

Cobbs-Douglas Production Function with Three Inputs

Last Thursday, we have introduced the Cobbs-Douglas function with three inputs: the capital investment x , amount of labor y , and materials and supply z . The new model becomes

$$Q(x, y, z) = Ax^\alpha y^\beta z^\gamma,$$

where A and a are positive constants with $0 < \alpha, \beta, \gamma < 1$ and $\alpha + \beta + \gamma = 1$.

Suppose that capital investment, labor and materials all have different unit cost: ρ , σ and τ respectively. The total amount of cost can be expressed by

$$C(x, y, z) = \rho x + \sigma y + \tau z.$$

If we restrict the total amount of cost to be capped at positive constant M , we have $C(x, y, z) \leq M$.

Since our domain is a closed and bounded region, by the extreme value theorem, the output must attain at least one absolute minimum and at least one absolute maximum. How do we find these points?

First, we divide the domain into two regions: the open set $U = \{(x, y, z) \mid \rho x + \sigma y + \tau z < M\}$ and the boundary set $\partial U = \{(x, y, z) \mid \rho x + \sigma y + \tau z = M\}$. By the first-derivative test, we can locate the local extrema by locating the critical points of f .

- (b) (15 points) Use the second-derivative test to show that this critical point $(x, y, z) = (0, 0, 0)$ is degenerate.
- (c) (5 points) Use the fact that x, y, z are non-negative numbers to show that $(x, y, z) = (0, 0, 0)$ is a local minimum.

Now, consider the output Q when restricted to the boundary, that is the level set $\partial U = \{(x, y, z) \mid C(x, y, z) = M\}$. Apply the method of Lagrange multiplier, we can locate all the critical points of $Q|_{\partial U}$.

- (c) (25 points) Locate all critical point(s) of $Q(x, y, z)$ restricted to the set ∂U .
- (d) (40 points) Use the Hessian criterion for constrained extrema to determine whether these constrained critical points of $Q|_{\partial U}$ are constrained minimum, constrained maximum, saddle point or degenerate.

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Zhe Xu



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