Welfare and Output with Taste Shocks and Income Effects

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Motivation

- How does welfare respond to changes in choice sets?

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- If demand stable and homothetic: can express welfare as chained (or Divisia) index.

- Foundation for aggregation procedures to calculate aggregate quantities and prices.

What We Do

- Consider demand that is unstable or non-homothetic.
- Characterize welfare change and Divisia in PE and GE in terms of suff. stats.
  - Divisia treats all expenditure-switching symmetrically (substitution, income, taste shocks), but welfare does not.
  - PE/GE distinction matters and interacts with preferences.
- Quantitative applications for long-run growth and fluctuations.

Selected Literature

- Biases of real consumption/GDP:
  Fisher & Shell (1968), Hausman (1981), Feenstra (1994), Basu et al. (2012), Aghion et al. (2019), Syverson (2017), Jones & Klenow (2016).
- Index numbers with taste shocks or non-homotheticity:
  Caves, Christensen, Diewert (1982), Balk (1989), Feenstra & Reinsdorf (2007), Redding & Weinstein (2020).
- Growth accounting and disaggregated macro:
  Solow (1951), Domar (1961), Hulten (1978), Long & Plosser (1983), Gabaix (2011), Acemoglu et al. (2012), Baqaee & Farhi (2019).
- Structural Transformation
  Baumol (1961), Kongsamut, Rebelo, Xie (2001), Buera & Kaboski (2009), Herrendorf et al. (2013), Boppart (2014), Comin et al. (2015), Alder et al. (2019).

Agenda

Microeconomic Problem

Macroeconomic Problem

Applications

Conclusion

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Set up

- Consider set $\{\succeq_x\}$ over vector of consumption goods c.
  (e.g. age, fads, advertising, state of nature)

- Represent preferences by $u(c; x)$ with indirect utility $v(p, \mathrm{I}; x)$.

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- Consider change from $(p_{t_0},\mathrm{I}_{t_0})$ to $(p_{t_1},\mathrm{I}_{t_1})$.

- Consider how welfare changes.

- Consider how (chained) real consumption changes.

- Compare the difference.

Micro Welfare and Real Consumption

Definition (Welfare)

Income needed under p_{t_0} to make $\succeq_{x_{t_1}}$ indifferent to $(p_{t_1}, \mathrm{I}_{t_1})$.

$$v(p_{t_0}, e^{\mathbf{EV^m}} I_{t_0}; x_{t_1}) = v(p_{t_1}, I_{t_1}; x_{t_1})$$

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Definition (Real consumption)

Change in real consumption is

$$\Delta \log Y = \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i \frac{p_{i,t} c_{i,t}}{\mathrm{I}_t} d \log p_{i,t}.$$

Change in real consumption versus welfare

Define $b(p, u, x)$ to be budget share given p, u, and x.

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$$\Delta \log Y = \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i b_i(p_t, u_t, x_t) d \log p_{i,t}.$$

$$EV^m = \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i b_i(p_t, u_{t_1}, x_{t_1}) d \log p_{i,t}.$$

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If preferences stable and homothetic, $b_i(p_t, u_t, x_t) = b_i(p_t, u_{t_1}, x_{t_1})$.

For welfare, treat price substitution $\neq$ income & taste shocks.

Key Intuition for Consumption vs. Welfare

$$\Delta \log Y = \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i b_i(p_t, u_t, x_t) d \log p_{i,t}.$$

$$EV^m = \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i b_i(p_t, u_{t_1}, x_{t_1}) d \log p_{i,t}.$$

- Consider change in welfare comparing 1950 to 2014.
- Spend more on healthcare in 2014 due to aging and income.
- Chained index uses 1950 demand to weight prices in 1950.
- Welfare-relevant uses 2014 demand to weight prices in 1950.

Implementation

- Consider e.g non-homothetic CES with taste shocks

$$e(p_t, u_t, x_t) = \left(\sum_i \omega_i x_{it} p_{it}^{1-\theta} u_t^{\xi_i} \right)^{\frac{1}{1-\theta}}$$

$\Delta \log u$ not good welfare measure (if non-homo. or unstable).

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$\Delta \log u$ not good welfare measure (if non-homo. or unstable).

- To measure welfare, integrate $b(p, u_{t_1}, x_{t_1})$:

$$EV^m = \Delta \log I + \log \left(\sum_i \bar{b}_{it_1} \left(\frac{p_{it_0}}{p_{it_1}} \right)^{1-\theta} \right)^{\frac{1}{1-\theta}} .$$

- If we know elasticity of substitution, we don't need to know income elasticities or taste shocks (or even separate them).

Consumption vs. Welfare: Second-order Approx.

Consider Taylor expansion in Δt:

$$\Delta \log Y \approx \underbrace{\Delta \log I - \mathbb{E}_b [\Delta \log p]}_{\text{First-order}}$$

,

$$EV^m \approx \Delta \log I - \mathbb{E}_b [\Delta \log p]$$

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quality change

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$$- \frac{1}{2}\underbrace{(\Delta \log I - \mathbb{E}_b[\Delta \log p])\,Cov_b(\varepsilon, \Delta \log p)}_{\text{income effect}} \quad ,$$

$$EV^m \approx \Delta \log I - \mathbb{E}_b[\Delta \log p] - \frac{1}{2}(1-\theta_0)\,Var_b(\Delta \log p)$$

$$-1 \times (\Delta \log I - \mathbb{E}_b[\Delta \log p])\,Cov_b(\varepsilon, \Delta \log p) \quad .$$

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No bias if covariances are zero. quality change

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Set up

- Perfectly competitive neoclassical economy, representative agent
- F primary factors, N goods

$$y_i = A_i G_i \left(\{m_{ij}\}_{j \in N}, \{l_{ij}\}_{j \in F} \right)$$

- Macro indirect utility is

$$V(A, L; x) = \max\{u(c; x) : c \text{ is feasible}\}.$$

- Consider changes in technologies from (A_{t_0}, L_{t_0}) to (A_{t_1}, L_{t_1}) and preferences from x_{t_0} to x_{t_1}.

Macro Welfare

To quantify welfare effect of changes in technologies, we ask:

Factors needed in t_0 to make $\succeq_{x_{t_1}}$ indifferent to t_1 technologies.

$$V(A_{t_0}, e^{\mathbf{EV^M}} L_{t_0}; x_{t_1}) = V(A_{t_1}, L_{t_1}; x_{t_1}).$$

- When preferences are stable + homothetic:
  - macro welfare is the same as micro welfare.
  - macro welfare is the same as "consumption equivalents;"

Intuition Why Macro Welfare $\neq$ Micro Welfare

- Suppose households age from t_0 to t_1, but technology unchanged.
- With DRS, relative price of healthcare higher in t_1.
- Micro welfare at falls from t_0 to t_1.
  A single old person likes prices in t_0 compared to t_1.
- Macro welfare does not change because technology unchanged.
  Society indifferent between technology in t_0 and t_1.
- Micro captures changes in technologies and demand, macro welfare captures only changes in technologies

Real GDP and Welfare

- Let $\lambda_i(A, u, x)$ be sales shares, $\frac{p_i y_i}{GDP}$, with demand $b(p, u, x)$.

Proposition

Change in real GDP and welfare in response to $(\Delta x, \Delta A)$ *is*

$$\Delta \log Y = \int_{t_0}^{t_1} \sum_i \lambda_i(A_t, u_t, x_t) d \log A_{i,t},$$

$$EV^M = \int_{t_0}^{t_1} \sum_i \lambda_i(A_t, u_{t_1}, x_{t_1}) d \log A_{i,t}.$$

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Define

$$\lambda^{ev}(A) \equiv \lambda(A, u_{t_1}, x_{t_1})$$

Implementation

- Consider non-homothetic CES consumer + CES producers.
- Observed sales:

$$\lambda_i d\log\lambda_i = \sum_{j\in\{0\}+N} \lambda_j(\theta_j - 1) Cov_{\Omega^{(j)}}\left(-d\log p, \Psi_{(i)}\right) + \underbrace{Cov_{\Omega^{(0)}}\left(d\log x, \Psi_{(i)}\right)}_{\text{taste shocks}} + \underbrace{Cov_{\Omega^{(0)}}(\varepsilon, \Psi_{(i)})\left(\sum_{k\in N}\lambda_k d\log A_k\right)}_{\text{income effects}}.$$

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- Welfare-relevant sales (starting at t_1 and going back to t_0)

$$\lambda_i^{ev} d\log\lambda_i^{ev} = \sum_{j\in\{0\}+N}\lambda_j^{ev}(\theta_j-1)Cov_{\Omega^{ev,(j)}}\left(-d\log p^{ev},\Psi_{(i)}^{ev}\right).$$

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- Real GDP uses $d\log\lambda_i$, welfare uses $d\log\lambda_i^{ev}$.

prices

Simple Examples

- One sector economy with no intermediates and one factor:

$$EV^M - \Delta \log Y \approx \frac{1}{2} \underbrace{Cov_b\left(\Delta \log x, \Delta \log A\right)}_{\text{bias due to taste shocks}} + \frac{1}{2} \underbrace{Cov_b\left(\varepsilon, \Delta \log A\right) \mathbb{E}_b[\Delta \log A]}_{\text{bias due to income effects}}.$$

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- With roundabout (larger changes in sales shares due to taste):

$$EV^M - \Delta \log Y \approx \frac{1}{2} \frac{1}{(1 - \Omega_{ii})} \left[Cov_b(\Delta \log x, \Delta \log A) + Cov_b\left(\varepsilon, \Delta \log A\right) \mathbb{E}_b[\Delta \log A] \right],$$

where Ω_{ii} is intermediate input share.

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Applications in Paper

- Structural transformation due to substitution effects has different welfare implications to income effects/taste shocks.

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  Welfare-relevant inflation is 0.5% higher than chained or SV.

  Taste shocks are positively correlated with price changes.

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  Taste shocks are positively correlated with price changes.

- During Covid-19 (correlated supply and demand shifters) large gaps between real GDP, macro welfare, and micro welfare.

Conclusion

- Toolbox for welfare computation. How to modify Divisia/Hulten for taste shocks and non homoth.
- Chaining doesn't correctly account for expenditure-switching caused by taste shocks or income effects.
- In these cases, distinct macro and micro notions of welfare.
- Characterize both and show gap with chained quantity significant when demand shifters covary with supply shifters.

Micro Welfare

$$v(p_{t_0}, e^{\mathbf{EV^m}} I_{t_0}; x_{t_1}) = v(p_{t_1}, I_{t_1}; x_{t_1}) \equiv u_{t_1}$$

Lemma

$$EV^m = \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i b_i(p_t, u_{t_1}, x_{t_1}) d \log p_{i,t}.$$

$$\begin{aligned} EV^m &= \log \frac{e(p_{t_0}, v(p_{t_1}, \mathrm{I}_{t_1}; x_{t_1}); x_{t_1})}{e(p_{t_0}, v(p_{t_0}, \mathrm{I}_{t_0}; x_{t_1}); x_{t_1})} = \log \frac{\mathrm{I}_{t_1}}{\mathrm{I}_{t_0}} \times \frac{e(p_{t_0}, u_{t_1}; x_{t_1})}{e(p_{t_1}, u_{t_1}; x_{t_1})} \\ &= \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i \frac{\partial \log e(p, v(p_{t_1}, \mathrm{I}_{t_1}; x_{t_1}); x_{t_1})}{\partial \log p_i} d \log p_i \\ &= \Delta \log \mathrm{I} - \int_{t_0}^{t_1} \sum_i b_i(p, u_{t_1}, x_{t_1}) \frac{d \log p_i}{dt} dt, \end{aligned}$$

An interpretation of welfare-relevant budget shares

- Difference between welfare and real consumption is $b_i^{ev} \neq b_i$.
- Fictitious consumer with expenditure function

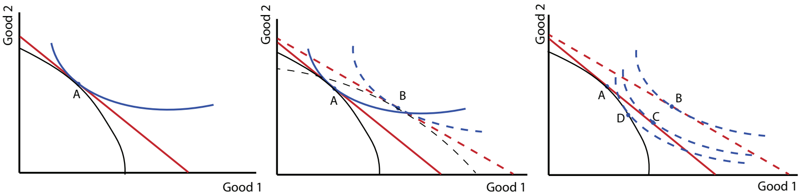
$$e^{ev}(p, u) = e(p, u_{t_1}, x_{t_1})u.$$

  Freeze final indifference curve and assume expansion path linear in income.
- Gives fictitious budget shares

$$b^{ev}(p, u) = b^{ev}(p).$$

- Real consumption for fictitious consumer equals welfare of original consumer!
- When homothetic and stable, $b_i^{ev} = b_i$.

Macro and micro welfare with nonlinear PPF



- When PPF is nonlinear, macro and microeconomic welfare question are not the same!

Application to Firm-Level Data

Proposition (Aggregation Bias)

For models with an industry structure,

$$\Delta \log EV^M \approx \Delta \log Y + \frac{1}{2}\sum_I b_I Cov_{b_{(I)}}(\Delta \log x_{(i)}, \Delta \log A_{(i)}) + \Theta,$$

The scalar Θ is the gap between real GDP and welfare in a version of the model with only industry-level shocks.

- Numerical example:
  $\sigma_A = 0.2, \sigma_x = 0.5, Corr(x, A) = 0.2.$
  $EV^M - \Delta \log Y \approx 1\%.$

  If shocks are persistent ρ: asymptotic bias $= \frac{\text{annual bias}}{1-\rho}$.

Changes in Prices

$$d \log p_i = -\sum_{j \in N} \Psi_{ij} d \log A_j + \sum_{f \in F} \Psi_{if}^F d \log \lambda_f.$$

and

$$d \log p_i^{ev} = -\sum_{j \in N} \Psi_{ij}^{ev} d \log A_j + \sum_{f \in F} \Psi_{if}^{ev,F} d \log \lambda_f^{ev}.$$

back

With Quality Change

Change in real consumption

$$\Delta \log Y \approx \Delta \log I - \mathbb{E}_b [\Delta \log \tilde{p}] - \frac{1}{2}(1-\theta_0) Var_b(d \log \tilde{p}) + \frac{1}{2}(1-\theta_0) Cov_b(d \log q, d \log \tilde{p}) - \frac{1}{2} Cov_b(d \log x, d \log \tilde{p}),$$

Change in welfare

$$EV^m \approx \Delta \log I - \mathbb{E}_b [\Delta \log \tilde{p} - \Delta \log q] - \frac{1}{2}(1-\theta_0) Var_b (\Delta \log \tilde{p}) - \frac{1}{2}(1-\theta_0) Var_b (\Delta \log q) + (1-\theta_0) Cov_b (\Delta \log \tilde{p}, \Delta \log q) - Cov_b (\Delta \log x, \Delta \log p),$$

Hence,

$$EV^m - \Delta \log Y \approx \underbrace{\mathbb{E}_b [\Delta \log q]}_{\text{average quality}} + \frac{1}{2} \underbrace{(\theta_0 - 1) Var_b (\Delta \log q)}_{\text{dispersion in quality}} + \frac{1}{2} \underbrace{(1-\theta_0) Cov_b (\Delta \log \tilde{p}, \Delta \log q)}_{\text{covariance of price and quality}} - \frac{1}{2} \underbrace{Cov_b (\Delta \log x, \Delta \log \tilde{p})}_{\text{covariance of taste and price}} + \underbrace{Cov_b (\Delta \log x, \Delta \log q)}_{\text{covariance of taste and quality}}.$$

back

Steady-state comparisons in dynamic model

- Intertemporal preferences

$$\mathscr{U}_t = \sum_{s=t}^{\infty} \beta^{s-t} u(C_s), \qquad \sum_i \omega_{i0} x_{it} \left(\frac{c_{is}}{C_s^{\xi_i}} \right)^{\frac{\theta_0 - 1}{\theta_0}} = 1$$

- Goods: $y_{is} = A_{is} G_i \left(\{m_{ijs}\}_{j \in N}, H(l_{is}, k_{is}) \right)$
- Investment: $I_s = A_{Is} I \left(\{m_{Ijs}\}_{j \in N}, H(l_{Is}, k_{Is}) \right)$.
- Capital accumulation $K_{s+1} = (1 - \delta)(K_s + I_s)$

Proposition

Consider two dynamic economies, denoted t_0 and t_1, that are in steady-state. The change in macro welfare is given by

$$EV^M = \log \left(\frac{\sum_i p_{it_1} c_{it_1}}{\sum_i p_{it_0} c_{it_0}} \right) + \log \left(\sum_i b_{it_1} \left(\frac{p_{it_0}}{p_{it_1}} \right)^{1-\theta_0} \right)^{\frac{1}{1-\theta_0}}.$$