Designing efficiency standards and labelling programs to accelerate long-term technological innovation

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Last Summer Study: Too many equations

$$\Delta P_A = -\Delta PVOC = -\Delta UEC \cdot \overline{P_E} \cdot \sum_{n=1}^{L} \frac{1}{(1+i)^n}$$

$$elasticity = \varepsilon = \frac{\Delta P_A / P_A}{\Delta Eff / Eff} = \frac{\partial \ln(P_A)}{\partial \ln(Eff)}$$

$$PWF = \sum_{n=1}^{L} \frac{1}{(1+i)^n}$$

$$Eff = \frac{1}{UEC}$$

$$\frac{\partial \phi(\psi,t)}{\partial t} = \frac{\frac{\partial \pi(\psi,t)}{\partial t} - \frac{\partial \pi(\phi,t)}{\partial t}}{\frac{\partial \pi(\phi,t)}{\partial \phi}}$$

$$\frac{\partial \zeta(\psi,t)}{\partial t} = \frac{\partial \zeta}{\partial \phi}\frac{\partial \phi}{\partial t} + \frac{\partial \zeta(\phi,t)}{\partial t}$$

$$\frac{\partial \pi(\phi,t)}{\partial t} = -b\frac{\partial \zeta(\phi,t)}{\partial t}$$

$$\frac{\partial \zeta(\phi,t)}{\partial t} = \frac{Q_0(t)}{(1+e^{\psi(\phi,t)})}\frac{1}{X(\phi,t)}$$

$$P = P_0\left(\frac{Eff}{Eff_0}\right)^{\frac{\alpha}{\beta}}$$

$$(\pi - \pi_0) = \frac{\alpha}{\beta}(\phi - \phi_0)$$

$$\pi(\psi,t_0) = \pi_0 + \alpha \cdot \psi$$

$$\frac{\partial}{\partial t}[\pi(\phi(\psi,t),t)] = \frac{\partial \pi}{\partial \phi}\frac{\partial \phi(\psi,t)}{\partial t} + \frac{\partial \pi(\phi,t)}{\partial t}$$

$$\phi(\psi,t_0) = \phi_0 + \beta \cdot \psi$$

This Summer Study: <u>Only 1 Equation</u>

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

a is the annual improvement rate of efficiency,

g is the incremental price of high efficiency products in the market,

q is the annual adoption rate of new, efficient products, and

e is the elasticity of price with respect to efficiency

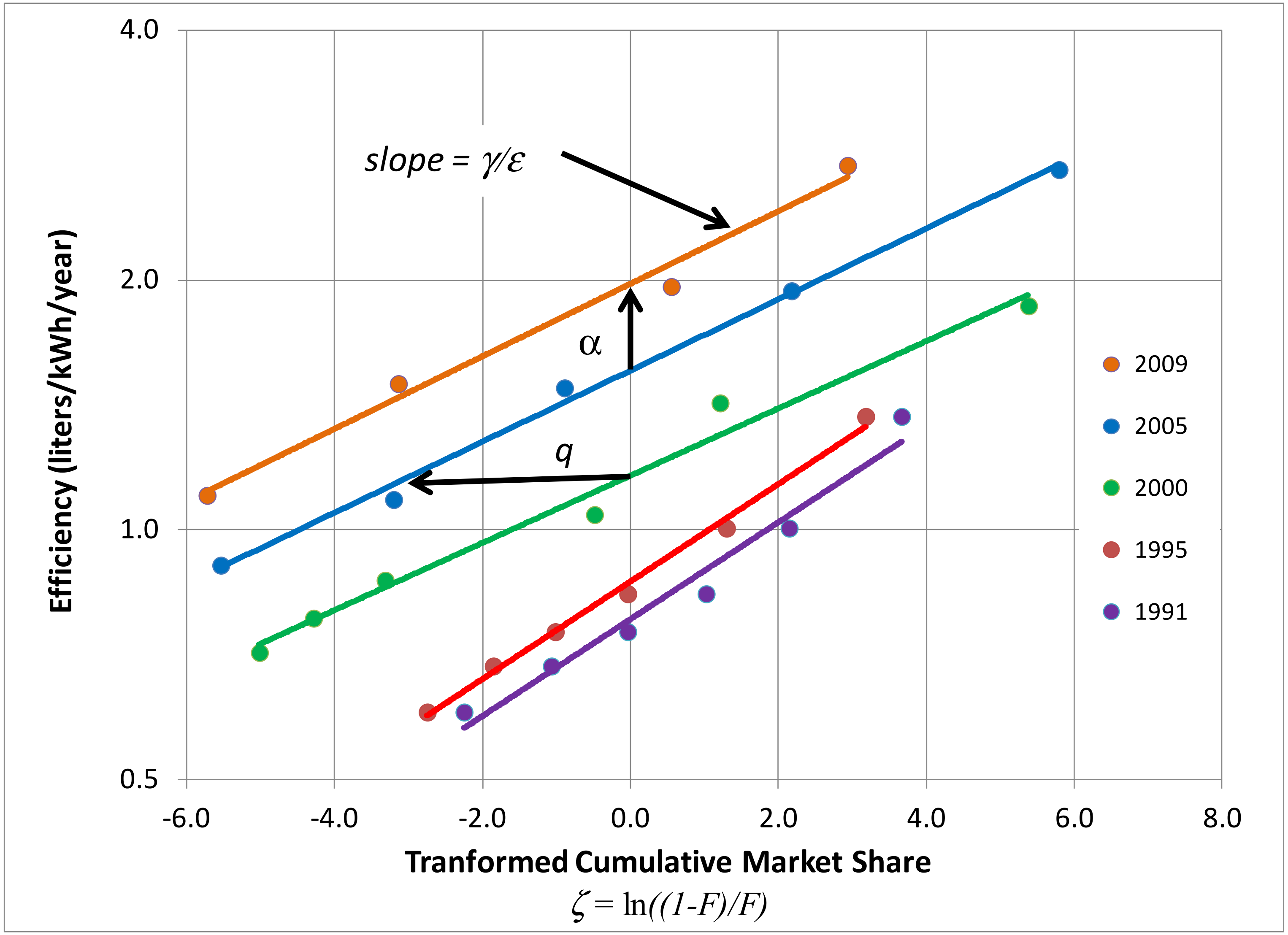
What does this equation say in words?

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

The "Moore's Law of Energy Efficiency" (MLEE), *(adoption form)*

- If customers are willing to pay higher prices for efficiency, innovation can be faster
- If the rate at which new products diffuse and adopted by consumers increases, innovation can be faster
- If the incremental price with respect to efficiency is small, innovation can be faster

Technical Reason for Equation



We discuss 6 measures/features

1. Increasing market transparency
2. Improving the accuracy and veracity of energy savings measurements
3. Crowd-sourcing energy savings data to increase knowledge of actual in-field energy savings
4. Correlating product consumer value (and desirable product attributes) with energy efficiency
5. Promoting EE for off-grid applications
6. Enhancing EE technology road mapping and research and development.

Market Transparency

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

May help increase willingness to pay for EE which can increase g.

Can help consumer find and adopt new, more efficient products faster which can increase q.

Improved savings estimation

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

May help increase willingness to pay for EE which can increase g.

Or if improved savings estimates show small benefits, this can decrease willingness to pay, which might have an adverse effect on efficiency adoption.

Crowd-sourced data

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

Should allow for more diverse estimates of energy savings, which should identify high energy savings applications/customers thus increasing g.

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Correlating savings with other non-energy values

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

- Should help increase adoption rate of new products, increasing *q*.
- May increase willingness to pay for EE which may increase ***g***.
- New features may “cross-subsidize” EE which should be able to help decrease ***e***.

Promoting Off-grid EE Products

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

Off-grid electricity is 2-10 times the cost of on-grid electricity allowing a larger *g*.

Off-grid markets in developing countries are likely to grow very fast, thus increasing *q*.

Enhanced R&D and Roadmapping

$$\alpha = \frac{\gamma \cdot q}{\varepsilon}$$

Helps insure continues availability of very high efficiency products thus increasing *g*.

Can help lower incremental cost of high efficiecy products thus decreasing *e*.

Conclusion, Part 1

- A Moore's Law of Energy Efficiency is starting to provide some quantitative tools for understanding how policy might impact efficiency improvement rates
- Efficiency improvement is proportional to range of efficiencies in the market and the adoption/diffusion rate for new, more efficient products
- Range of efficiencies in the market is the relative range of prices (for efficient) products divided by elasticity of price with respect to efficiency
- Given a fixed incremental willingness to pay, the efficiency improvement rate is inversely proportional to the price elasticity with respect to efficiency

Conclusion, Part 2

- The parameters of the MLEE equation can potentially be monitored in real time
- Given real-time monitoring of markets, policy and program administrators can perform empirical policy/program experiments
- It is hoped that with such increased knowledge and transparency regarding which policies can impact efficiency improvement rates and how, that the SE4All goal of doubling the EE improvement rate can be achieved or exceeded