

Living Within our Means: The Case of Population Growth and Economic Development under Scarce Water Resources

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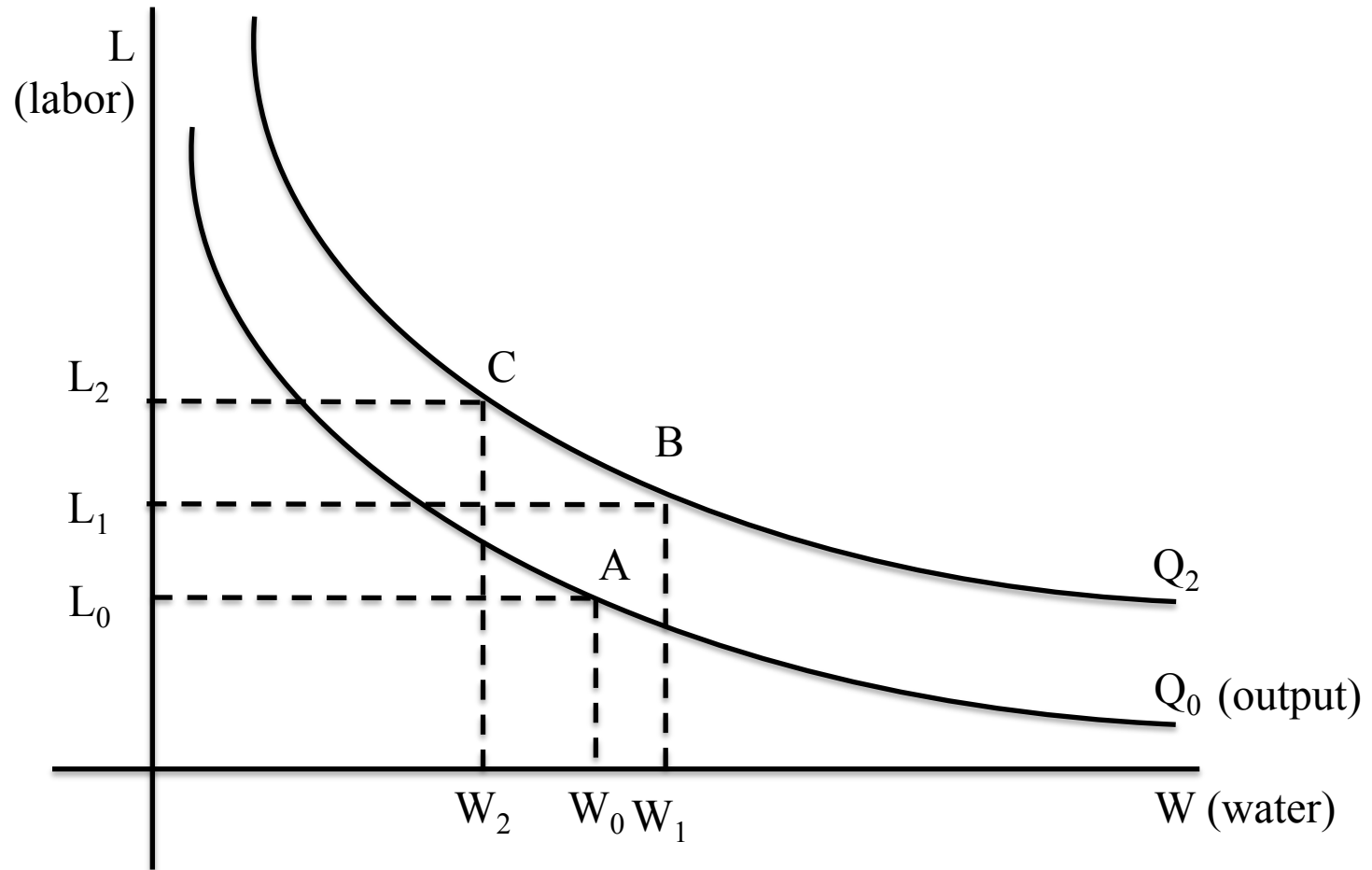
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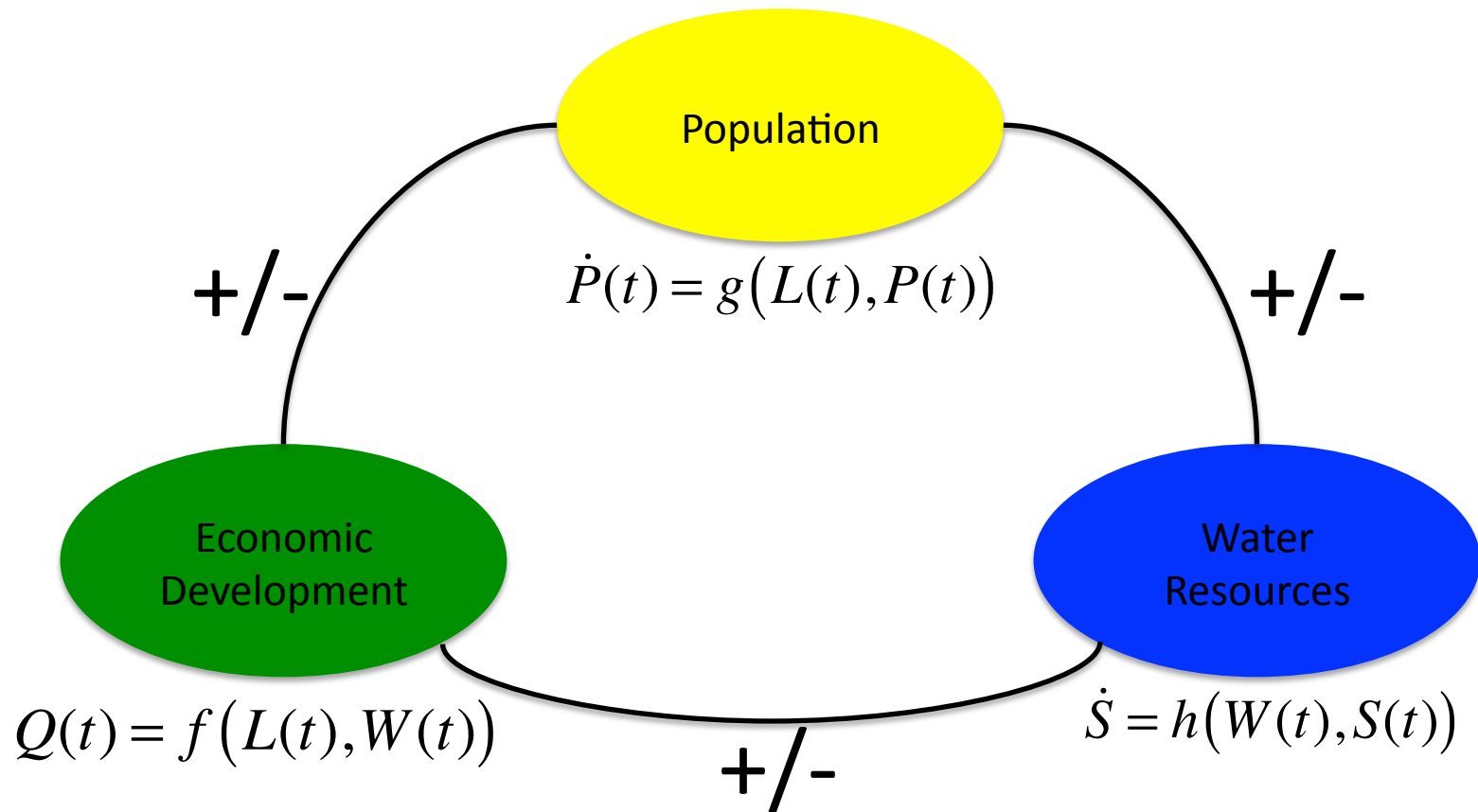
Preview and Motivation

- Economic development creates jobs
 - Jobs create population growth
 - Population growth leads to more water demand
- Water resources are scarce
- So, what does economic development look like that is water resources informed?

Tradeoffs in Labor and Water



Building Blocks to the Development, Growth and Scarcity Problem



Dynamic Optimization Conditions

On the margin:

- the value of labor product equals the cost to change the population size – opportunity cost

$$e^{-\rho t} f_L = -\lambda g_L$$

- the value of water product equals the cost to change the water supply – opportunity cost

$$e^{-\rho t} f_W = -\mu h_W$$

Shadow Values

- The shadow value measures the change in the objective given a change in the constraint.
- The shadow value of population can be either positive or negative – “it depends.”

$$\lambda = -e^{-\rho t} \frac{f_L}{g_L}$$

- The shadow value of the water supply is positive.

$$\mu = -e^{-\rho t} \frac{f_W}{h_W}$$

Optimal Input Mix Over Time

- The time paths show the optimal changes in the inputs, and what affects the change.
- The change in labor depends on water demand and population.

$$\dot{L} = \left[\frac{g_L}{g_L f_{LL} - f_L g_{LL}} \right] \left((\rho - g_P) f_L - f_{WL} \dot{W} + g_{LP} \frac{f_L}{g_L} \dot{P} \right)$$

- The change in water depends on labor but also on water supply.

$$\dot{W} = \left[\frac{h_W}{h_W f_{WW} - f_W h_{WW}} \right] \left((\rho - h_S) f_W - f_{WL} \dot{L} + \frac{f_W}{h_W} h_{WS} \dot{S} \right)$$

Summary and Extensions

- Modeled interaction in output, population and water resources
- Optimal economic development is possible, but it depends on the optimal choice of inputs
- Specify functional forms, parameterize then build simulation model for numerical analysis