

# Linear Algebra

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## 1 Linear Systems

### General Linear Equation

#### General Linear Equation (multi variable)

$$\sum_{i=1}^n \bar{a}_i x_i = \bar{a}_1 x_1 + \bar{a}_2 x_2 + \cdots + \bar{a}_n x_n = \bar{b}$$

More elegantly,

$$\bar{\mathbf{a}} \cdot \mathbf{x} = \bar{b}, \quad \bar{\mathbf{a}} = (\bar{a}_1, \dots, \bar{a}_n), \mathbf{x} = (x_1, \dots, x_n)$$

Note: General Linear Equation (one variable) is:

$$\bar{a}x = \bar{b}$$

- $\bar{a}_i, \bar{b}$ : parameters (given)
- $x_i$ : variables
- Importance of linearity: Linear approximation

## 2 Examples of Linear Models

### 2.1 Markov Models of Unemployment

#### Ex3. Markov Models of Unemployment

##### Main Concept and Assumptions

- Binary state: employed ( $E$ ) or unemployed ( $U$ )
- Four possible events with constant probability:

- $\Pr(E \rightarrow E) = \bar{q}$
- $\Pr(E \rightarrow U) = 1 - \bar{q}$
- $\Pr(U \rightarrow E) = \bar{p}$
- $\Pr(U \rightarrow U) = 1 - \bar{p}$

- Markov process: Stochastic, memoryless process
- $x_t$ : ratio of employed workers
- $y_t$ : ratio of unemployed workers

### Steady state of unemployment rate $y^*$

#### Main Question

- Existence of steady state s.t.,

$$x_{t+1} \approx x_t = x^*, \quad y_{t+1} \approx y_t = y^* \quad \forall t > \bar{T}$$

- Stability of above steady state ( $\rightarrow$  need dynamic analysis: PASS)
- Hall (1966)'s estimation (by Races, male only)
  - $p_W \approx 0.136, q_W \approx 0.998$
  - $p_B \approx 0.102, q_B \approx 0.996$

$$y_W^* \approx 0.014 < y_B^* \approx 0.037$$

## 2.2 IS-LM (Linear version)

### Model

- Hicks's interpretation of Keynes (1936)

$$Y = C + I + G \quad (\text{IS Schedule: Real side})$$

- $C = \bar{b}Y, \quad \bar{b} \in (0, 1)$
- $S = Y - C = (1 - \bar{b})Y = \bar{s}Y$
- $I = \bar{I}^0 - \bar{a}r$

$$\bar{M}_s = M_{dt} + M_{ds} = \underbrace{\bar{m}Y}_{M_{dt}} + \underbrace{\bar{M}^0 - \bar{h}r}_{M_{ds}} \quad (\text{LM Schedule: Monetary side})$$

- Endogenous variables:  $r, Y$
- Exogenous variables (given parameters):  $M_s, G, a, h, I^0, M^0, m$