INTEGRATED MODELING OF WATER CONSUMPTION IN SINGAPORE

Kua Harn-Wei
Assistant Professor
Department of Building
School of Design and Environment
National University of Singapore

CONTENT

- The concept
- Why water?
- The Team
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- Methodology
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THE CONCEPT

- Sustainability science
  - Framework to apply scientific enquiry to address sustainable development issues
  - Four key words:
    - **Integrative**
    - **Stakeholder engagement**
    - **Place-based**
    - **Reflective**
- Using water consumption as a platform to practice sustainability science concept

WHY WATER?

- Singapore is enjoying some successes in sustainable water management

- Many challenges ahead:
  - A possible future with 6 million people
  - Per capita consumption to be reduced from 165 to 150 liters per day
  - Transplanting of lessons learnt to other industrial sectors

THE TEAM

- Dr. Kua Harn Wei (Principle Investigator), Department of Building
  - Sustainability policy
  - Sustainable building materials
  - Carbon sequestration technology
- Associate Professor Dr. David Ho Kim Hin, Department of Real Estate
  - Real estate market analysis and modeling
- Associate Professor Dr. Lee Siew Eang, Department of Building
  - Director, Energy and Sustainability Unit
  - Energy policy
  - Carbon accounting
- Public Utilities Board, Water Supply (Network) Department

National University of Singapore

WHAT DO WE NEED?
WHAT DOES SINGAPORE NEED?

OBJECTIVES

- Empirically establish the relationships between water consumption and key variables;
- Identify key differences in various sectors and groups in society;
- Prescribe policies to encourage reduction in water consumption;
- Transplant lessons learnt to other sectors.

THE METHODOLOGY

Water conservation programs

Population density

Household income & GDP

WATER CONSUMPTION

Weather conditions

Pricing structure of water

Energy price

Water cost

$$I = P_1 x + \sum_{i=1}^{N} p_i c_i + f, \text{if } x \le \tilde{x}$$

$$I = P_2 x + \sum_{i=1}^{N} p_i c_i + f - d, \text{if } x > \tilde{x}$$

I : income

P_i : unit price of water

p_i : unit price of i^{th} consumption

c_i : number of units of i^{th} consumption

f : water-borne fees

d : difference variable

$\tilde{x}$: 'tipping point', where price changes

$$\begin{pmatrix} GWC_{\text{Total}} \\ GWC_{\text{Residential}} \\ GWC_{\text{Industrial}} \\ GWC_{\text{Commercial}} \end{pmatrix} = \begin{pmatrix} \alpha_0 & \alpha_1 & \alpha_2 & & \alpha_m \\ \beta_0 & \beta_1 & \beta_2 & \dots & \beta_m \\ \gamma_0 & \gamma_1 & \gamma_2 & & \gamma_m \\ \delta_0 & \delta_1 & \delta_2 & & \delta_m \end{pmatrix} \begin{pmatrix} 1 \\ \left(\sum_i n_i . P_i\right) \\ \left(\sum_i n_i . (I + d_i)\right) \\ c_1 \\ c_2 \\ \vdots \\ c_k \\ Z_1 \\ \vdots \\ Z_l \\ \varepsilon \end{pmatrix}$$

Consumers want to maximize utility:

$$\max_{c_i} U = \max_{c_i} U(c_i(c_j)),$$

considering any internal substitution among consumption items

Subject to: …

$$I = P_1 x + \sum_{i=1}^{N} p_i c_i + f, \text{ if } x \leq \tilde{x}$$

$$I = P_2 x + \sum_{i=1}^{N} p_i c_i + f - d, \text{ if } x > \tilde{x}$$

CONCLUSIONS

- Tried to be as place-based and integrative as possible;
- Desired outcome:
  - Stakeholder engagement;
  - Causes policymakers and consumers to reflect on themselves.
- Intend to involve students in future