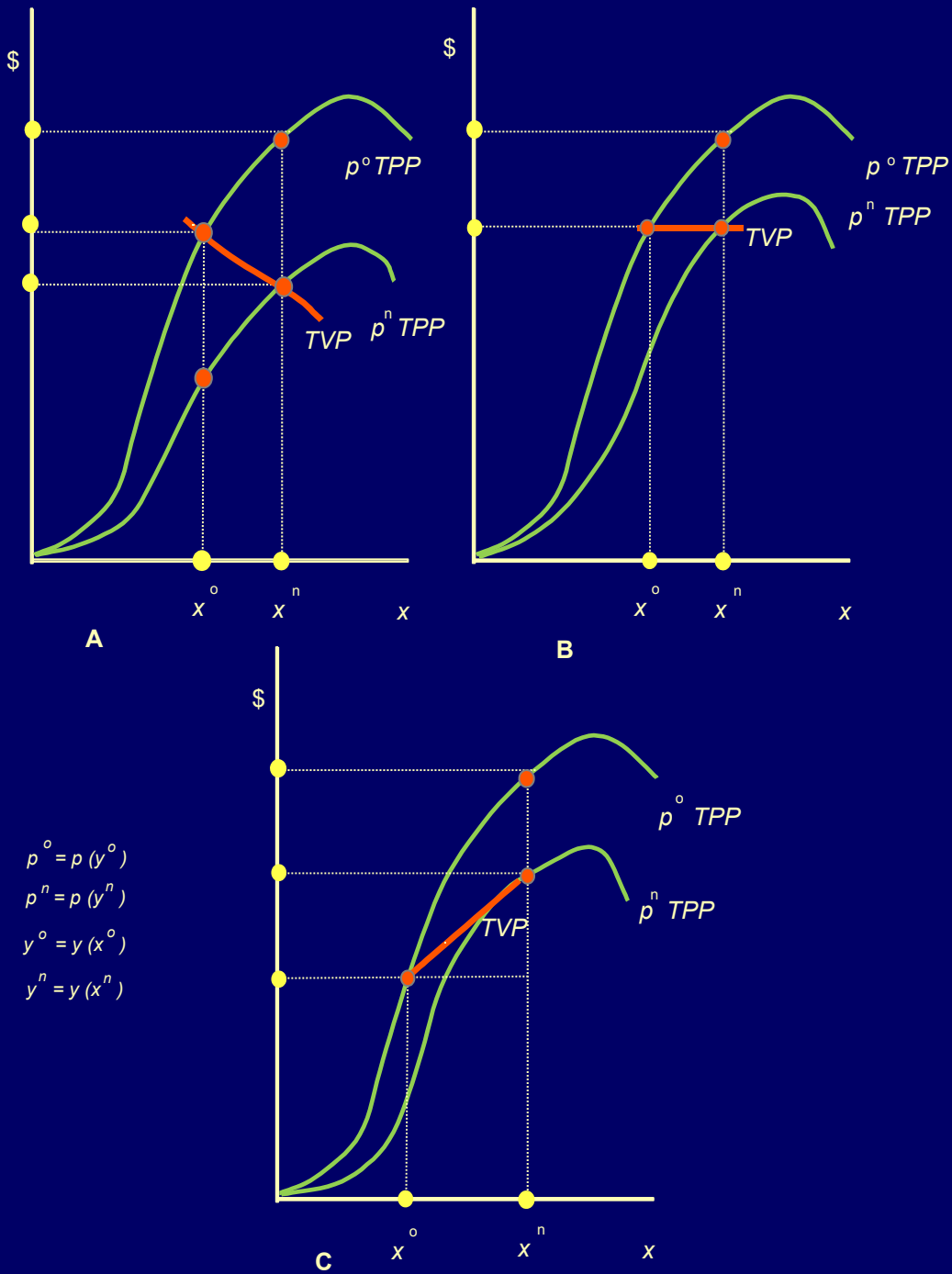


Figure 14.2 Possible *TVP* Functions Under Variable Product Prices

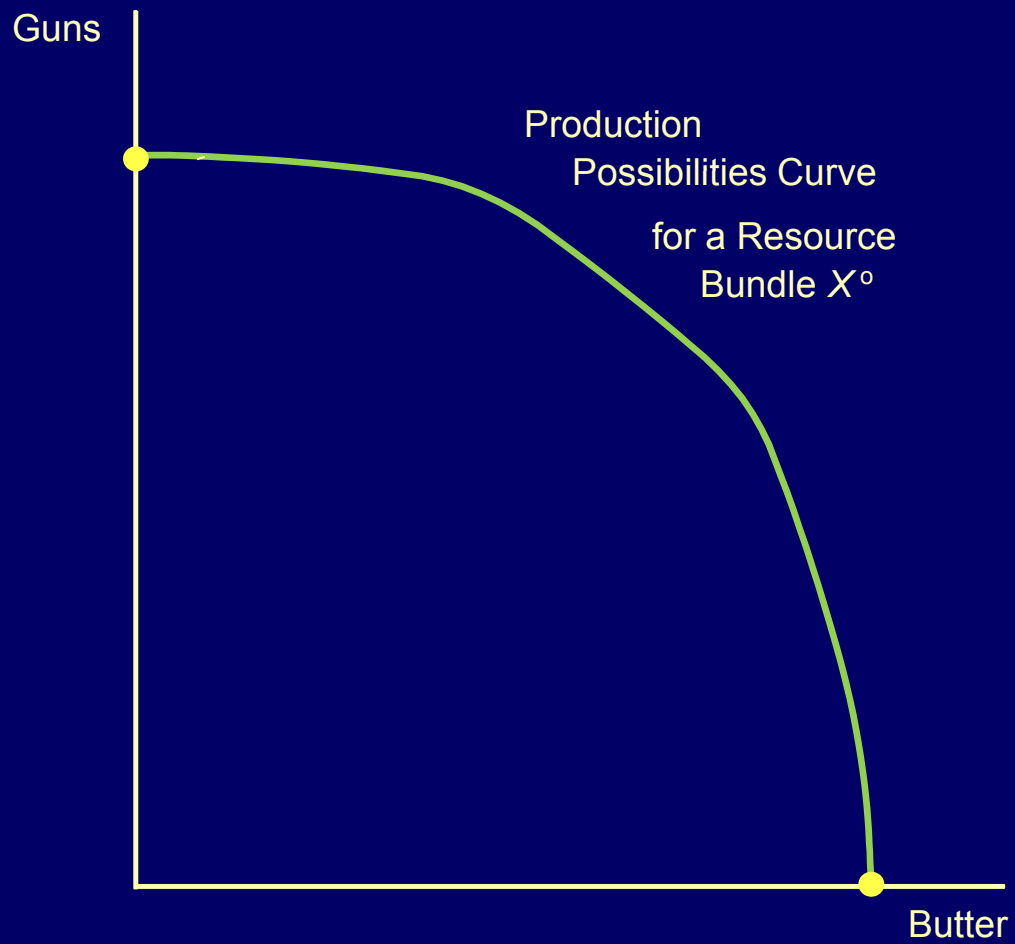
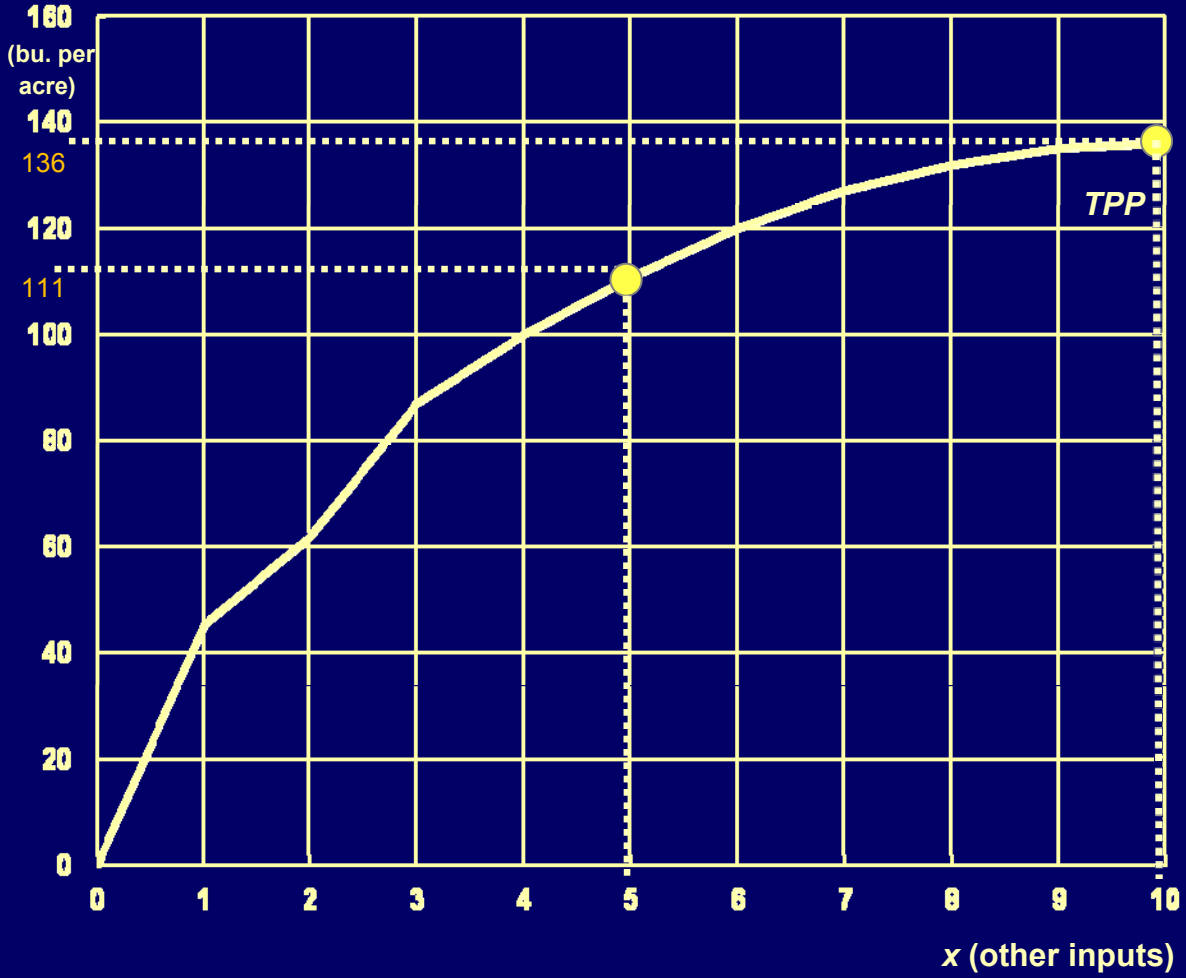


Figure 15.1 A Classic Production Possibilities Curve

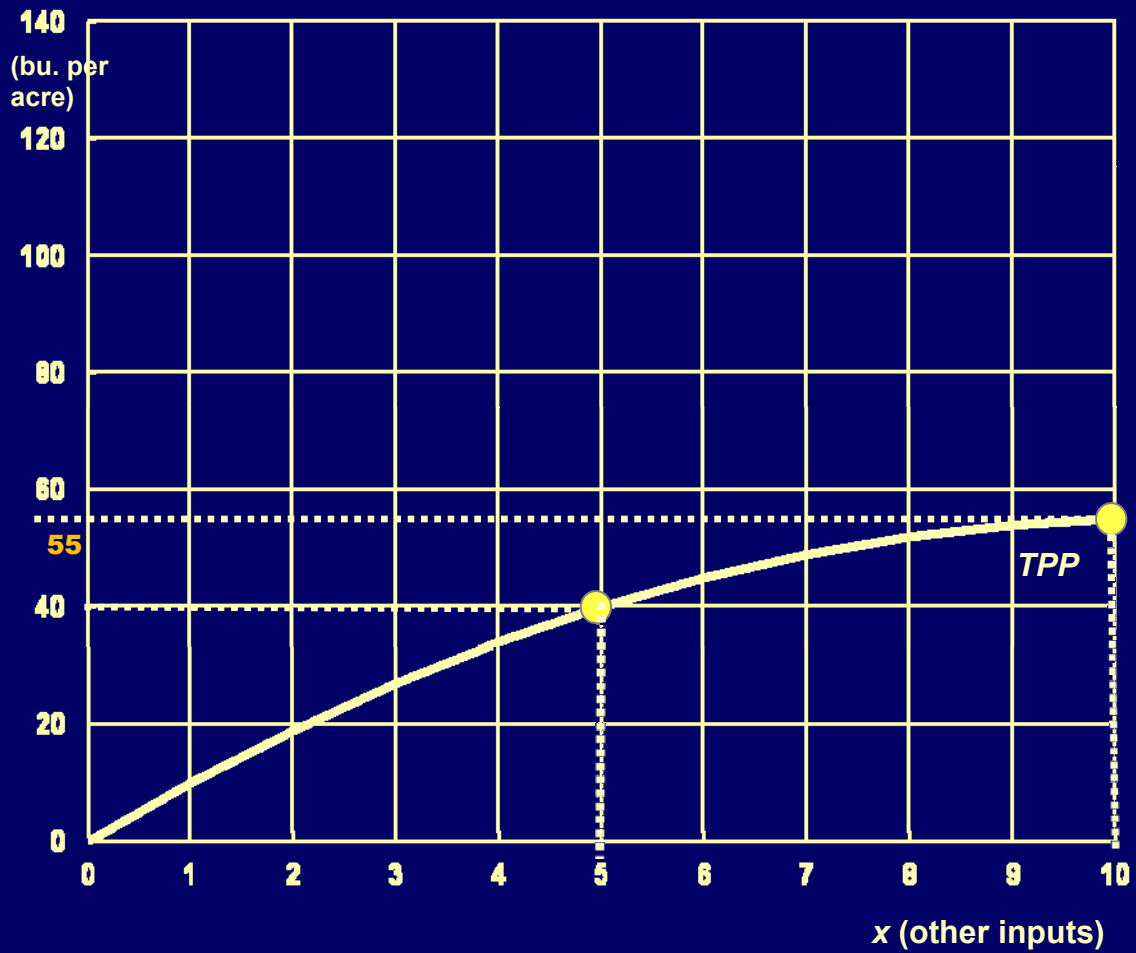
Corn



Panel A

Figure 15.2 Deriving a Product Transformation Function from Two Production Functions

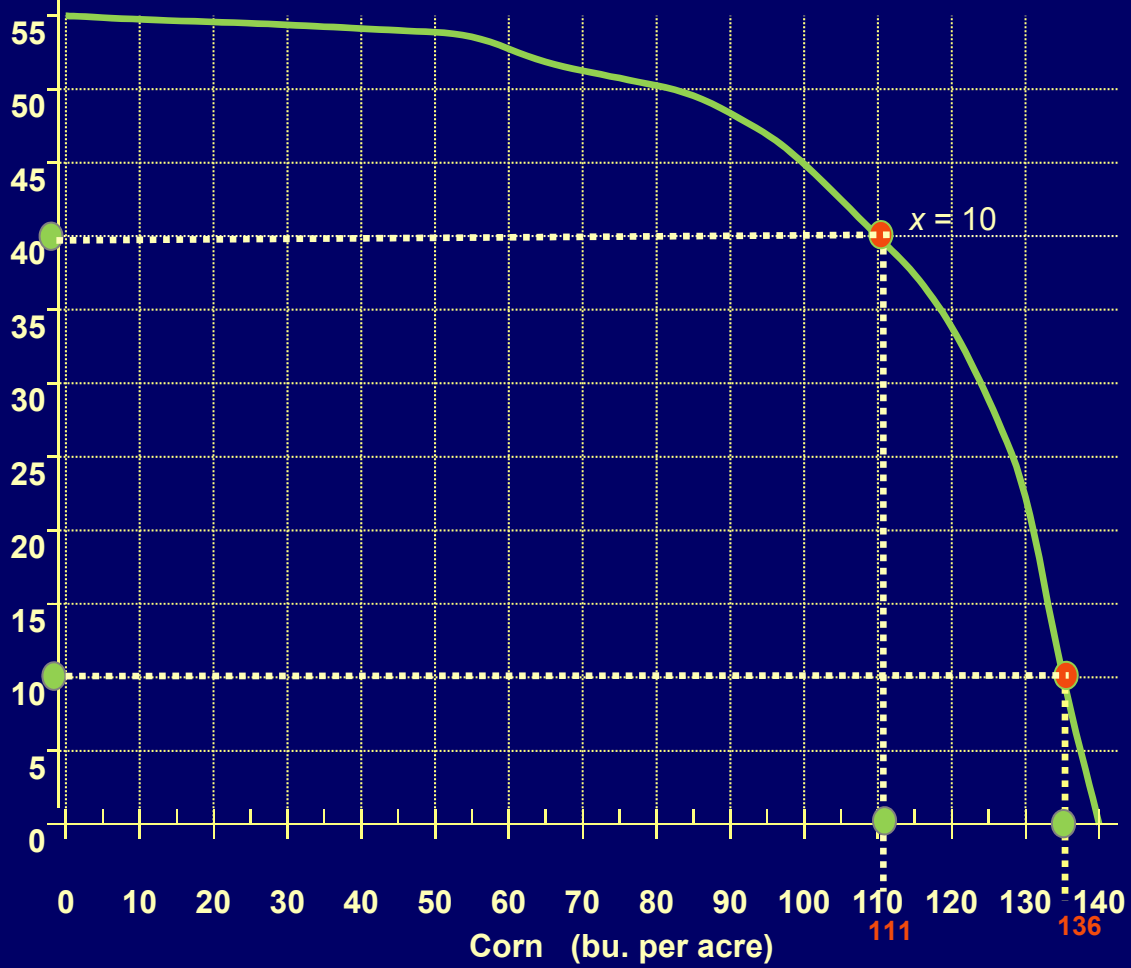
Soybeans



Panel B

Figure 15.2 Deriving a Product Transformation Function from Two Production Functions

Soybeans (bu. per acre)



Panel C

Figure 15.2 Deriving a Product Transformation Function from Two Production Functions

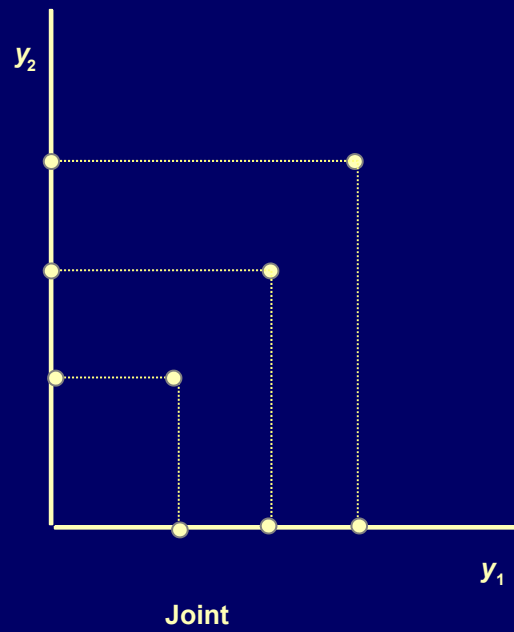
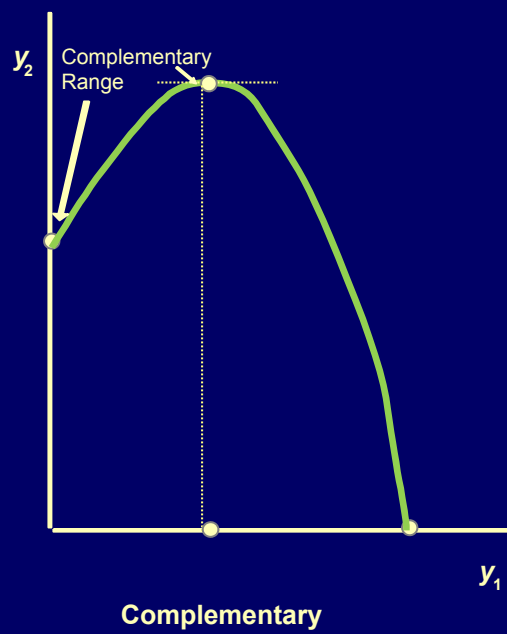
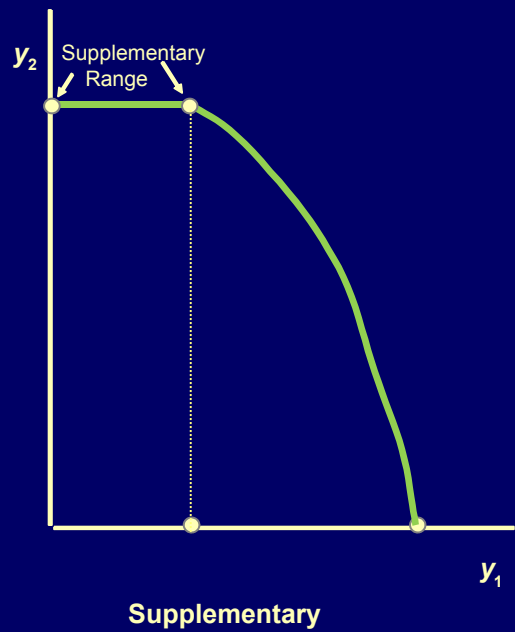
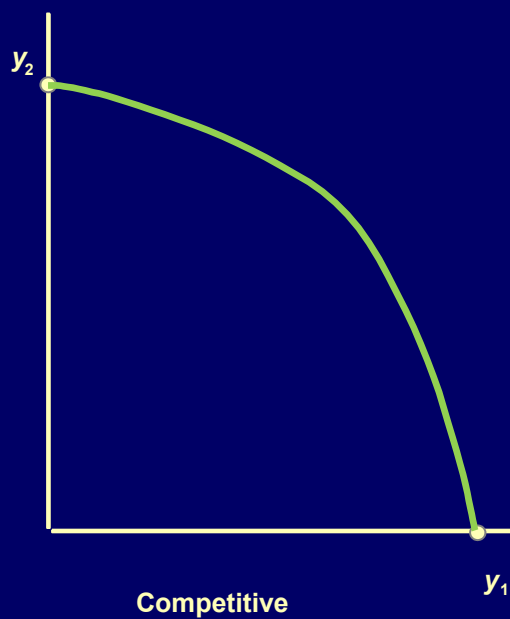


Figure 15.3 Competitive, Supplementary, Complementary and Joint Products

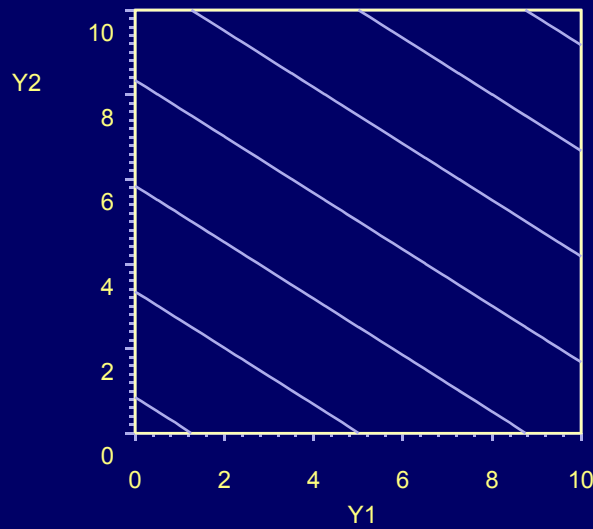
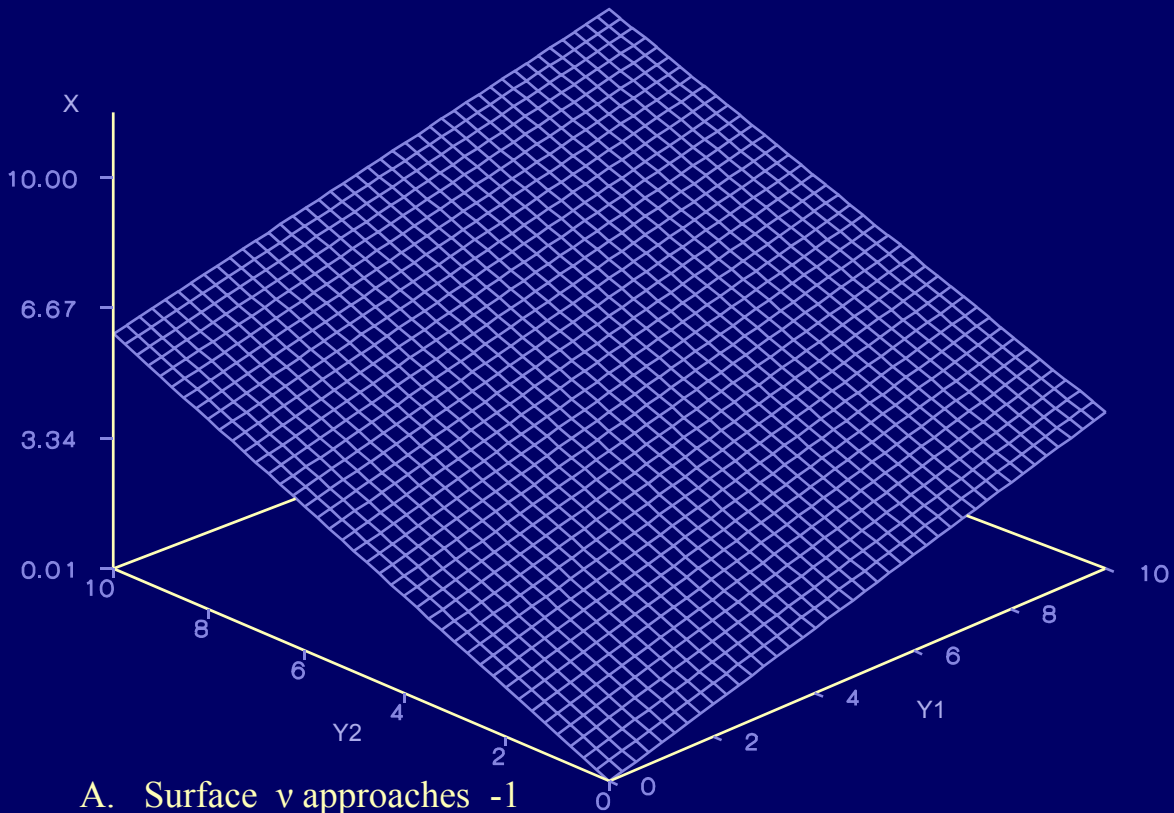
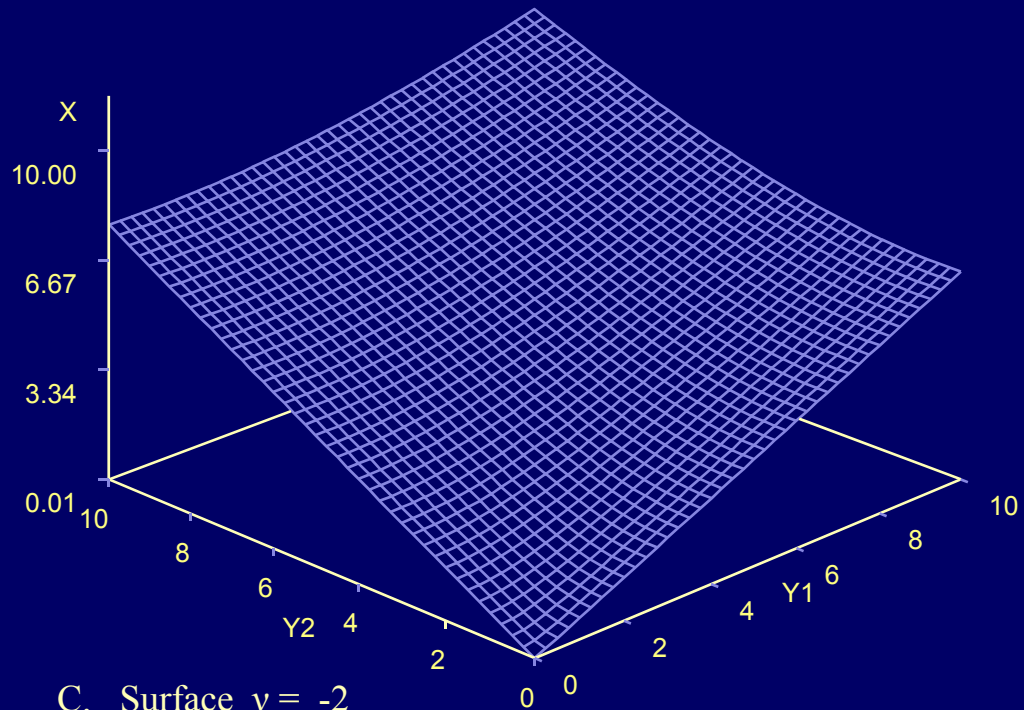
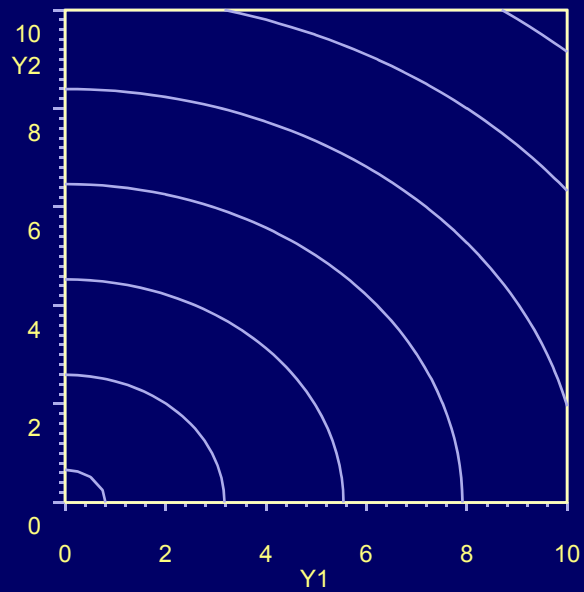


Figure 15.4 Isoproduct Surfaces and Isoproduct Contours for a CES Type of Function, $v < -1$

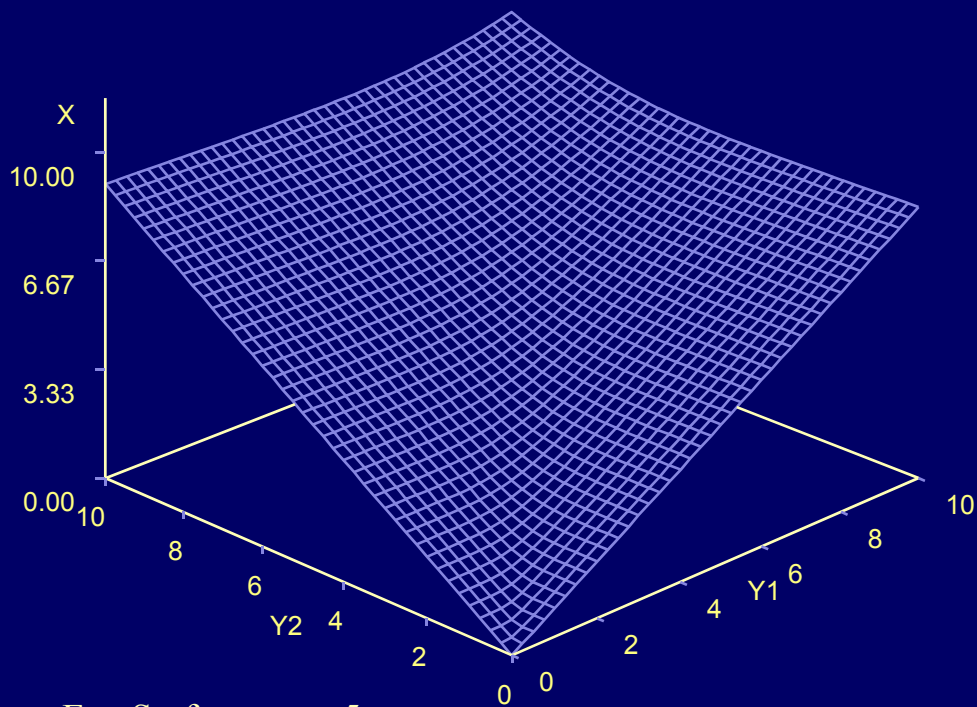


C. Surface $v = -2$

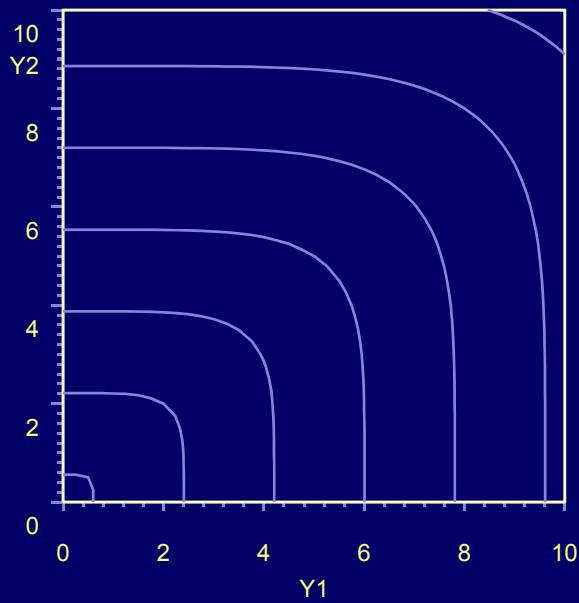


D. Isoproduct Contours $v = -2$

Figure 15.4 Isoproduct Surfaces and Isoproduct Contours for a CES Type of Function, $v < -1$

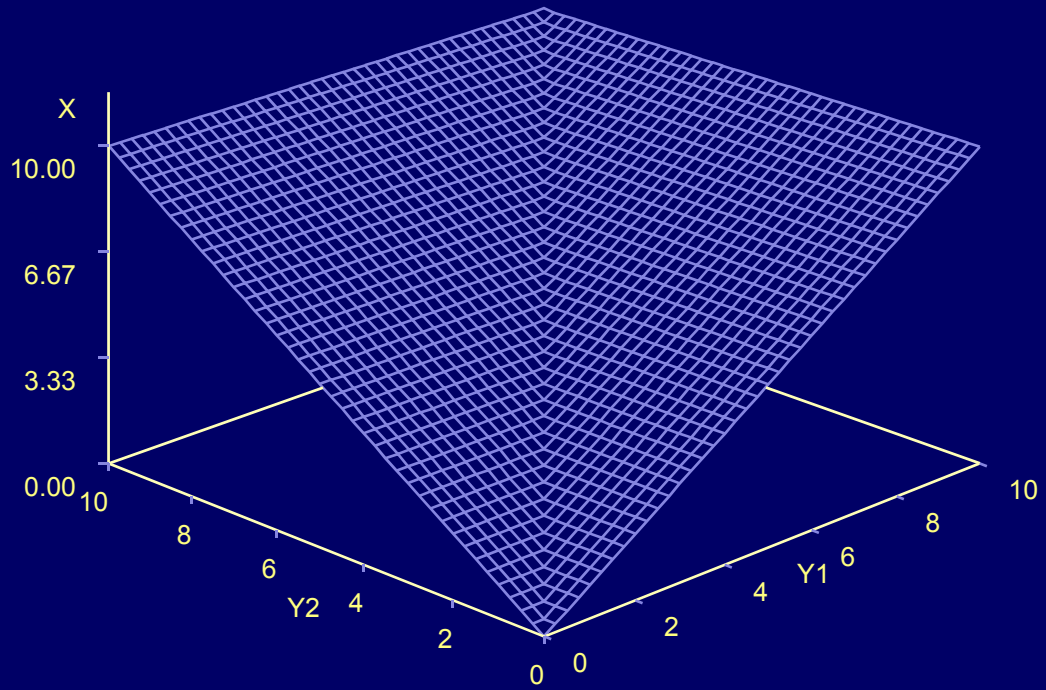


E. Surface $v = -5$

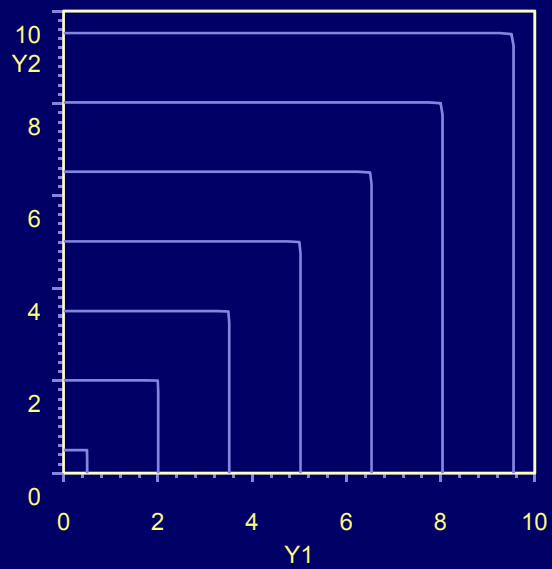


F. Isoproduct Contours $v = -5$

Figure 15.4 Isoproduct Surfaces and Isoproduct Contours for a CES Type of Function, $v < -1$



G. Surface $v = -200$



H. Isoproduct Contours $v = -200$

Figure 15.4 Isoproduct Surfaces and Isoproduct Contours for a CES Type of Function, $v < -1$

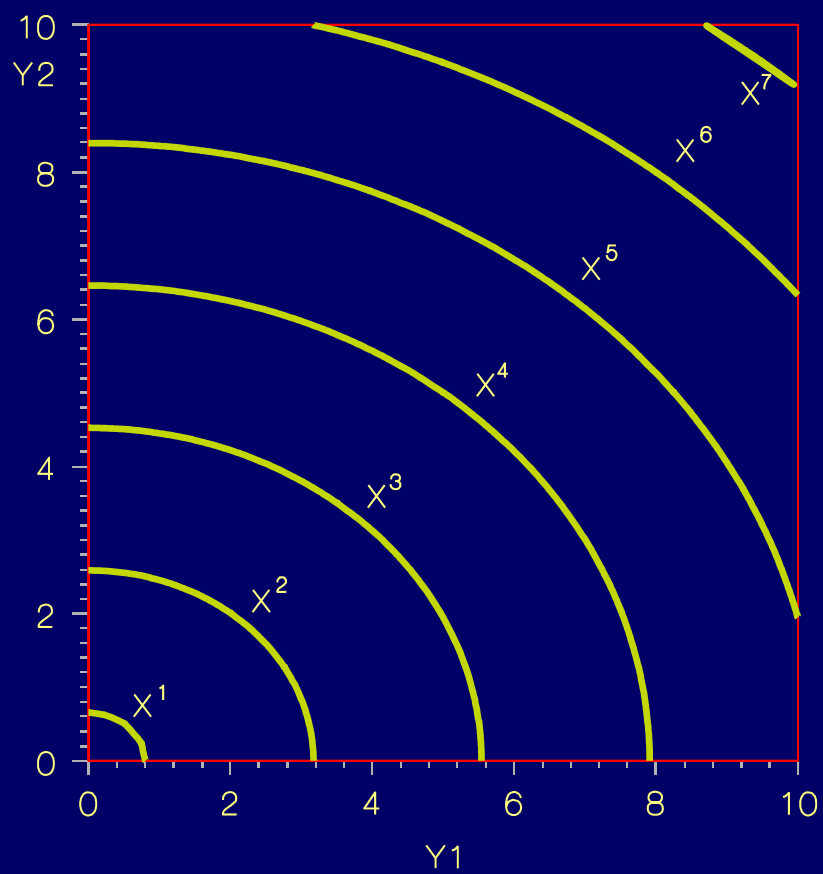


Figure 16.1 A Family of Product Transformation Functions

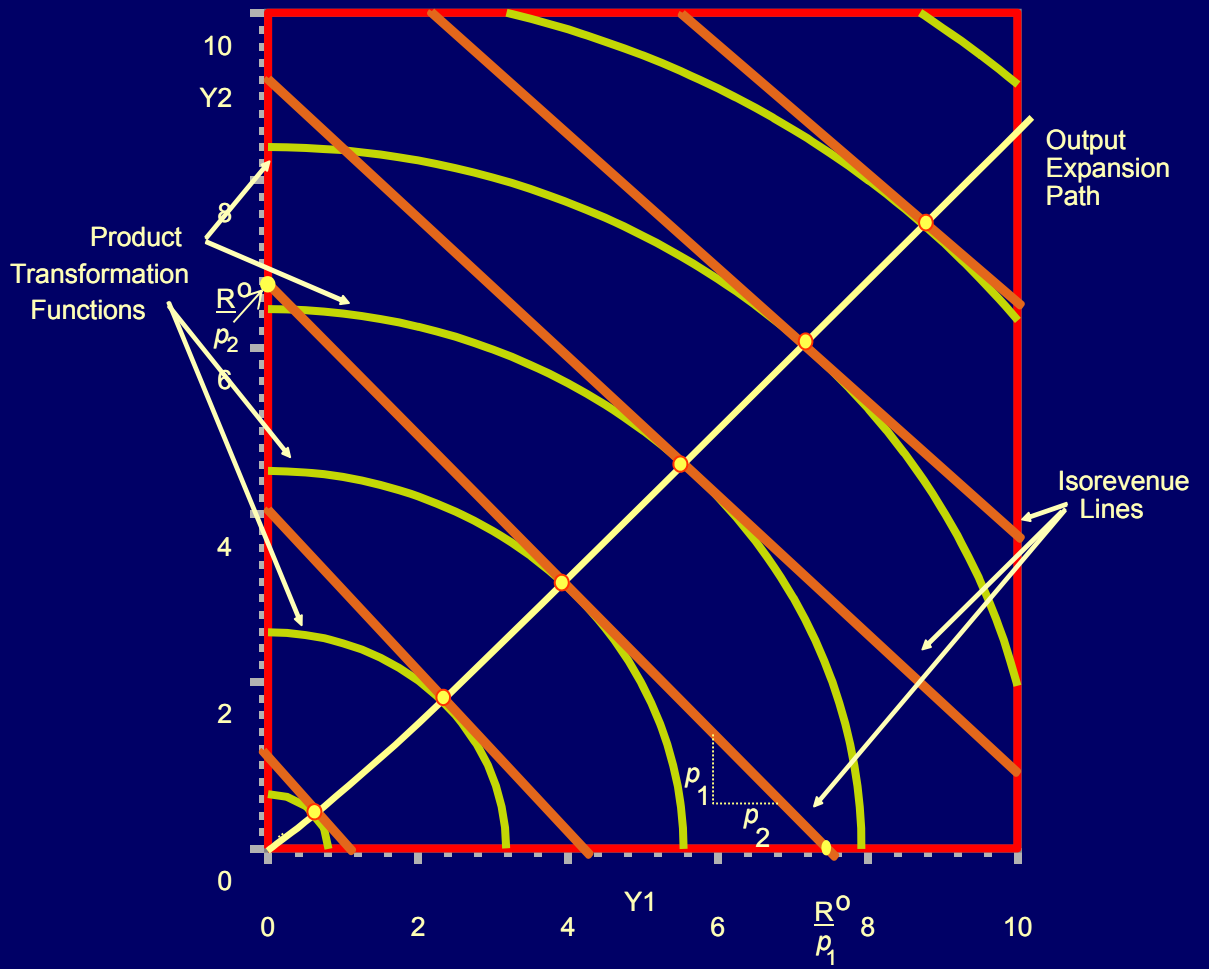


Figure 16.2 Product Transformation Functions, Isorevenue Lines and the Output Expansion Path

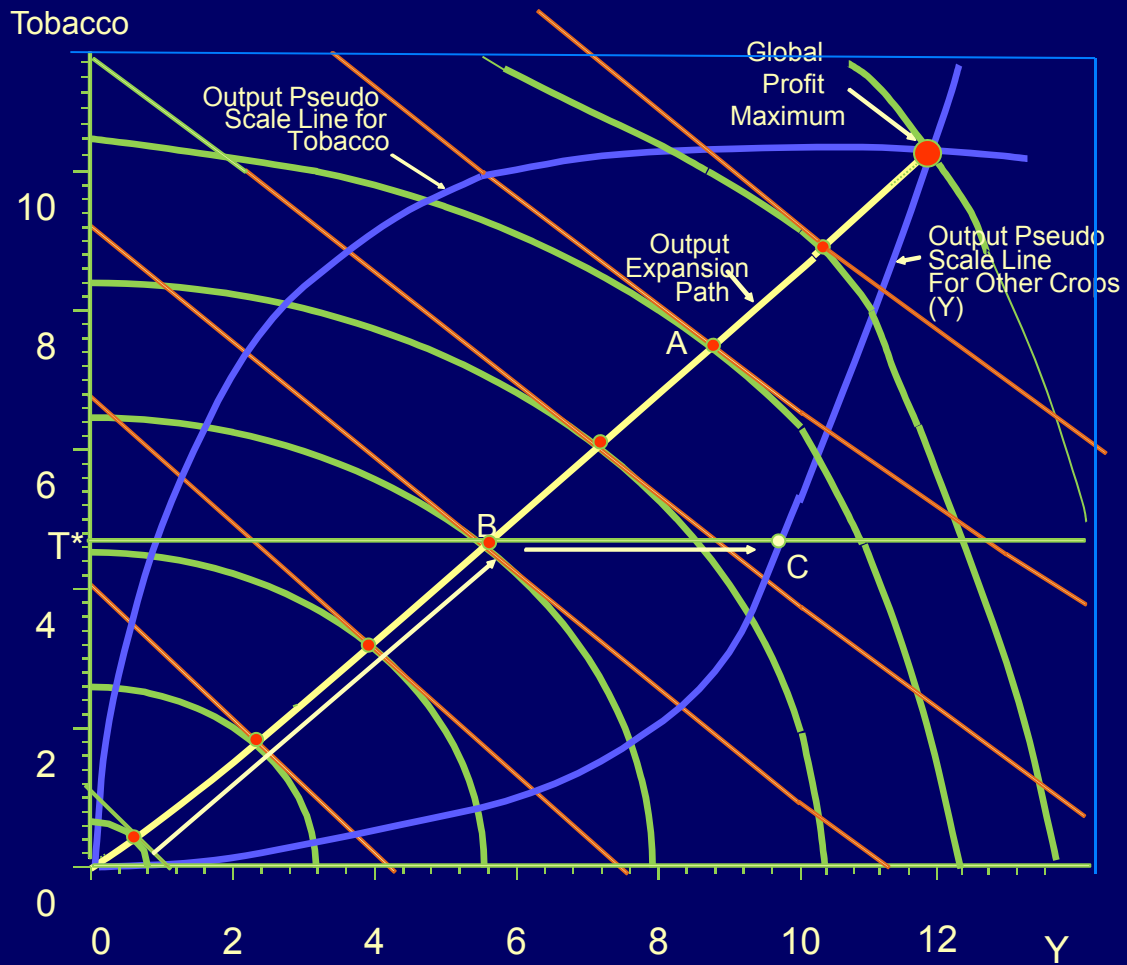


Figure 16.3 An Output Quota

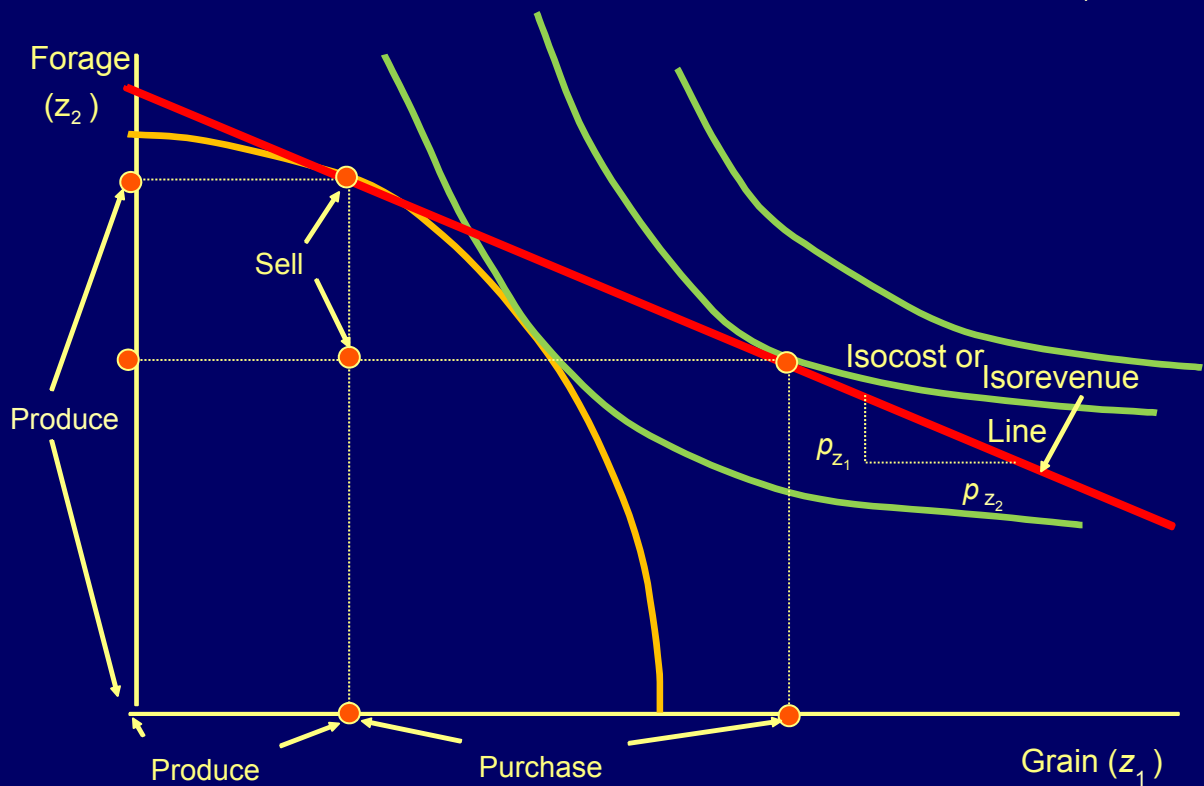
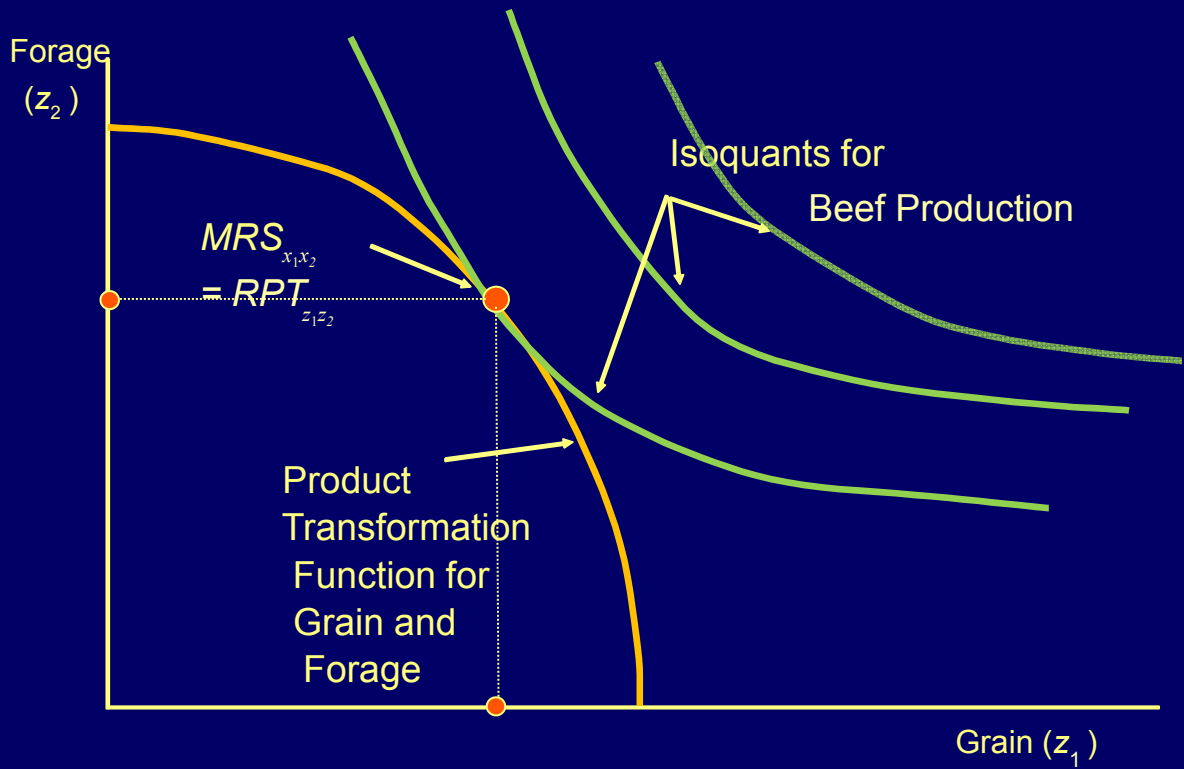


Figure 17.1 An Intermediate Product Model

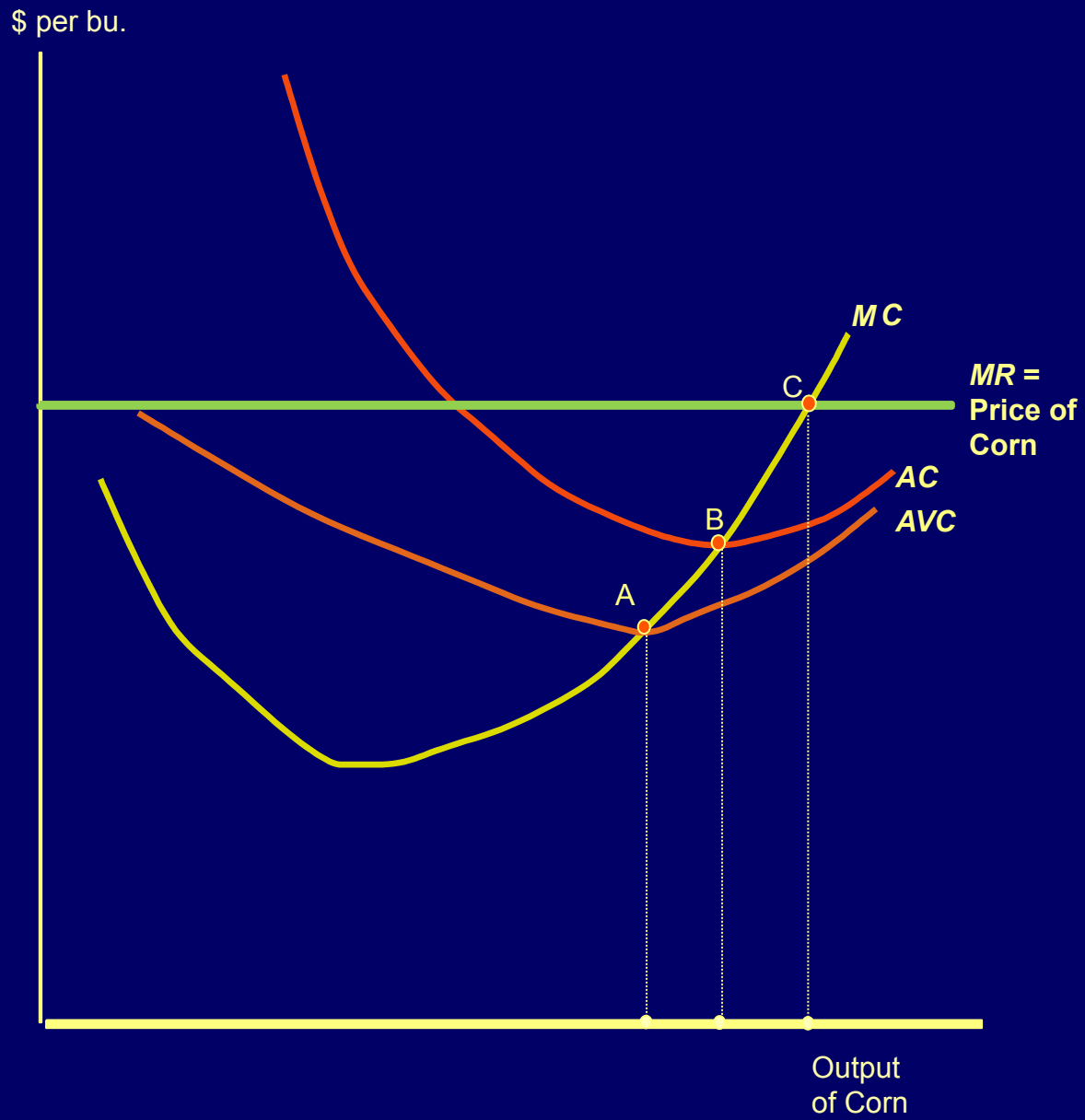
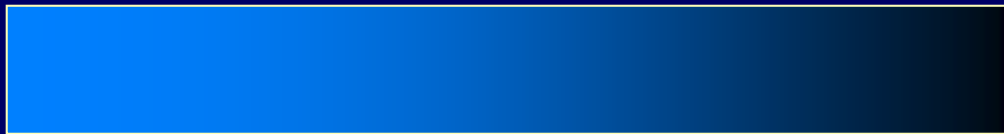


Figure 19.1 Output of Corn and Per Bushel Cost of Production

Probabilities
and Outcomes
are Known

Probabilities
And Outcomes
Are not known



Risky Events

Uncertain Events

Figure 20.1 A Risk and Uncertainty Continuum

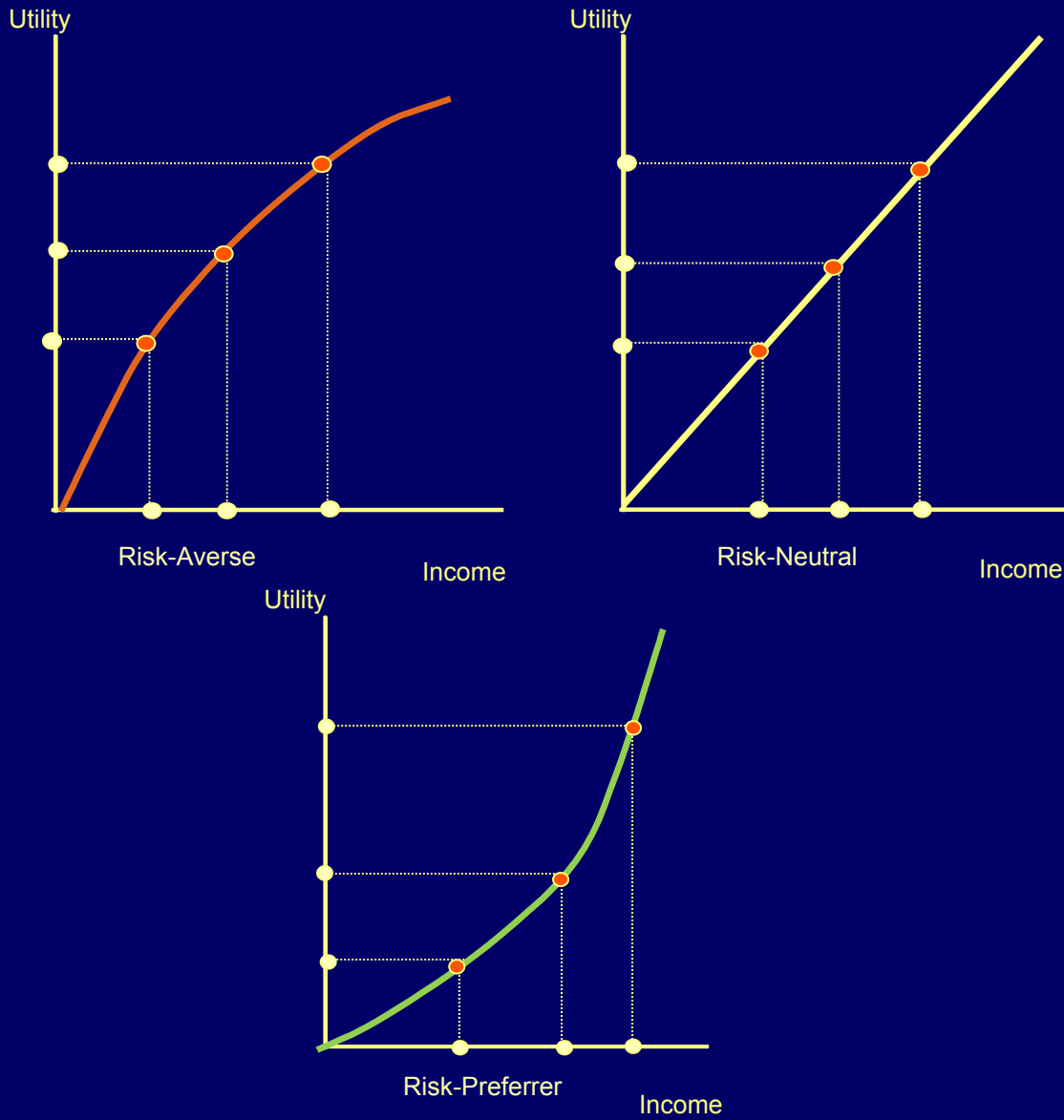


Figure 20.2 Three Possible Functions Linking Utility to Income

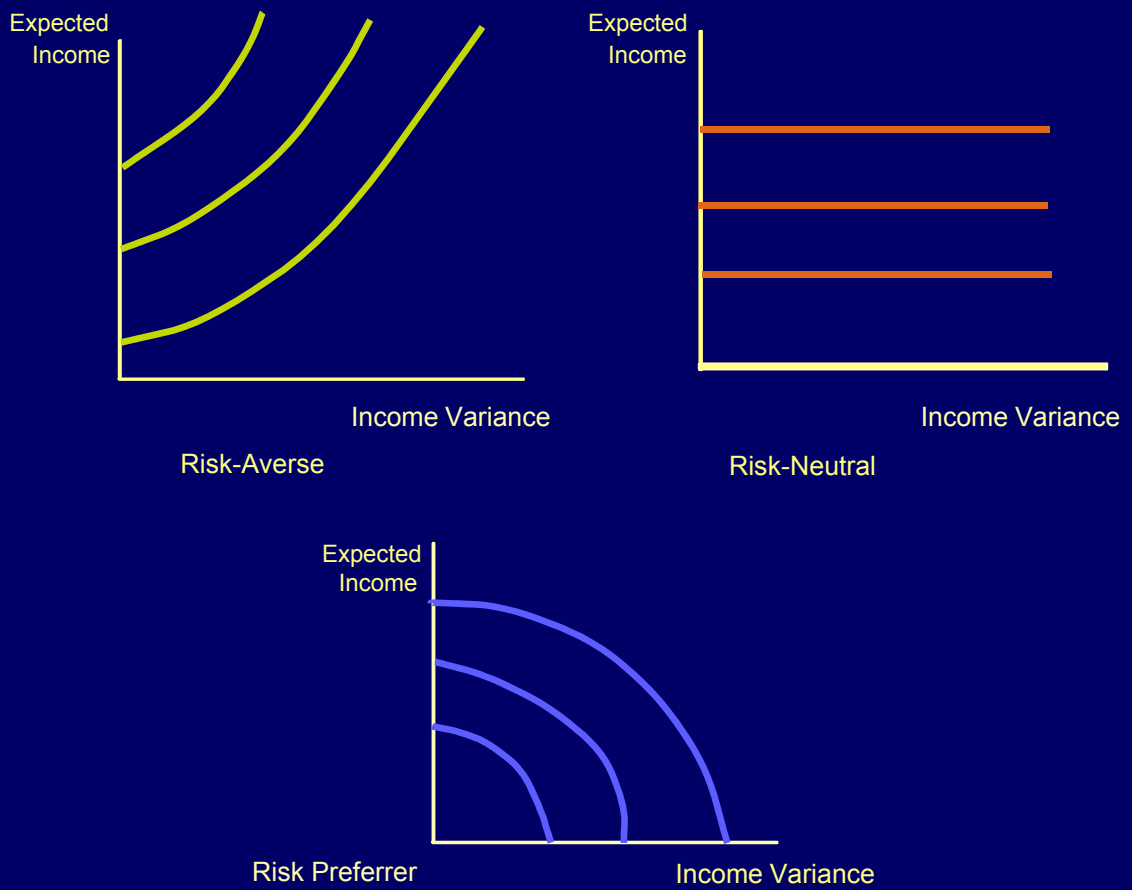


Figure 20.3 Indifference Curves Linking the Variance of Expected Income with Expected Income

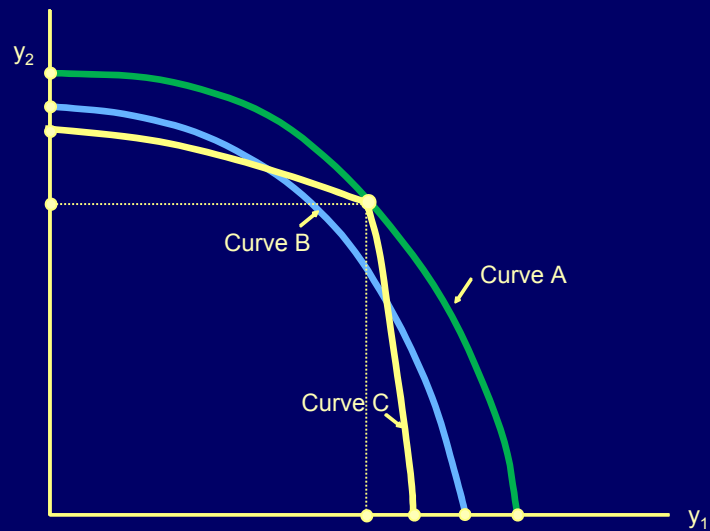


Figure 20.4 Long Run Planning: Specialized and Non-Specialized Facilities

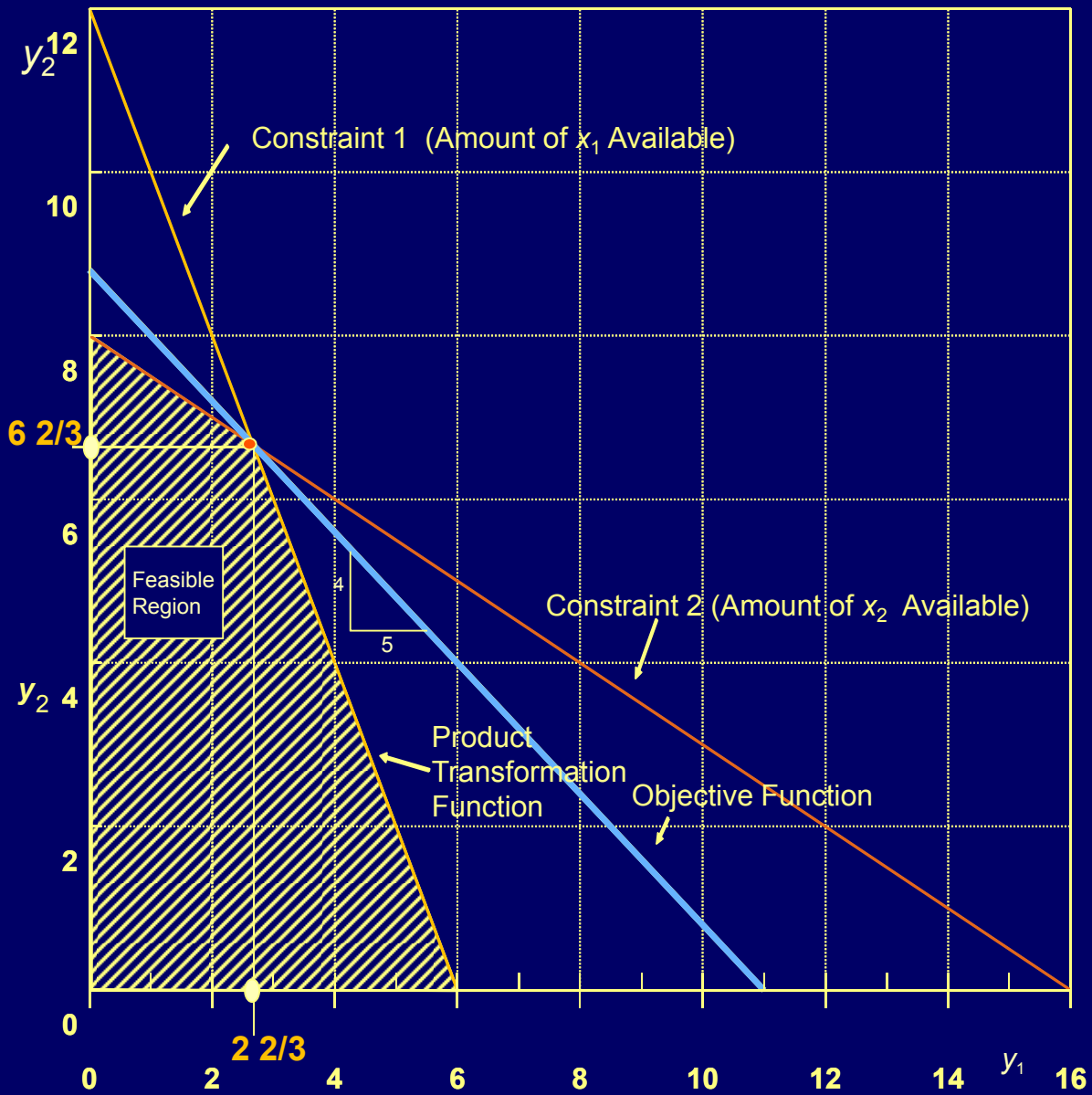


Figure 22.1 Linear Programming Solution in Product Space

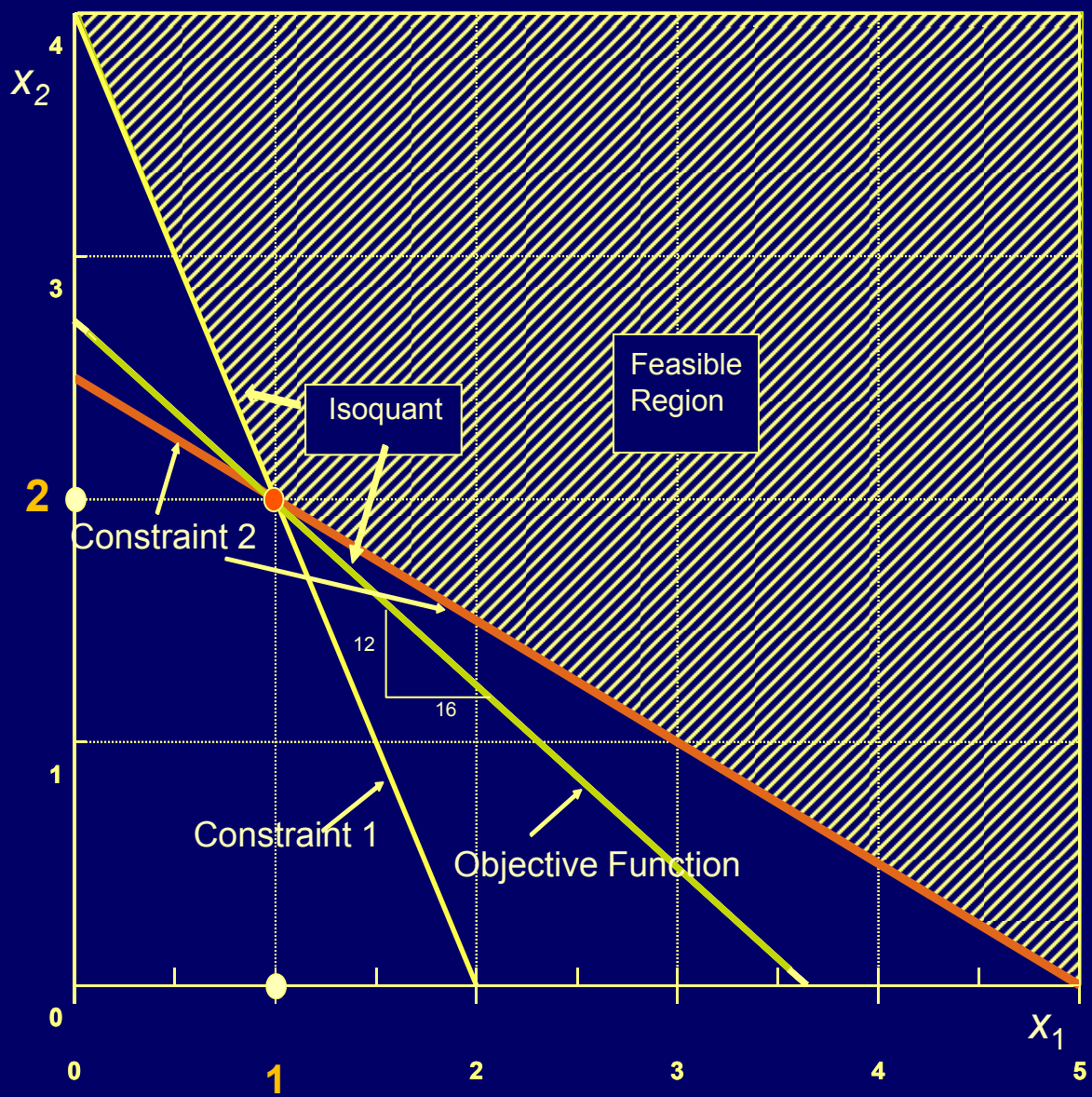


Figure 24.2 Linear Programming Solution in Factor Space

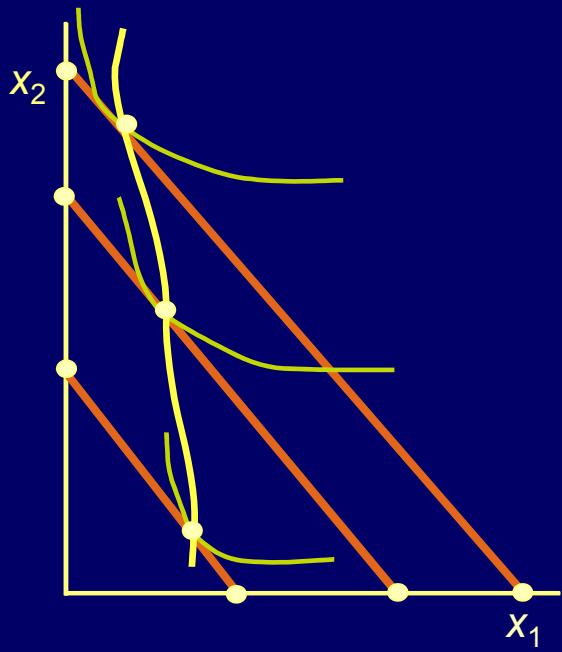


Diagram A

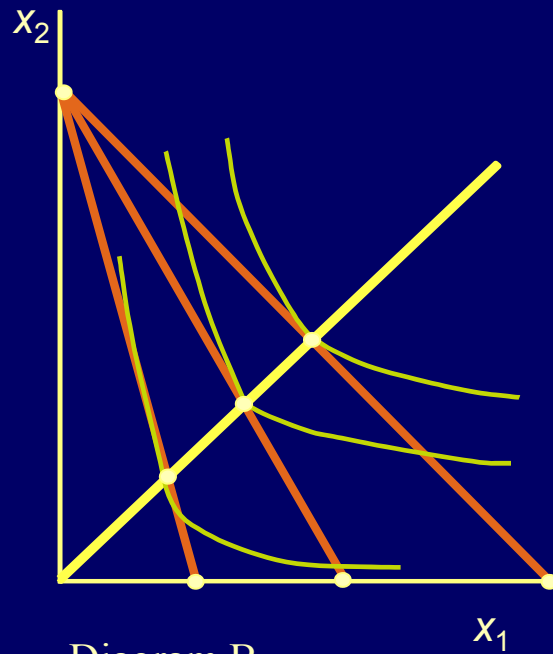


Diagram B

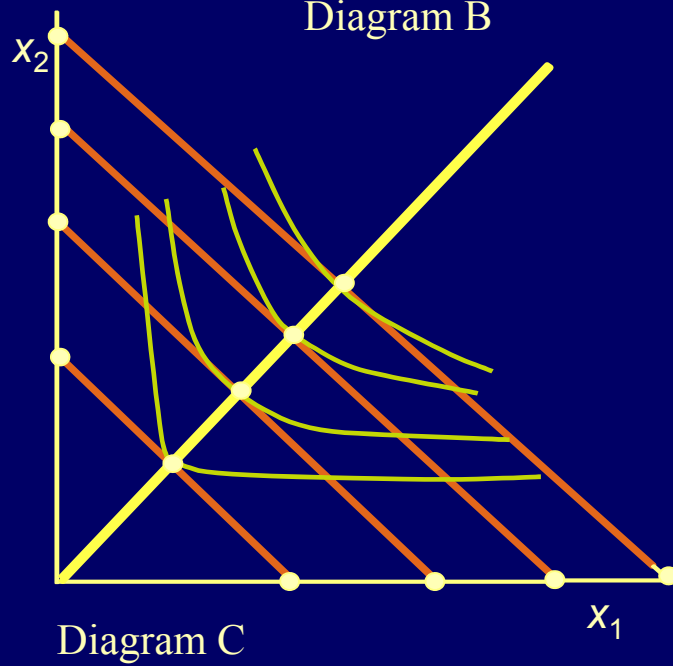


Diagram C

Figure 23.1 Some Possible Impacts of Technological Change

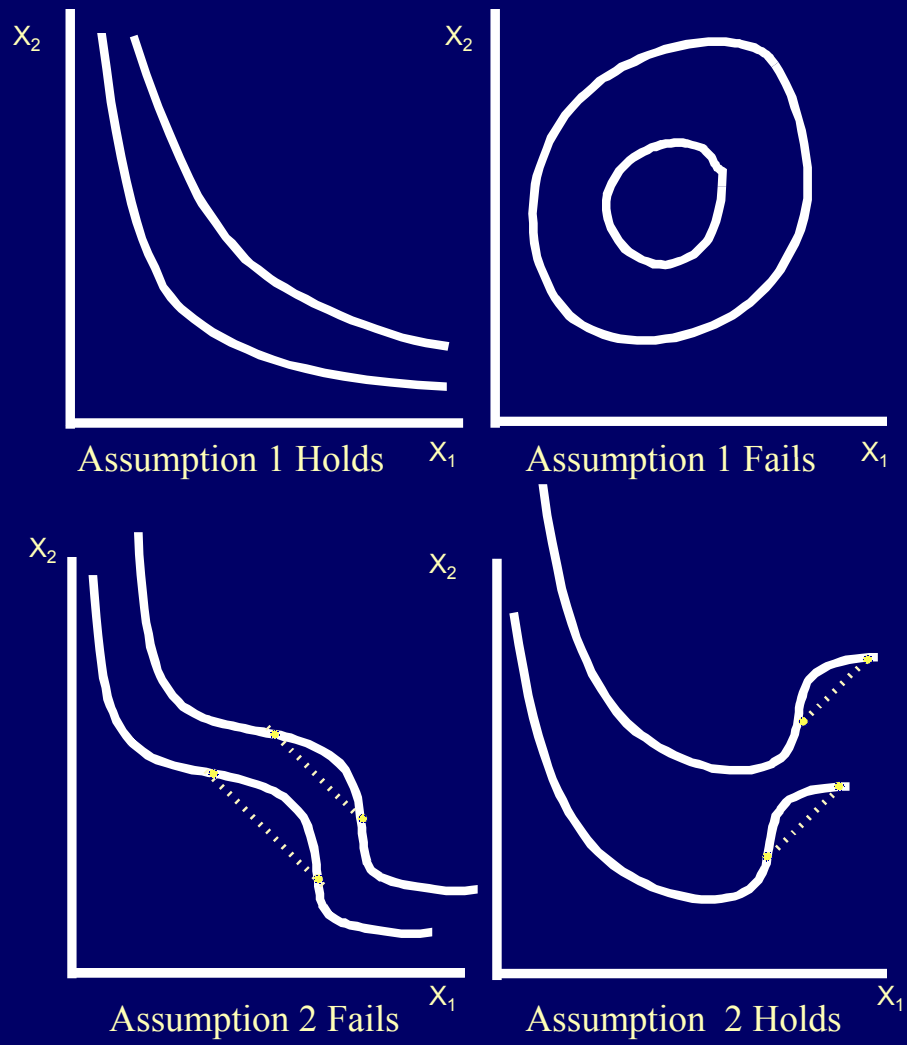


Figure 24.1 Assumptions (1) and (2) and the Isoquant Map

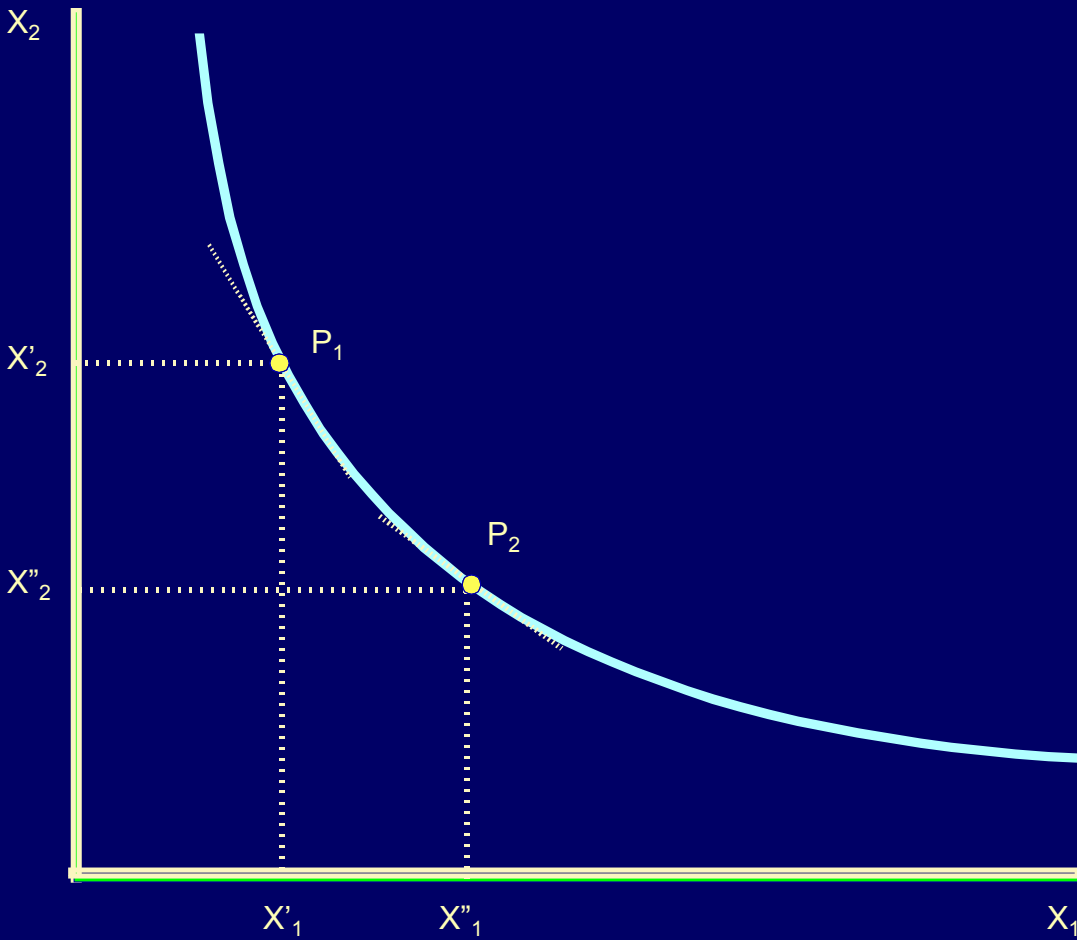


Figure 24.2 A Graphical Representation of the Elasticity of Substitution