Section 6
Theory of Cost

N. Gregory Mankiw and Mark P. Taylor (2023), “*Microeconomics*”, Cengage Learning, Chapter 6
-Pepper, A., & Gore, J. (2015). Behavioral agency theory new foundations for theorizing about executive compensation. Journal of Management, 41(4), 1045-1068

The slides of this section are mainly based on the 6th edition of the book by Mankiw and Taylor (2023). In some slides we reproduce figures, sentences and definitions given in the book.

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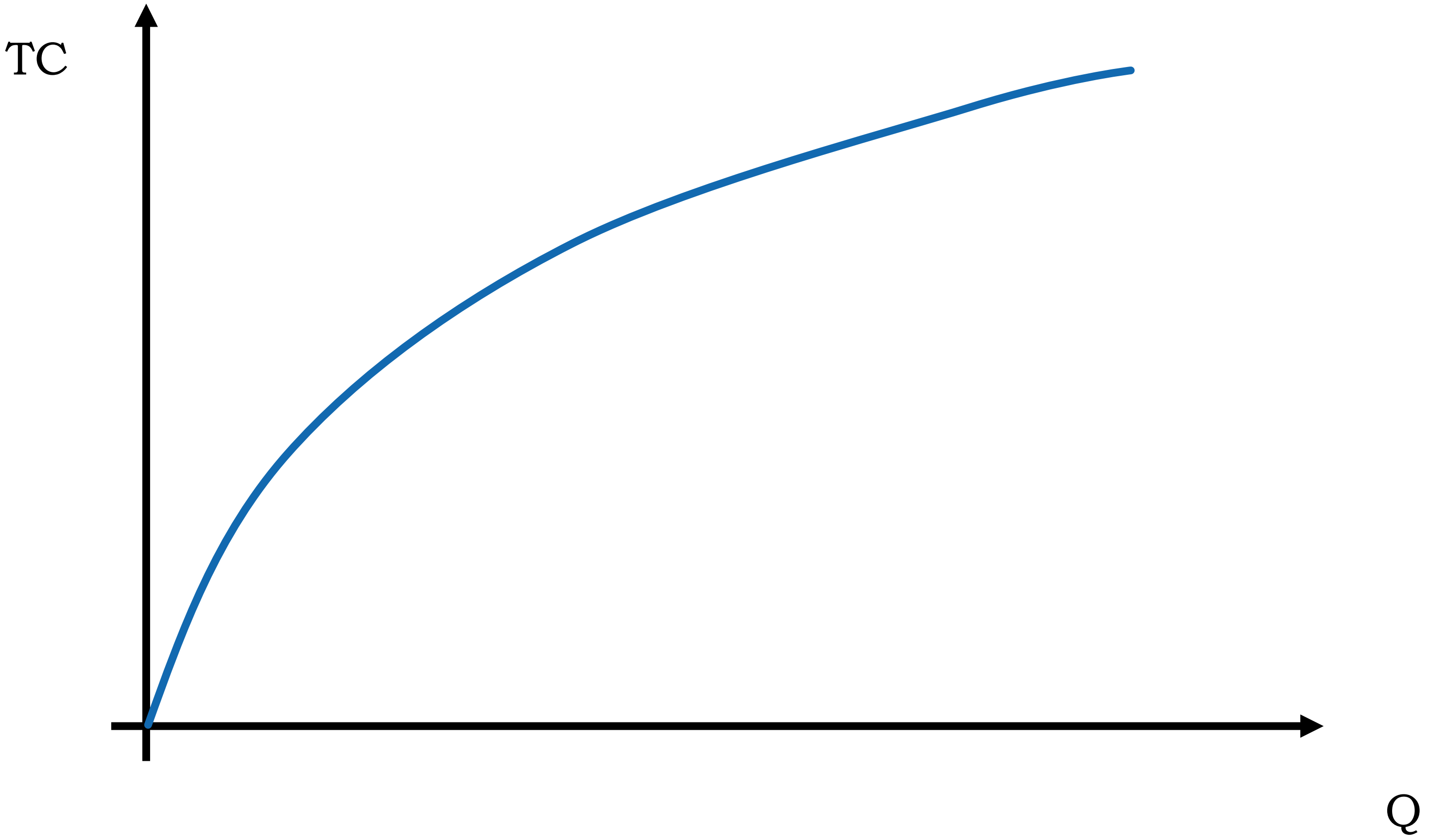
Cost Function



Introductory Video: Bonus-Pay and decision making

https://www.youtube.com/watch?v=PchOtUc2Rm4

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A. Production Theory

Production Theory

Production and cost theory is best understood in **4 distinct steps**:

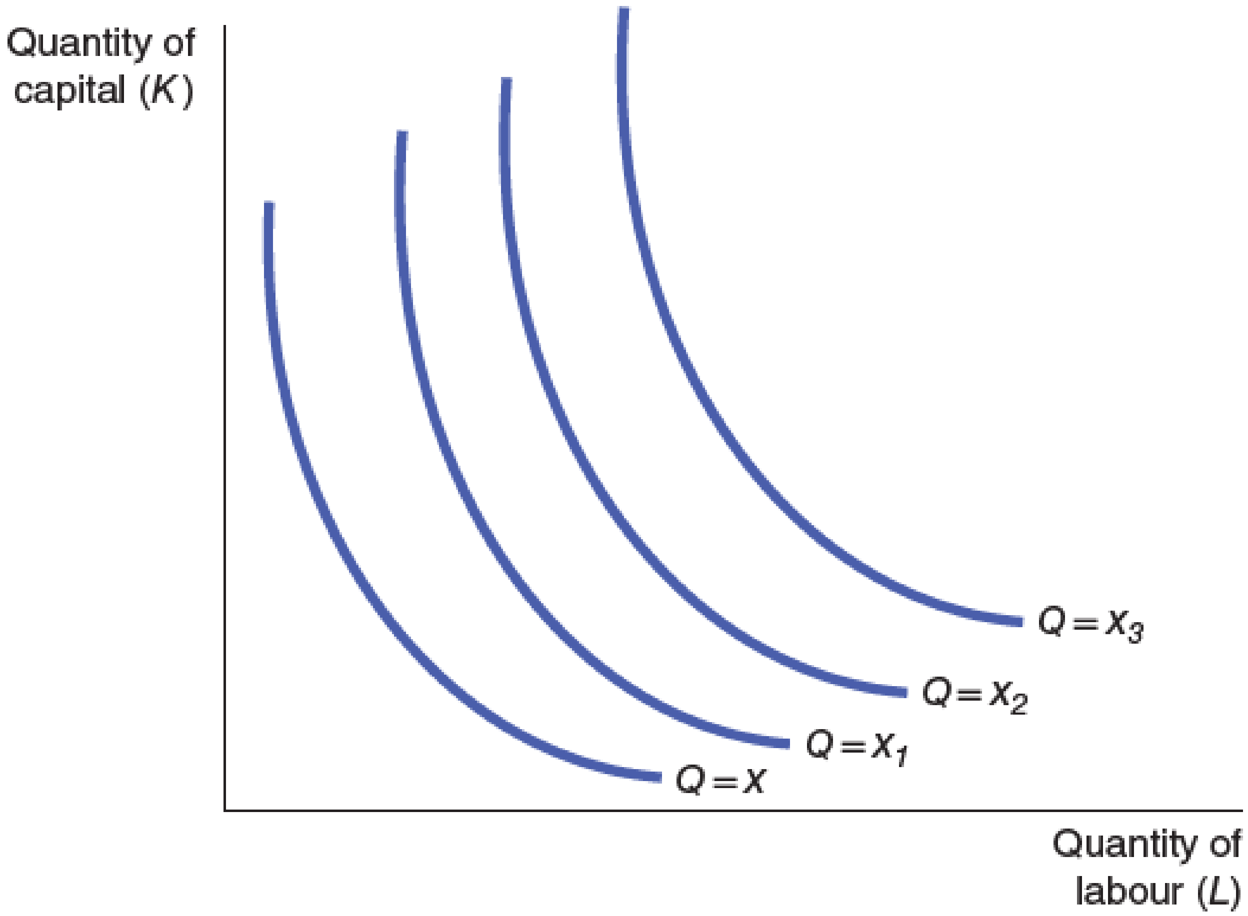
1) We will study the **isoquants**
2) Then we will turn to the **isocosts**
3) Finally we combine isoquants and isocosts to determine **firm choices**
4) Derive the cost function using math

Isoquants

Another way how to describe a production process that makes use of two inputs is to use **isoquants**.

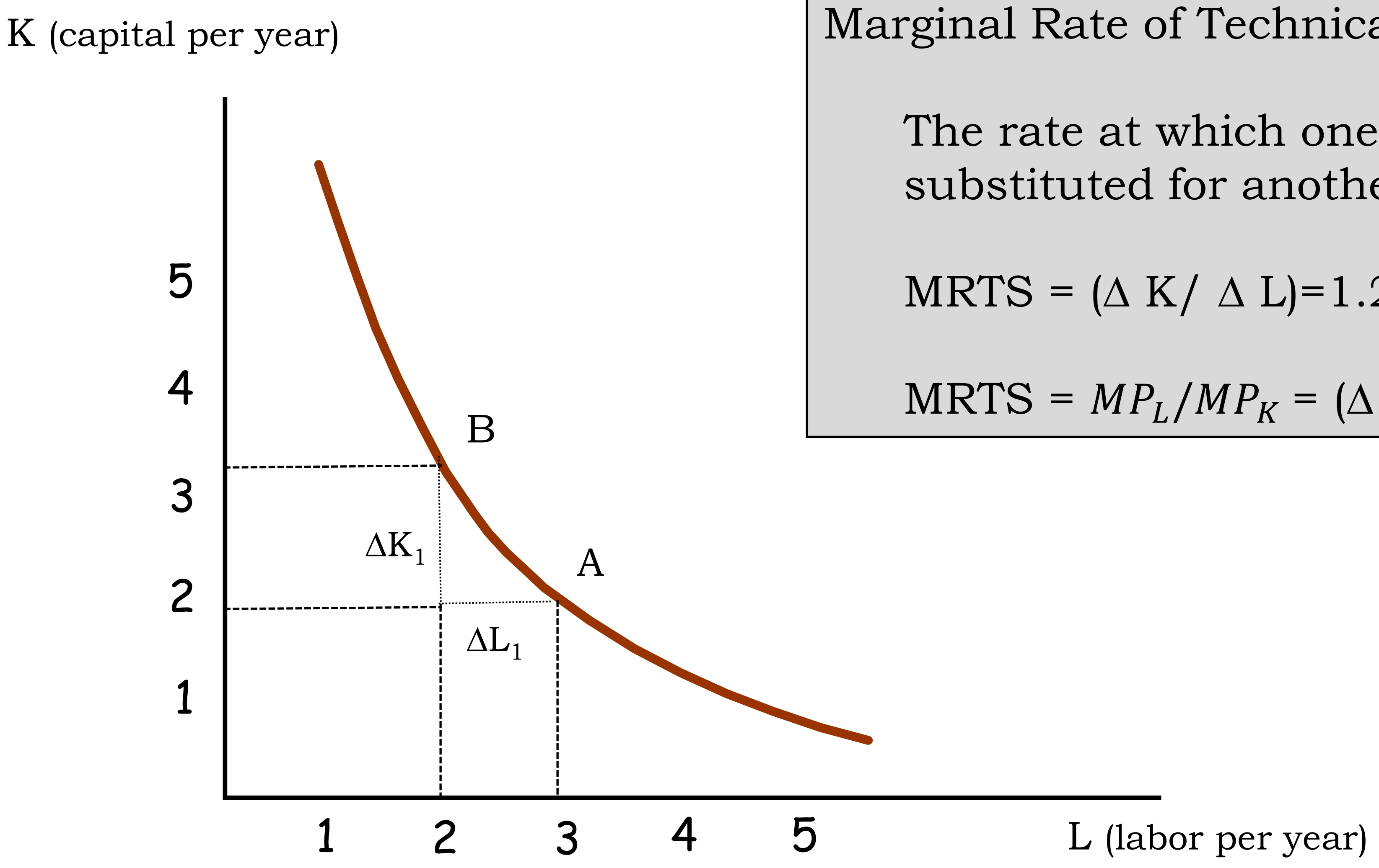
- **Isoquant:** a function representing all possible combinations of factor inputs that can be used to produce a given level of output.

Production Isoquants (II)



Source: Mankiw & Taylor (2023), “Microeconomics”

Marginal Rate of Technical Substitution



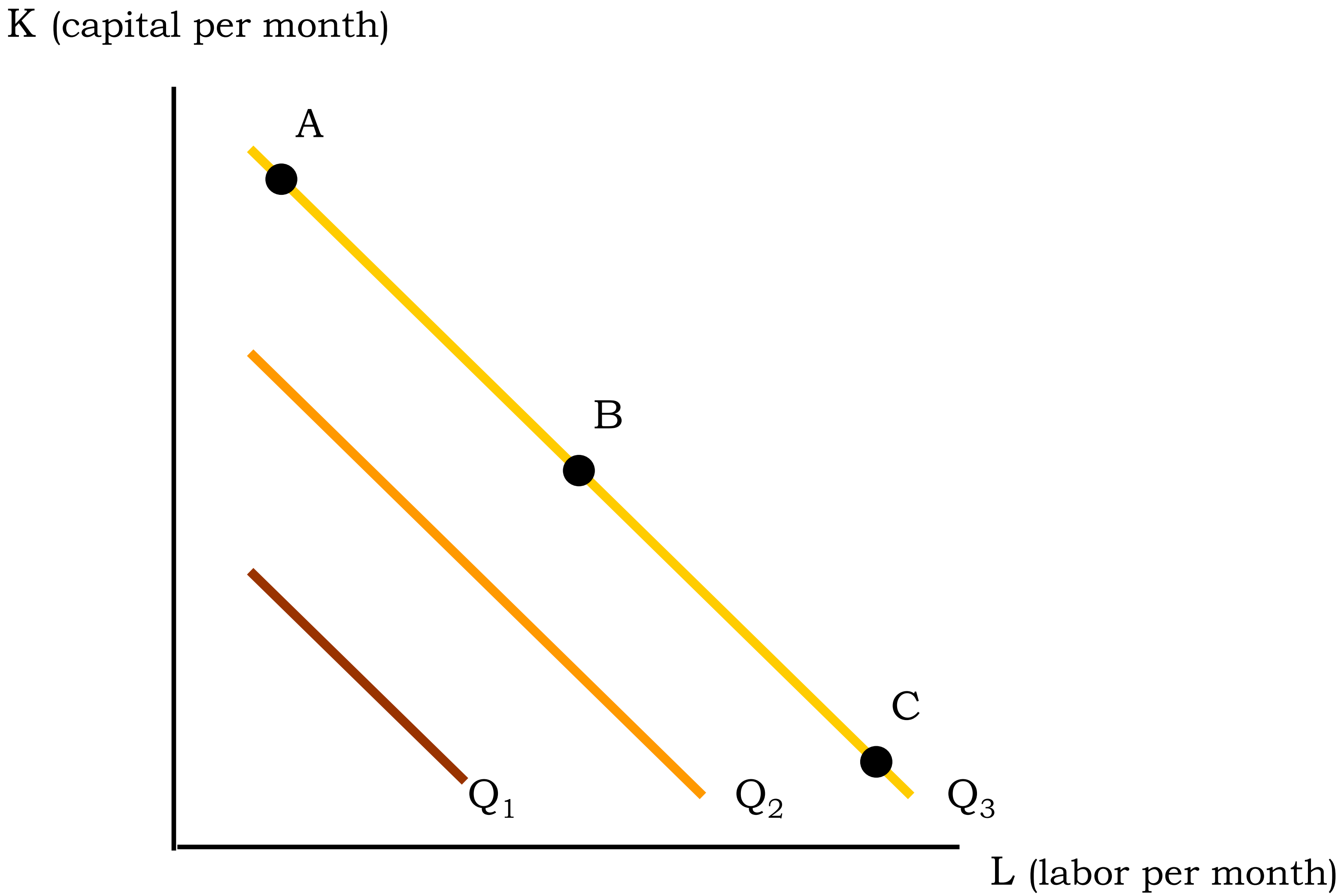
Marginal Rate of Technical Substitution (MRTS):

The rate at which one factor input can be substituted for another at a given level of output

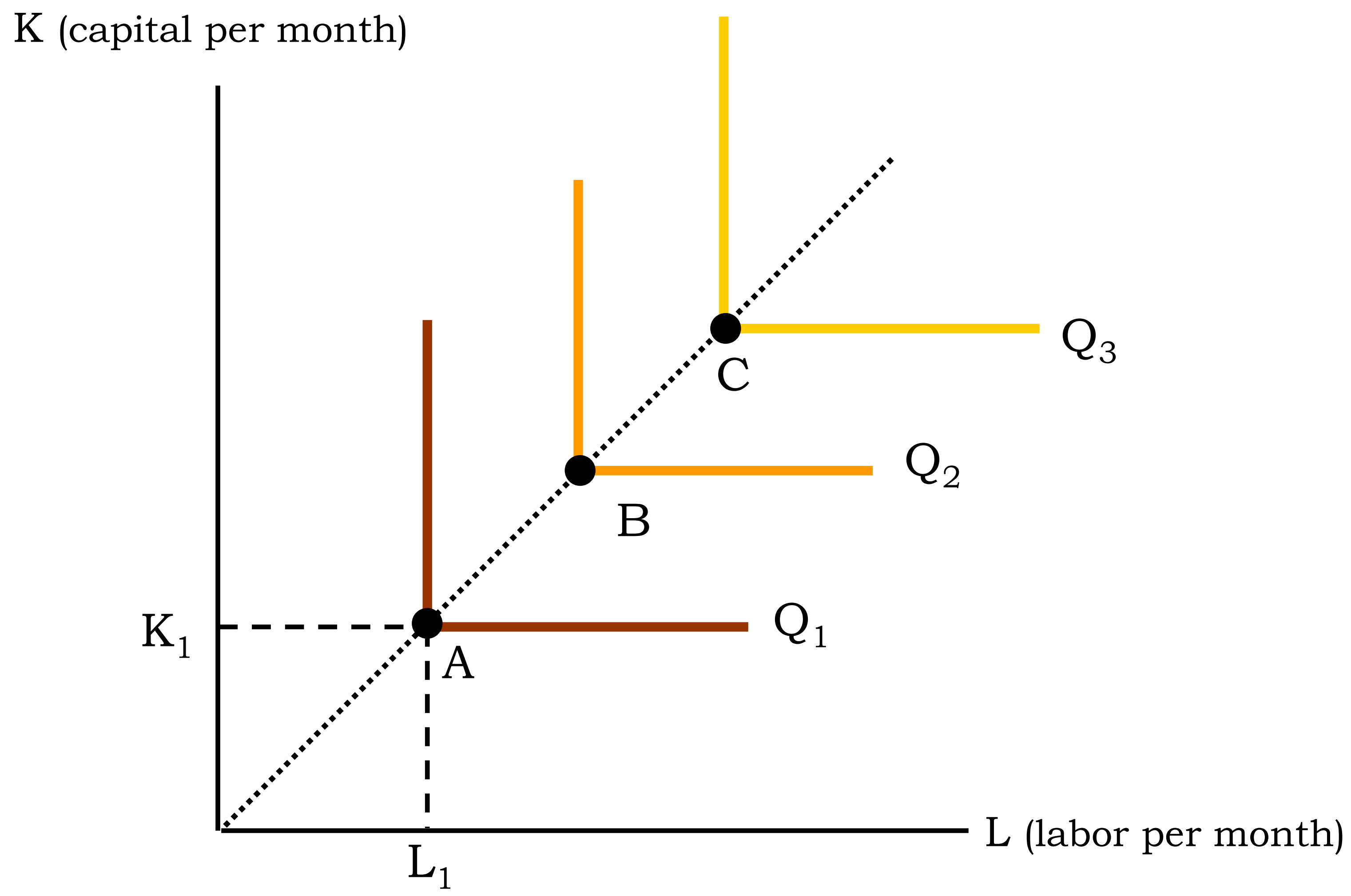
MRTS = (Δ K/ Δ L)=1.25

MRTS = MP_L/MP_K = (Δ Q/ Δ L)/ (Δ Q/ Δ K)

Isoquants when Inputs are Perfect Substitutes

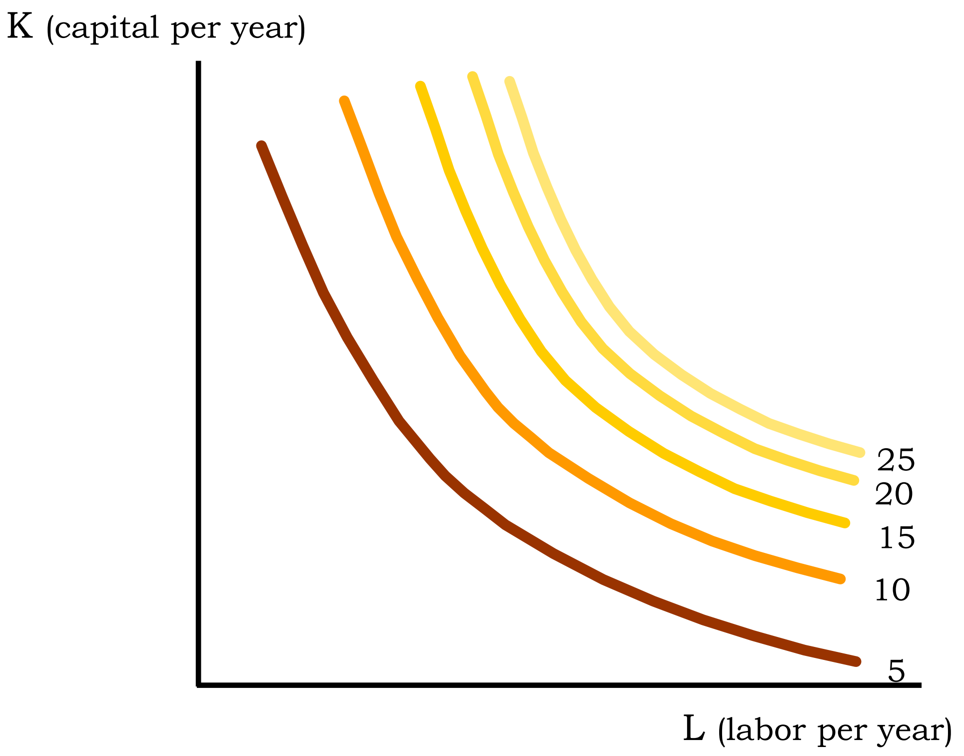


Fixed-Proportions Production Function → Inputs are Perfect Complements

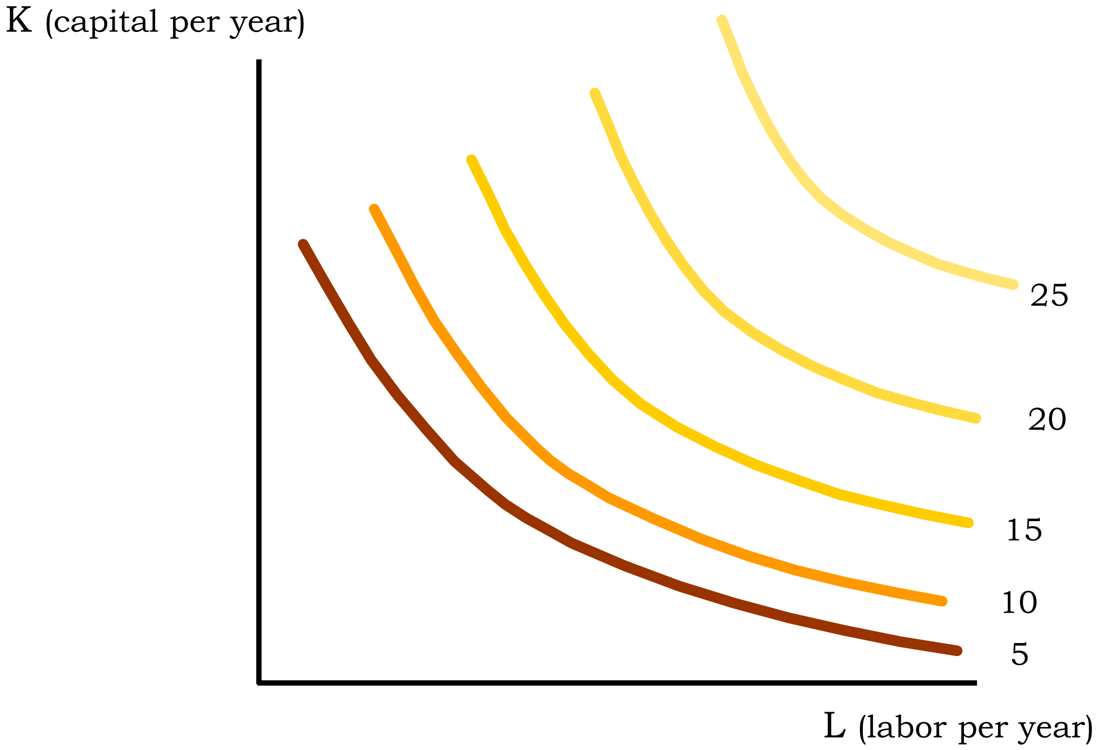


Isoquants and Return-to-Scale

Increasing return to scale



Decreasing return to scale



B. Cost Theory

Isocost line

- $TC = P_L L + P_K K$
- Two inputs: labor (L) & capital (K)
- The price of labor (P_L)
- The price of capital (P_K)

- The Isocost Line
  - **The isocost line**: a line showing the different combination of factor inputs which can be purchased with a given budget

Isocost Line

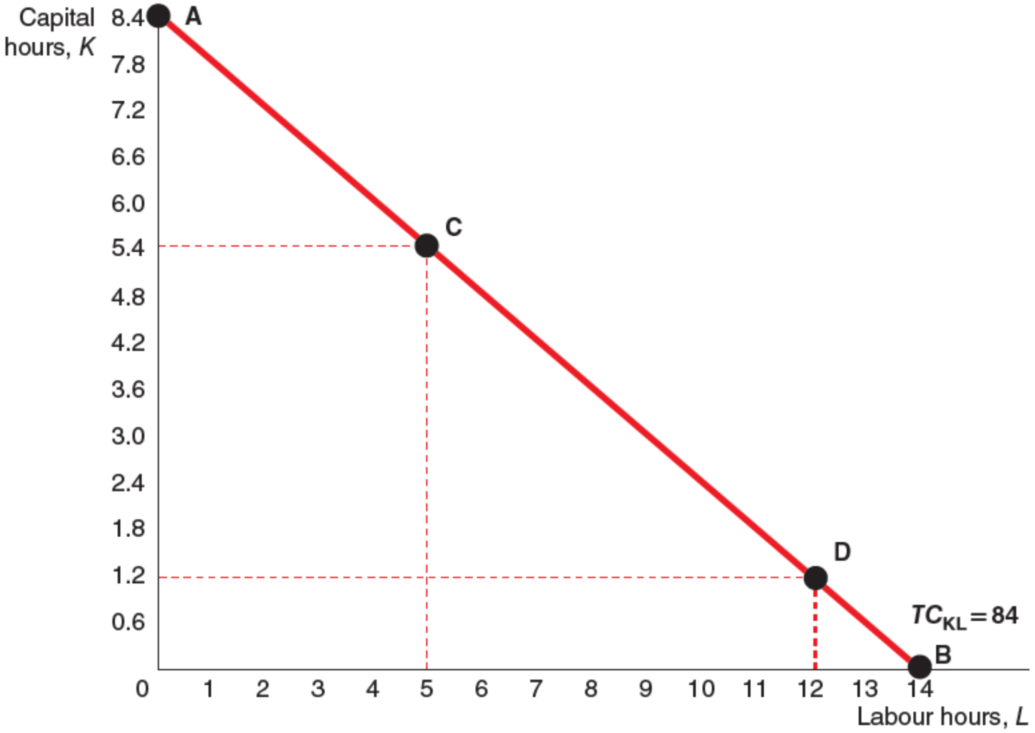


TABLE 10.1 Factor Combinations to Satisfy the Equation $K = 8.4 - 0.6L$

K	L
8.4	0
7.8	1
7.2	2
6.6	3
6.0	4
5.4	5
4.8	6
4.2	7
3.6	8
3.0	9
2.4	10
1.8	11
1.2	12
0.6	13
0	14

Source: Mankiw & Taylor (2020), "Microeconomics", Chapter 10, p. 235

Isocost line

We rewrite the total cost equation (TC = P_LL + P_kK):

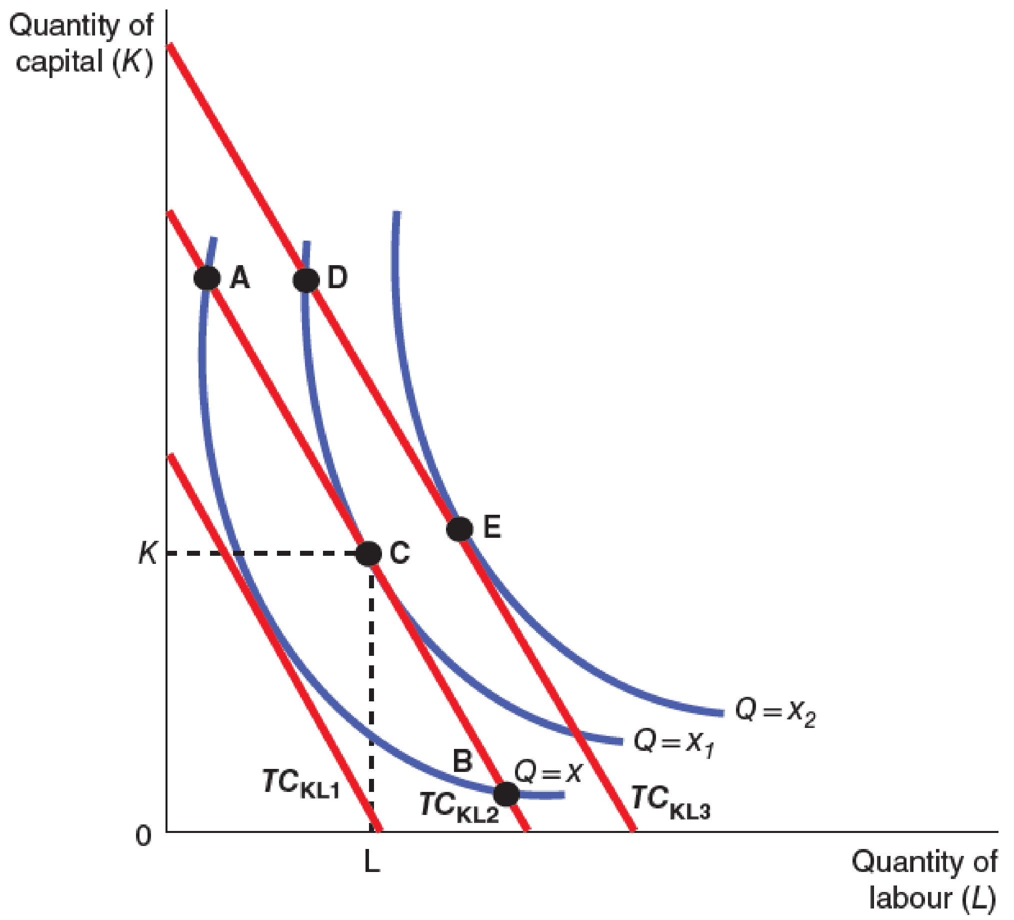
- $K = \frac{TC}{P_k} - (\frac{P_L}{P_k})L$

$$\frac{\Delta K}{\Delta L} = -\left(\frac{P_L}{P_K}\right)$$

The slope of the isocost line:

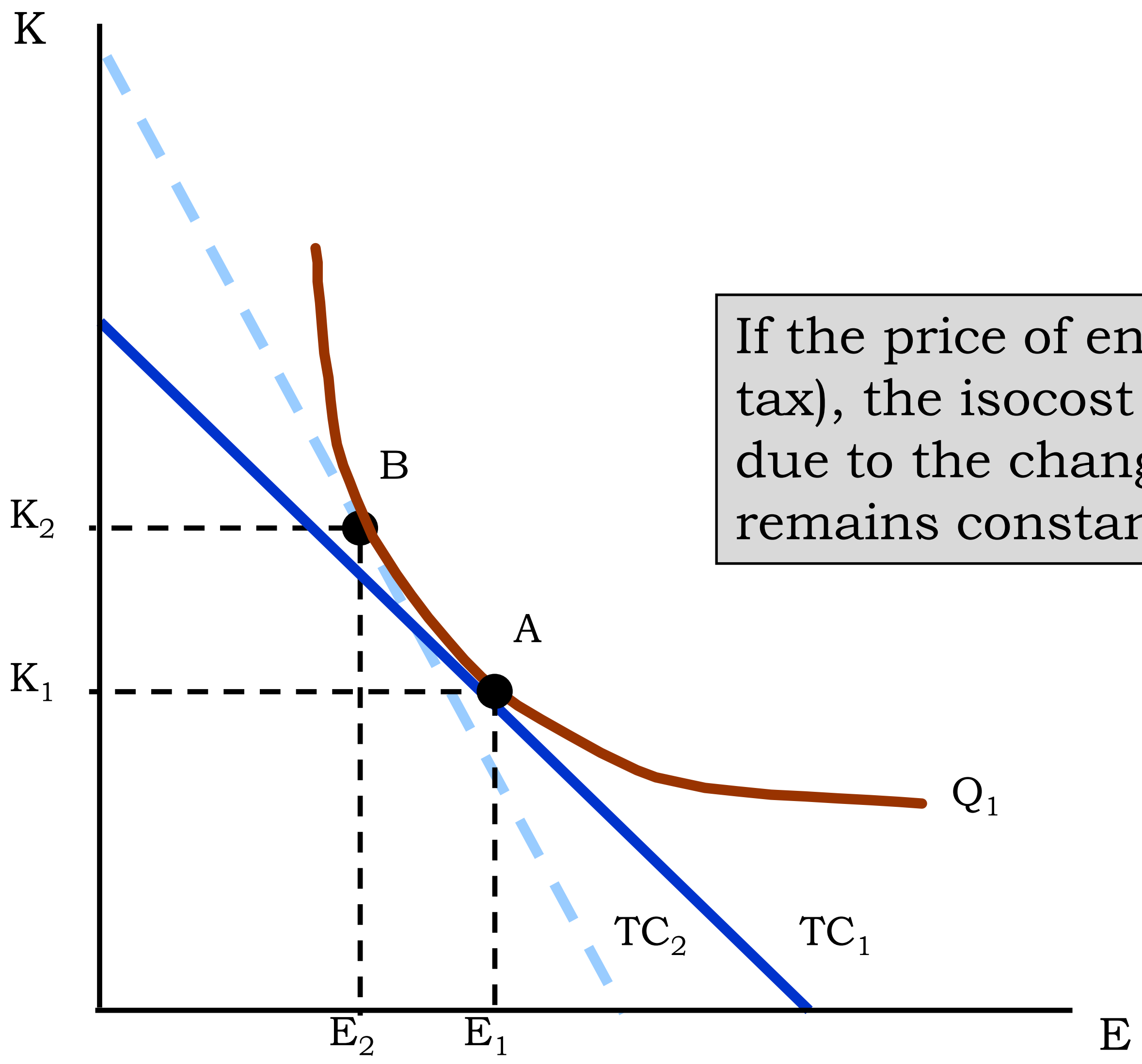
- Is equal to the ratio of wage rate to the rental cost of capital
- Tells us the rate at which a firm can give up a unit of labor to buy (P_L/P_k) units of capital while holding the total cost at the same level

Least-Cost Input Combination



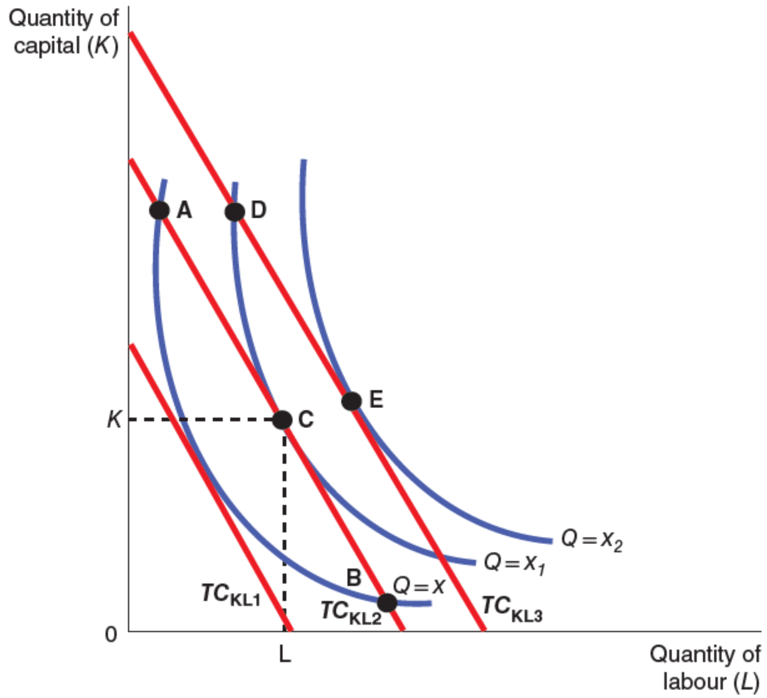
Source: Mankiw & Taylor (2023), "Microeconomics"

Input Substitution when an Input Price Changes

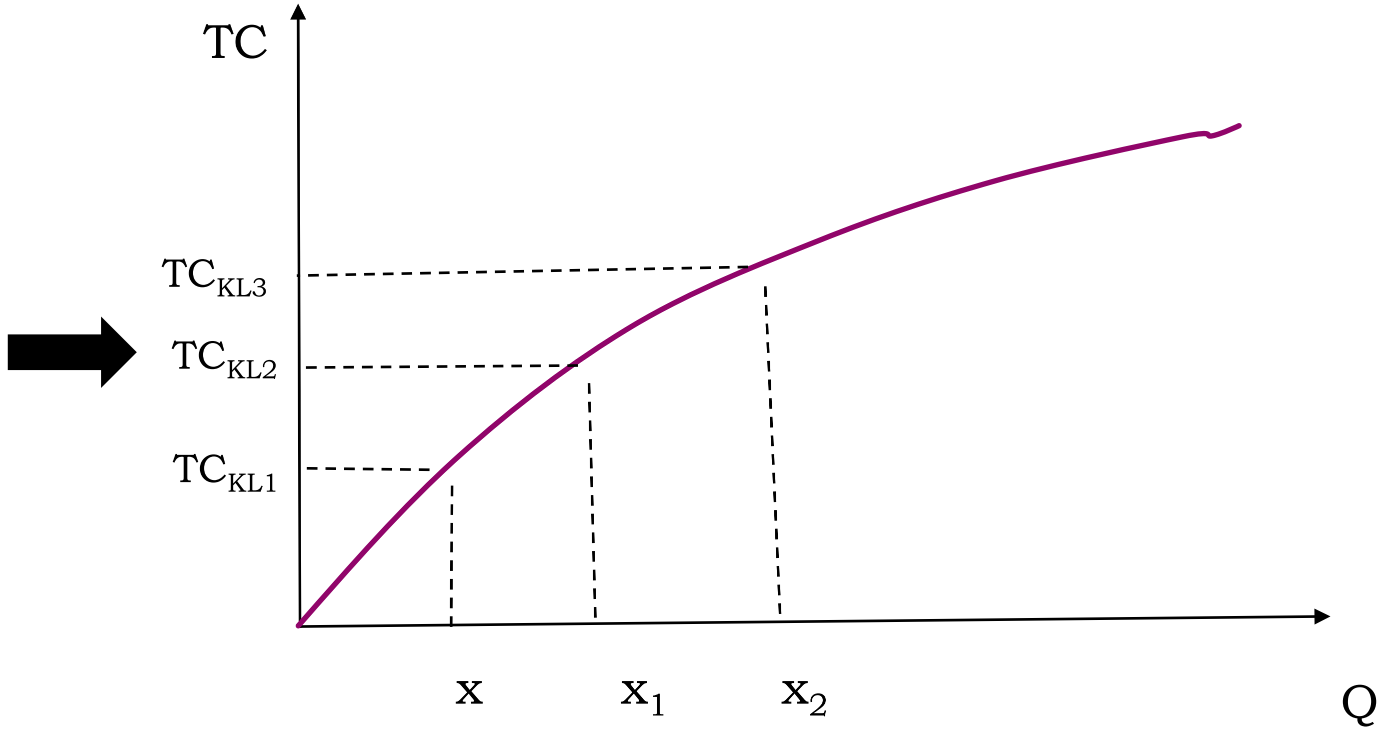


If the price of energy increases (e.g. $CO2$ tax), the isocost curve becomes steeper due to the change in the slope (output remains constant)

Least-Cost Input Combination and total cost function

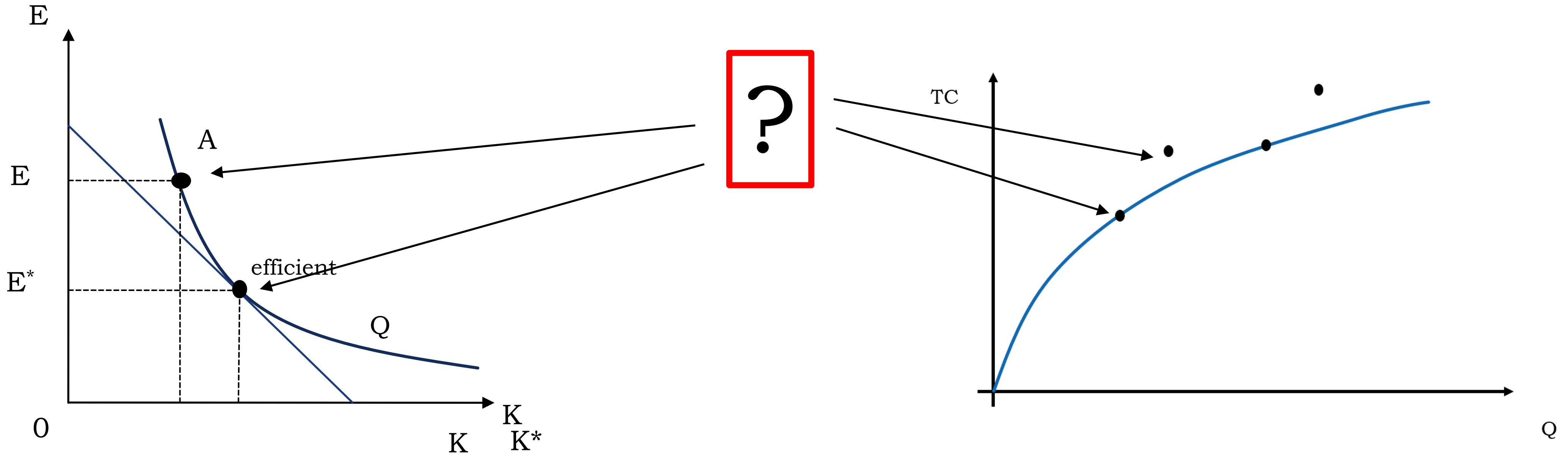


Source: Mankiw & Taylor (2023), "Microeconomics"



C. Cost inefficiency, Behavioral Economics and Principal Agent theory

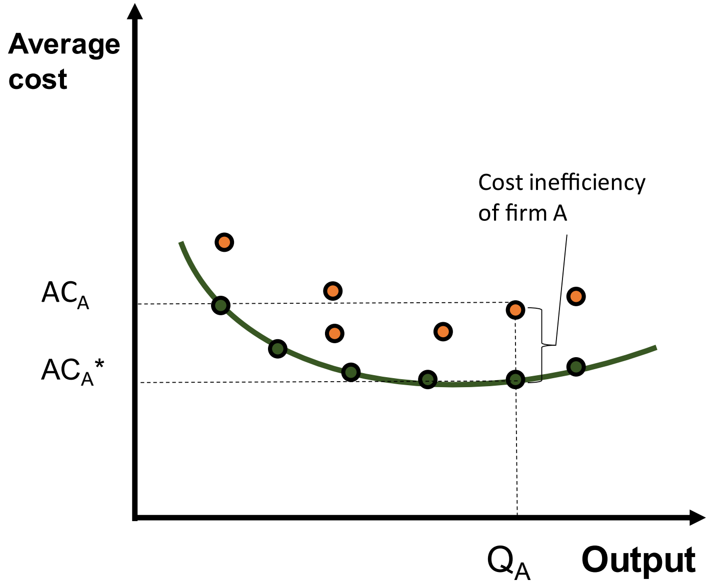
Do firms always minimize the cost?



Inefficiency (cost –inefficiency)

- **Inefficiency**: Firms fail to minimize cost of production due to the use of more inputs than technologically necessary or choosing a wrong combination of inputs

- Neoclassical economic theory assumes that firms always take optimal input decisions and hence operate on their cost frontier.



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Productivity change and efficiency in the Swiss nursing home industry

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ABSTRACT
Enhancing nursing home efficiency and productivity is a challenging task for health policy makers due to population ageing trends and increasing healthcare costs. In this study, we analyse nursing home efficiency and productivity using data from the universe of Swiss nursing homes for the period 2007–2015. We estimate a translog cost frontier via generalized true random effects models, which allow to disentangle the transient and the persistent components of inefficiency. In particular, we apply the simulated maximum likelihood approach proposed recently by scholars and then improve our estimates with a Mundlak correction. We find that total factor productivity change has dropped in recent years, and both efficiency components show scope for improvement. However, the marginal gains from transient efficiency measures are potentially larger, and could provide a more valid contribution to reverse the decreasing trend in total factor productivity change.

KEYWORDS
Nursing homes; total factor productivity change; transient and persistent efficiency; cost frontier

JEL CLASSIFICATION
D24; I11

Table 3. Nursing homes efficiency scores.

	Mean	SD	Min	Max
Panel A: Transient efficiency scores				
Baseline	0.872	0.075	0.385	0.983
Mundlak	0.866	0.080	0.368	0.984
Panel B: Persistent efficiency scores				
Baseline	0.893	0.011	0.868	0.999
Mundlak	0.965	0.001	0.946	0.975
Panel C: Overall efficiency scores				
Baseline	0.779	0.065	0.363	0.881
Mundlak	0.836	0.077	0.358	0.949

The table reports persistent, transient and overall efficiency scores derived from translog cost frontiers estimated using the GTRE model proposed by Filippini and Greene (2016). *Baseline* efficiency scores are derived from the baseline cost frontier (column 1 in Table 2), and *Mundlak* efficiency scores are derived from the cost frontier with Mundlak correction (column 2 in Table 2).

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Persistent and transient cost efficiency—an application to the Swiss hydropower sector

Massimo Filippini[1,2] · Thomas Geissmann[1,3] · William H. Greene[4]

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Abstract Electricity prices on the European market have decreased significantly over the past few years, resulting in a deterioration of Swiss hydropower firms' competitiveness and profitability. One option to improve the sector's competitiveness is to increase cost efficiency. The goal of this study is to quantify the level of persistent and transient cost efficiency of individual firms by applying the generalized true random effects (GTRE) model introduced by Colombi et al. (Journal of Productivity Analysis 42(2): 123–136, 2014) and Filippini and Greene (Journal of Productivity Analysis 45(2): 187–196, 2016). Applying this newly developed GTREM model to a total cost function, the level of cost efficiency of 65 Swiss hydropower firms is analyzed for the period between 2000 and 2013. A true random effects specification is estimated as a benchmark for the transient level of cost efficiency. The results show the presence of both transient as well as persistent cost inefficiencies. The GTREM predicts the aggregate level of cost inefficiency to amount to 21.8% (8.0% transient, 13.8% persistent) on average between 2000 and 2013. These two components differ in interpretation and implication. From an individual firm's perspective, the two types of cost inefficiencies might require a firm's management to respond with different improvement strategies. The existing level of persistent inefficiency could prevent the hydropower firms from adjusting their production processes to new market environments. From a regulatory point of view, the results of this study could be used in the scope and determination of the amount of financial support given to struggling firms.

Keywords Efficiency measurement · Stochastic frontier analysis · Persistent and transient cost efficiency · Hydropower

JEL classification C01 · C23 · D23 · L94 · Q25

1 Introduction

Ever since Switzerland's electrification at the beginning of

Table 4 Descriptive statistics of estimated cost efficiencies

	GTREM persistent	TREM	GTREM transient
Mean	0.862	0.936	0.920
Min	0.857	0.675	0.673
Max	0.888	0.994	0.991
Std. dev.	0.007	0.045	0.053
25% Pc.	0.858	0.919	0.903
Median	0.859	0.949	0.938
75% Pc.	0.863	0.966	0.955

Note: This table presents descriptive statistics of the cost efficiency estimates of the TREM and GTREM frontier models. Statistics are based on the full sample of observations

Theories that explain the level of cost inefficiency

- **X-Inefficiency and selective rationality** (Liebenstein 1966)

- **Principal Agent Theory** (Alchian and H. Demsetz 1972)

➢ Principal agent problem

- **Behavioral agency theory** (Behavioral agency theory; Pepper & Gore 2015)

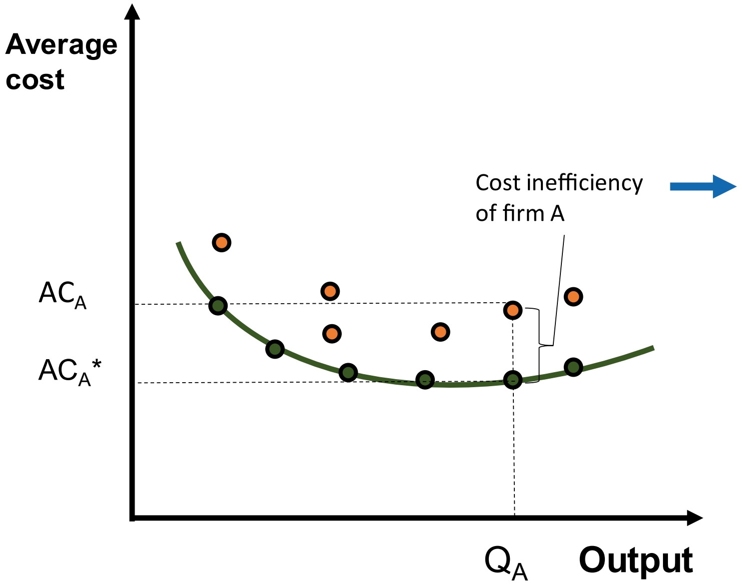
X-Inefficiency and selective rationality

According to Liebenstein, perhaps one of the earliest behavioral economists, the behavior of a firm's management can deviate from the rational behavior assumed by neoclassical microeconomic theory (cost minimization and profit maximization). This deviation is based on the Liebenstein concept of selective rationality. The level of selective rationality of a manager or management depends on internal and external pressures. External pressures rely on the market competition level, while internal pressures depend on the duality of management personality. On the one hand, there are internal forces that drive the individual to be rational, to try to manage the company in the best way possible; on the other hand, there are forces that drive the manager to be impulsive, to make decisions that are poorly reasoned and therefore not necessarily attractive to the company.

Allocative Efficiency vs. "X-Efficiency"

Harvey Leibenstein

The American Economic Review
Vol. 56, No. 3 (Jun., 1966), pp. 392-415
(24 pages)
Published by: American Economic Association



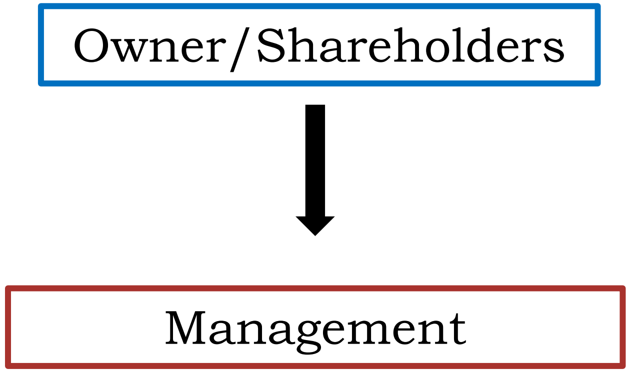
→ Also called X-Inefficiency

Principal-Agent Problem

- A principal-agent problem arises when there is a conflict of interest between the owner (principal) of a firm and the management (agent)

- Presence of asymmetric information between the management and the owner.

- Manager can act in his interest at the owner' expense,
- ➢ the principal-agent problem is an example of moral hazard.



- Situation that can create cost inefficiency

Principal-Agent Theory

At the base of managers' inefficient behavior we find:

- Poor management effort (less than desired by the owner);
- A different risk appetite compared to the owner. Managers often take low-risk actions to protect themselves from possible failures;

Principal-Agent Theory

In order to ensure that managers comply with the objectives of the principal and implement it economically (efficient), the principal has two strategies:

1. «Control» the agent's work, check management results (problem of asymmetric information);

2. Match agent's interests with own ones (definition of incentive strategies):

- Participation of manager in ownership of company;
- Others monetary incentive mechanisms.

Behavioral-Agent Theory

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Behavioral Agency Theory: New Foundations for Theorizing About Executive Compensation

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London School of Economics and Political Science
Julie Gore

Table 1
Assumptions About the Nature of Man Under Positive Agency Theory and Behavioral Agency Theory

Assumption	Economic Man	Behavioral Economic Man
Principals' risk preference	Principals are risk neutral	As for agency theory
Agents' utility function	Agents are rent seeking; agents' utility is positively contingent on pecuniary incentives and negatively contingent on effort	As for agency theory, but subject to constraints relating to rationality, motivation, loss, risk, uncertainty, and time preferences
Agents' rationality	Agents are rational	Agents are boundedly rational, i.e., subject to neurophysiological rate and storage limits on the powers of agents to receive, store, retrieve, and process information without error
Agents' motivation	There is no nonpecuniary agent motivation	Motivation is both intrinsic and extrinsic; intrinsic and extrinsic motivation are neither independent nor additive
Agents' risk preference	Agents are risk averse	Agents are loss averse below a gain/loss inflection point; otherwise risk averse
Agents' time preferences	Agents' time preferences are calculated according to an exponential discount factor	Agents' time preferences are calculated according to a hyperbolic discount factor
Agents' preference for perceived equitable pay	Not defined	Agents are inequity averse

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Structural and managerial cost differences in nonprofit nursing homes

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A R T I C L E I N F O

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Keywords:
cost efficiency
Nursing homes
Nonprofit
Ownership

A B S T R A C T

Population aging is challenging governments to find new solutions to finance the increasing demand for nursing home care and slow down the increase in expenditures. In this light, many European countries are currently considering reforms to increase efficiency in the provision of nursing home services. One popular restructuring policy is the transformation of public organizations into private nonprofit organizations. The underlying assumption is that private nonprofit nursing homes are more efficient than public nursing homes. However, there is limited empirical evidence to support this view. This analysis aims to contribute to the evidence base on this issue by investigating the impact of the organizational form on the costs of nursing homes. We use a sample of 45 nursing homes from one Swiss canton over a 5-year period (2001–2005). The applied estimation strategy provides more accurate estimates as compared to previous studies. In particular, we distinguish between cost differences that are under the control of the managers from those that are not (structural). Our findings suggest that public nursing homes are more costly than private nursing homes, although the difference is small. This cost difference is mainly driven by structural rather than managerial costs. Therefore, cost-reducing policies that promote private nonprofit nursing homes are expected to reduce costs only slightly.

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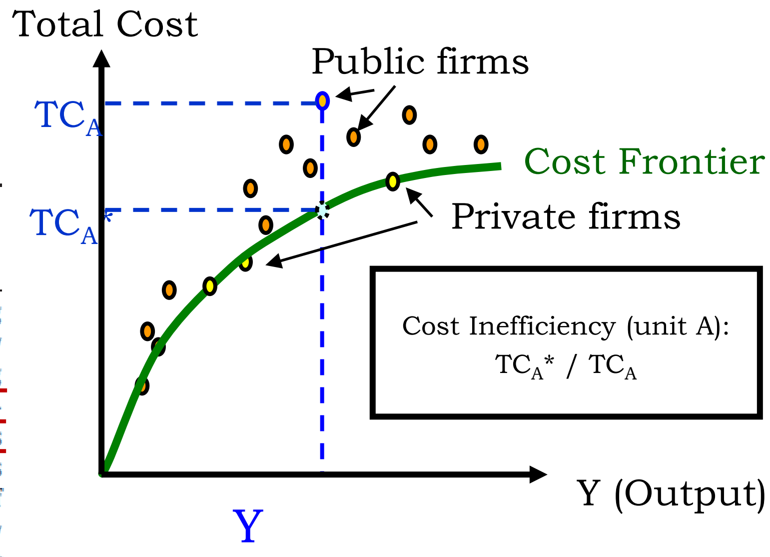

3. Institutional forms in nursing home care

According to the ownership type, NFP NHs are usually categorized into public and private NHs. Although these types are supposed to reflect differences in the control of funds and the production process, the classification may not effectively capture differences in the organizational form. A more sophisticated insight looks at the institutional form, which underlines property rights or legal constraints affecting different institutions. Hence, public-law NHs are public administrative units without a separate juridical status from the local public administration and are directly integrated into it. The governing body is represented by local politicians (city council), while the executive arm is left to the municipality, which delegates it to a manager. Conversely, private-law NFP NHs usually take the form of a foundation. Generally, foundations are created by individuals or private legal entities. In some cases, local governments decide to create private-law NFP NHs. Therefore, when local governments set up a foundation to provide nursing home services, this is a private-law institution owned by the government. In both of these cases the governing body is the foundation council.

These institutional types apply to Switzerland where the provision of NH services is dominated by NFP institutions regulated at cantonal (state) level. In some cantons the provision is further decentralized at the municipality level. In this case, each NH provides care to the residents of a given area. The choice of the NH does not depend on price and quality aspects since individuals are usually assigned to the NH in the former place of residence. Therefore, NHs generally operate as local monopolies, i.e. clients have no choice of NH. Prices are subsidized by the cantonal regulator, leading to excess demand and waiting lists. In the Swiss Canton of Ticino, where we focus this analysis, around 51% of NFP NHs are private-law organizations, and 49% are public-law organizations.

$$C = f(Y, P_l, P_k, P_m, Q_1, Q_2, Z, \tau). \tag{9}$$

$$\begin{aligned}
\ln\left(\frac{C}{P_m}\right) &= \delta_0 + \delta_Y \ln Y + \delta_{Q_1} \ln Q_1 + \delta_{Q_2} \ln Q_2 + \delta_{P_l} \ln \frac{P_l}{P_m} + \\
&+ \delta_{P_k} \ln \frac{P_k}{P_m} + \frac{1}{2}\delta_{YY}(\ln Y)^2 + \frac{1}{2}\delta_{Q_1Q_1}(\ln Q_1)^2 + \frac{1}{2}\delta_{Q_2Q_2}(\ln Q_2)^2 + \\
&+ \frac{1}{2}\delta_{P_lP_l}\left(\ln \frac{P_l}{P_m}\right)^2 + \frac{1}{2}\delta_{P_kP_k}\left(\ln \frac{P_k}{P_m}\right)^2 + \delta_{YQ_1} \ln Y \ln Q_1 + \\
&+ \delta_{YQ_2} \ln Y \ln Q_2 + \delta_{YP_l} \ln Y \ln \frac{P_l}{P_m} + \delta_{YP_k} \ln Y \ln \frac{P_k}{P_m} + \\
&+ \delta_{Q_1P_l} \ln Q_1 \ln \frac{P_l}{P_m} + \delta_{Q_1P_k} \ln Q_1 \ln \frac{P_k}{P_m} + \delta_{Q_1Q_2} \ln Q_1 \ln Q_2 + \\
&+ \delta_{P_lQ_2} \ln \frac{P_l}{P_m} \ln Q_2 + \delta_{P_kQ_2} \ln \frac{P_k}{P_m} \ln Q_2 + \delta_{P_kP_l} \ln \frac{P_k}{P_m} \ln \frac{P_l}{P_m} + \\
&+ \delta_Z Z + \delta_t \tau + \varepsilon_{it} + \alpha_i,
\end{aligned} \tag{10}$$

Table 2
Descriptive statistics of the main costs and input variables (210 observations).

Variables	Mean
Average cost (Sfr/resident day)	232.80
Total annual resident days (Y)	24032
Average dependency index (Q_1)	3.08
Nursing staff ratio (Q_2)	0.966
Average labor price in Sfr per employee (P_l)	80266
Average capital price in Sfr per bed (P_k)	5398
Average material price in Sfr per meal (P_m)	8.35
Number of beds	68

Notes: All monetary values are in 2005 Swiss francs (Sfr), adjusted by the national Consu

Mean Q_1	0.367***	0.112
Mean P_l	0.124***	0.044
Mean Q_1Q_2	-2.298***	0.712
Mean YQ_1	0.538**	0.257
Z	0.021***	0.006
δ_0	15.373***	0.011
σ_α	0.027***	0.003
σ	0.044***	0.006
λ	1.473**	0.645

Table 6
Mean managerial inefficiency of public-law and private-law NHs.

Mean managerial inefficiency	Mean	Std. dev.	Min	Max
All NHs (N = 210)				
Model 1a	0.0324	0.0191	0.0087	0.1647
Model 1b	0.0251	0.0113	0.0083	0.0972
Model 2a	0.0326	0.0193	0.0086	0.1671
Model 2b	0.0281	0.0143	0.0086	0.1193
Private-law NHs (N = 107)				
Model 1a	0.0333	0.0224	0.0088	0.1647
Model 1b	0.0253	0.0131	0.0083	0.0972
Model 2a	0.0337	0.0228	0.0089	0.1671
Model 2b	0.0291	0.0168	0.0086	0.1192
Public-law NHs (N = 103)				
Model 1a	0.0315	0.0149	0.0087	0.0709
Model 1b	0.0250	0.0090	0.0097	0.0500
Model 2a	0.0316	0.0150	0.0086	0.0712
Model 2b	0.0271	0.0110	0.0093	0.0587

D. Appendix

Substitution Method to Optimization Problems (I)

- The substitution method is a technique for solving two-variable constrained optimization problems.

- It involves substituting a constraint function in an objective function and then solve the problem as an unconstraint problem (3 steps).

- Example (maximization problem):

Objective function: $\max z = x^{1/2}y^{1/2}$

Constraint: $\text{s.t. } x + y = 4$

Source: Binger & Hoffman (1997), “Microeconomics with Calculus”, Chapter 3

Substitution Method to Optimization Problems (II)

1. Express the **constraint** with either x or y as the dependent variable:

$$y = 4 - x$$

2. Substitute the **constraint** in the **objective function**:

$$z = x^{1/2}y^{1/2} = x^{1/2}(4 - x)^{1/2}$$

Source: Binger & Hoffman (1997), “Microeconomics with Calculus”, Chapter 3

Substitution Method to Optimization Problems (III)

3. Maximize the new **objective function** with respect to the remaining independent variable by setting its first derivative to zero and solving:

$$\frac{dz}{dx} = \frac{1}{2}x^{-1/2}(4-x)^{1/2} - \frac{1}{2}x^{1/2}(4-x)^{-1/2} = 0$$

$$\rightarrow \frac{(4-x)^{1/2}}{x^{1/2}} = \frac{x^{1/2}}{(4-x)^{1/2}} \rightarrow 4-x = x \rightarrow \boldsymbol{x^* = 2}$$

$$\rightarrow \boldsymbol{y^* = 4 - x^* = 2,\ z^* = (x^*)^{1/2}(y^*)^{1/2} = 2}$$

Note that both the product rule and the chain rule were used in order to take the first derivative of z.

Source: Binger & Hoffman (1997), "Microeconomics with Calculus", Chapter 3

Exercise

A firm produces the quantity Q of some commodity using the inputs labor L and capital K at input prices $P_L = 1$ CHF and $P_K = 2$ CHF, respectively. The production function is assumed to be *Cobb-Douglas*, namely $Q(K, L) = K^{0.7}L^{0.3}$. Suppose the firm wished to produce $Q = 10$ units.

Solve the cost minimization problem and report the (cost-effective) input quantities and the minimum cost of production.

Solution I

- The problem consists of minimizing a cost function subject to a constraint:
  min $\boldsymbol{C = P_K K + P_L L}$
  s.t. $\boldsymbol{Q(K, L) = K^{0.7} L^{0.3}}$

- The quantities given are $P_K = 2$ CHF, $P_L = 1$ CHF and $Q = 10$ units.

- **Substitution Method:** Using the constraint an expression for K is derived:
  $\boldsymbol{10 = K^{0.7} L^{0.3} \rightarrow K = 10^{\frac{1}{0.7}} L^{-\frac{0.3}{0.7}} = 26.827\, L^{-0.43}}$

- Replace K, P_K and P_L in the cost function:
  $\boldsymbol{C = 2 * 26.827\, L^{-0.43} + L}$

Solution II

- As we are looking for the amount of labor that minimizes cost, we set the first derivative of the cost function wrt labor to 0:
  $$\frac{dC}{dL} = -23.071L^{-1.43} + 1 = 0 \rightarrow L^* = 8.98$$

- Going back into the production function to find K:
  $$K = 26.827\,L^{-0.43} \quad \rightarrow \quad K^* = 10.44$$

- Inserting both values into the cost function give its minimum:
  $$C = P_K K + P_L L = 2 * 10.44 + 1 * 8.98 = 29.86$$