

Labor Supply: Static and Dynamic

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Outline

- 1 Introduction
- 2 Static Labor Supply
- 3 Dynamic Labor Supply
- 4 Estimating Elasticities

Plan

- Simple static and dynamic labor supply models
 - recap for some
 - brings us to same page
 - illustrate numerical approach with closed form checks
- Keane (2011, sections 1–5)
 - same notation as him

Motivation: Labor supply Elasticities are Important!

Figure: Estimated Elasticities. Hicks, Men (Keane, 2011).

TABLE I
OPTIMAL TOP BRACKET TAX RATES FOR DIFFERENT LABOR SUPPLY ELASTICITIES

Labor supply elasticity (ϵ)	Optimal top-bracket tax rate (τ) = $1/(1+\alpha^*\epsilon)$		
	$\alpha = 1.50$	$\alpha = 1.67$	$\alpha = 2.0$
2.0	25%	23%	20%
1.0	40%	37%	33%
0.67	50%	47%	43%
0.5	57%	54%	50%
0.3	69%	67%	63%
0.2	77%	75%	71%
0.1	87%	86%	83%
0.0	100%	100%	100%

Note: These rates assume the government places essentially no value on giving extra income to the top earners.

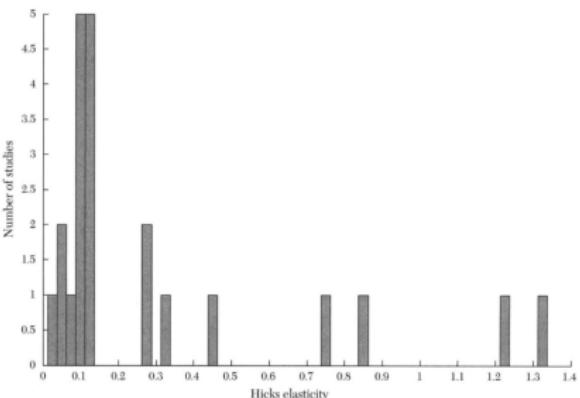


Figure 5. Distribution of Hicks Elasticity of Substitution Estimates

Note: The figure contains a frequency distribution of the twenty-two estimates of the Hicks elasticity of substitution discussed in this survey.

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Static Setup

- Individuals maximize utility wrt. consumption and hours worked

$$\max_{C,h} U(C, h) = \frac{C^{1+\eta}}{1+\eta} - \beta \frac{h^{1+\gamma}}{1+\gamma}$$

where

- $\eta \leq 0$ is the CRRA coefficient
- $\gamma \geq 0$ is curvature in hours

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- subject to the budget constraint

$$C = (1 - \tau)wh + N$$

where

- τ is the (flat) marginal tax rate
- w is the hourly wage rate
- N is non-labor income

Static Solution

- Insert budget constraint

$$\max_h \frac{((1 - \tau)wh + N)^{1+\eta}}{1 + \eta} - \beta \frac{h^{1+\gamma}}{1 + \gamma}$$

- First order condition (FOC)

$$\begin{aligned}\frac{\partial U}{\partial h} &= (1 - \tau)w((1 - \tau)wh + N)^\eta - \beta h^\gamma \\ &= 0\end{aligned}$$

such that the MRS is

$$(1 - \tau)w = \frac{\beta h^\gamma}{((1 - \tau)wh + N)^\eta} \quad (1)$$

Static Elasticities

- **No analytic solution** for optimal hours, $h^*(w, N)$.
We can solve numerically!
- **Elasticities** can be derived analytically (see extra slides)!
Can compare with numerical!

Static Elasticities

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We can solve numerically!
- **Elasticities** can be derived analytically (see extra slides)!
Can compare with numerical!
- **Slutsky equation:**

$$\frac{\partial h}{\partial w} = \left. \frac{\partial h}{\partial w} \right|_u + h \frac{\partial h}{\partial N}$$

- **In elasticities** (% change from 1% change)

$$\frac{w}{h} \frac{\partial h}{\partial w} = \left. \frac{w}{h} \frac{\partial h}{\partial w} \right|_u + \frac{wh}{N} \frac{h}{h} \frac{\partial h}{\partial N}$$
$$\underbrace{e_M}_{\text{marshall}} = \underbrace{e_H}_{\text{hicks}} + \underbrace{\frac{wh}{N} e_I}_{\text{income effect}}$$

Static Elasticities

- Letting $S = \frac{(1-\tau)wh}{(1-\tau)wh+N}$, we have (see extra slides)

$$e_M = \frac{\partial \log h}{\partial \log w} = \frac{1 + \eta S}{\gamma - \eta S}$$

$$e_H = \left. \frac{\partial \log h}{\partial \log w} \right|_u = \frac{1}{\gamma - \eta S}$$

$$ie = \frac{\eta S}{\gamma - \eta S} < 0$$

- Since $\eta \leq 0$:

$$e_H > e_M$$

that is, “ignoring income effects gives a larger response”.

Static Elasticities

- **Numerical “check”** of these results

Simple setup

Shows how to do it

Can check results

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1. **Solve** optimal labor supply, $h^*(w, N)$
2. **Simulate baseline** labor supply for $w \rightarrow h_i(w, N)$
3. **Simulate alternative** with 1% higher wage $\rightarrow h_i(w(1 + 0.01), N)$
4. **Calculate** average pct change,

$$\frac{1}{n} \sum_{i=1}^n \frac{h_i(w(1 + 0.01), N) - h_i(w, N)}{h_i(w, N)} \times 100$$

- **Q:** Which of the elasticities should this equal?

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 - Perfect foresight + deterministic
 - Exogenous wages, w_1 and w_2
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- 2-period model with **saving/borrowing**
 - Perfect foresight + deterministic
 - Exogenous wages, w_1 and w_2
 - Same per-period utility as before
- Discounted utility is

$$U = U_1(C_1, h_1) + \rho U_2(C_2, h_2)$$

where

$$C_1 = (1 - \tau)w_1 h_1 + N_1 + b$$

$$C_2 = (1 - \tau)w_2 h_2 + N_2 - b(1 + r)$$

and $b = -[(1 - \tau)w_1 h_1 + N_1 - C_1]$ is borrowing.

Dynamic Labor Supply

- We find optimal h_1 , h_2 and b by maximizing utility
- First order conditions (FOCs)

$$\frac{\partial U}{\partial h_1} = [(1 - \tau)w_1 h_1 + N_1 + b]^\eta w_1 (1 - \tau) - \beta h_1^\gamma = 0 \quad (2)$$

$$\frac{\partial U}{\partial h_2} = [(1 - \tau)w_2 h_2 + N_2 - b(1 + r)]^\eta w_2 (1 - \tau) - \beta h_2^\gamma = 0 \quad (3)$$

$$\begin{aligned} \frac{\partial U}{\partial b} &= [(1 - \tau)w_1 h_1 + N_1 + b]^\eta \\ &- \rho[(1 - \tau)w_2 h_2 + N_2 - b(1 + r)]^\eta (1 + r) = 0 \end{aligned} \quad (4)$$

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- Again, no closed-form solution for optimal labor supply
- We can find elasticities
 - and simulate them!
 - e_H and e_M basically the same as in static case
(because no human capital)

Frisch Elasticity

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Elasticity of intertemporal substitution

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$$e_F \equiv \left. \frac{\partial \log h_t}{\partial \log w_t} \right|_{\lambda_t}$$

where

λ_t : marginal utility of wealth

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- λ_t potentially depends on all state variables, such as wages.
- In our setting (see extra slide)

$$e_F = \frac{1}{\gamma}$$

Summary: Elasticities

- **Combining**, we have

$$e_F > e_H > e_M$$

in this model.

- **Frisch:** Can be simulated as an anticipated *transitory* increase in wage (income and wealth effects are small and assumed negligible)
- **Marshall:** Can be simulated as a unanticipated *permanent* increase in wage
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 - We can then bound the efficiency loss from labor income taxation.
 - And bound the optimal tax rate (see table from beginning).

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- **Next time:** If there is learning by doing (human capital accumulation) this relationship/result might not hold due to downward bias in e_F !

Solving the 2-period model

- **Backwards induction.**
- **Last period:** What is the state variable?

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$$V_2(b) = \max_{C_2, h_2} U_2(C_2, h_2)$$

s.t.

$$C_2 = (1 - \tau)w_2 h_2 + N_2 - (1 + r)b > 0$$

such that for a grid of \vec{b} we solve for

$$h_2^*(b) = \arg \max_{h_2} U_2((1 - \tau)w_2 h_2 + N_2 - (1 + r)b, h_2)$$

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- **First period:**

$$V_1 = \max_{C_1, h_1} U_1(C_1, h_1) + \rho V_2(b)$$

s.t.

$$b = -[(1 - \tau)w_1 h_1 + N_1 - C_1]$$

Life-Cycle Model

- T periods, a_t is savings. No uncertainty (for now)
- Bellman Equation

$$V_t(a_t) = \max_{C_t, h_t} U(C_t, h_t) + \rho V_{t+1}(a_{t+1})$$

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$$a_{t+1} = (1+r)(a_t + (1-\tau_t)w_t h_t - C_t)$$

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- **Exogenous wages:**
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- **Endogenous wages** (through human capital, as next time):

$$w_t = w(1 + \alpha k_t)$$

$$k_{t+1} = k_t + h_t$$

- Human capital, k_t , is a new state variable
- Elasticities are different
- In general no simple formula
- *Can always simulate!*

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Estimating Elasticities

- **Regressions** often like (pioneered by MaCurdy, 1981)

$$\log h_{it} = \alpha + e \log(w_{it}(1 - \tau_t)) + \beta_I N_{it} + \varepsilon_{it}$$

- Controlling for non-labor income, $N \rightarrow e$ is **Marshall** elasticity.

Estimating Elasticities

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- Our **models can illuminate** potential problems (Keane, 2011, sec 4)
 1. Endogeneity of wages: tastes for work
 2. Endogeneity of wages: simultaneity
 3. Endogeneity of taxes (non-linear)
 4. Measurement error (downward bias)
 5. Wages only observed for workers (selection)
 6. Savings and non-labor earnings
 7. Human capital and other dynamics (next time)

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 6. Savings and non-labor earnings
 7. Human capital and other dynamics (next time)
- Structural estimation can handle most of these

Estimated Elasticities: Men

TABLE 6
SUMMARY OF ELASTICITY ESTIMATES FOR MALES

Authors of study	Year	Marshall	Hicks	Frisch
<i>Static models</i>				
Kosters	1969	-0.09	0.05	
Ashenfelter-Heckman	1973	-0.16	0.11	
Boskin	1973	-0.07	0.10	
Hall	1973	n/a	0.45	
Eight British studies*	1976-83	-0.16	0.13	
Eight NIT studies*	1977-84	0.03	0.13	
Burtless-Hausman	1978	0.00	0.07-0.13	
Wales-Woodland	1979	0.14	0.84	
Hausman	1981	0.00	0.74	
Blomquist	1983	0.08	0.11	
Blomquist-Hansson-Busewitz	1990	0.12	0.13	
MacCurdy-Green-Paarsch	1990	0.00	0.07	
Triest	1990	0.05	0.05	
Van Soest-Woittiez-Kapteyn	1990	0.19	0.28	
Ecklof-Sacklen	2000	0.05	0.27	
Blomquist-Ecklof-Newey	2001	0.08	0.09	
<i>Dynamic models</i>				
MacCurdy	1981	0.08 ^b		0.15
MacCurdy	1983	0.70	1.22	6.25
Browning-Deaton-Irish	1985			0.09
Blundell-Walker	1986	-0.07	0.02	0.03
Altonji ^c	1986	-0.24	0.11	0.17
Altonji ^d	1986			0.31
Altug-Miller	1990			0.14
Angrist	1991			0.63
Ziliak-Kniesner	1999	0.12	0.13	0.16
Pistaferri	2003	0.51 ^b		0.70
Imai-Keane	2004	0.40 ^e	1.32 ^e	0.30-2.75 ^f
Ziliak-Kniesner	2005	-0.47	0.33	0.54
Aaronson-French	2009			0.16-0.61
Average		0.06	0.31	0.85

Notes: Where ranges are reported, mid-point is used to take means.

* = Average of the studies surveyed by Pencavel (1986).

^b = Effect of surprise permanent wage increase.

Estimated Elasticities, Women.

- Women have been viewed as more “complex”

Literature started later

When dynamic models was used more

TABLE 7
SUMMARY OF ELASTICITY ESTIMATES FOR WOMEN

Authors of study	Year	Marshall	Hicks	Frisch	Uncompensated (dynamic)	Tax response
<i>Static, life-cycle and life-cycle consistent models</i>						
Cogan	1981	0.89 ^a				
Heckman-MaCurdy	1982			2.35		
Blundell-Walker	1986	-0.20	0.01	0.03		
Blundell-Duncan-Meghir	1998	0.17	0.20			
Kimmel-Kniesner	1998			3.05 ^b		
Moffitt	1984				1.25	
<i>Dynamic structural models</i>						
Eckstein-Wolpin	1989				5.0	
Van der Klauuw	1996				3.6	
Francesconi	2002				5.6	
Keane-Wolpin	2010				2.8	
<i>Difference-in-difference methods</i>						
Eissa	1995, 1996a				0.77–1.60 ^b	

Notes:

^a = Elasticity conditional on positive work hours.

^b = Sum of elasticities on extensive and intensive margins.

Next Time

- **Next time:**
 - Dynamic labor supply with learning by doing
 - Human capital accumulation from working
 - (Uncertainty?)
- **Literature:**
 - Keane (2016): “Life-Cycle Labour Supply with Human Capital: Econometric and Behavioural Implications”
 - **Read** before lecture
 - **Reading guide:**
 - Section 0: Introduction
 - Section 1: Dynamic model. *Key section, main focus.*
 - Section 2: Simulations of 2-period model. skim/drop.
 - Section 3: Quantitative role of HC. Read fast, *focus on 3.2.*
 - Section 4: Comparison with extensive margin. Read if time

References I

- KEANE, M. P. (2011): "Labor Supply and Taxes: A Survey," *Journal of Economic Literature*, 49(4), 961–1075.
- (2016): "Life-cycle Labour Supply with Human Capital: Econometric and Behavioural Implications," *The Economic Journal*, 126(592), 546–577.
- MACURDY, T. E. (1981): "An Empirical Model of Labor Supply in a Life-Cycle Setting," *Journal of political Economy*, 89(6), 1059–1085.

Finding elasticities in static model

- Taking logs of eq. (1):

$$\underbrace{\log(1 - \tau) + \log(w)}_{\text{LHS}} = \underbrace{\log(\beta) + \gamma \log(h) - \eta \log((1 - \tau)wh + N)}_{\text{RHS}} \quad (5)$$

- Derivative wrt. $\log w$ gives (while keeping N fixed)

$$\frac{\partial \text{RHS}}{\partial \log w} = \gamma \underbrace{\frac{\partial \log h}{\partial \log w}}_{e_M} - \eta \left(\underbrace{\frac{\partial \log(\bullet)}{\partial w} \frac{\partial w}{\partial \log w}}_w + \underbrace{\frac{\partial \log(\bullet)}{\partial h} \frac{\partial h}{\partial \log h} \frac{\partial \log h}{\partial \log w}}_{h e_M} \right)$$

where $\log(\bullet) = \log((1 - \tau)wh + N)$.

Marshall

- Letting $S = \frac{(1-\tau)wh}{(1-\tau)wh+N}$, we have that

$$\frac{\partial \text{RHS}}{\partial \log w} = \gamma e_M - \eta(S + Se_M)$$
$$\frac{\partial \text{LHS}}{\partial \log w} = 1$$

such that

$$1 = \gamma e_M - \eta(S + Se_M)$$
$$\Updownarrow$$
$$e_M = \frac{1 + \eta S}{\gamma - \eta S}$$

Income effect

- Similarly, the income elasticity is

$$\begin{aligned} e_I &= \frac{\partial \log h}{\partial \log N} \\ &= \frac{\eta(1-S)}{\gamma - \eta S} \end{aligned}$$

- Found similarly, using that $1 - S = \frac{N}{(1-\tau)wh+N}$.
- The income effect is then

$$\begin{aligned} ie &= \frac{wh(1-\tau)}{N} e_I \\ &= \frac{\eta S}{\gamma - \eta S} \end{aligned}$$

where

$$ie < 0$$

because $\eta \leq 0$.

Hicks

- The Hicks, or “compensated” elasticity is

$$\begin{aligned}e_H &= \frac{\partial \log h}{\partial \log w} \Big|_u \\&= e_M - ie \\&= \frac{1 + \eta S}{\gamma - \eta S} - \frac{\eta S}{\gamma - \eta S} \\&= \frac{1}{\gamma - \eta S}\end{aligned}$$

using the Slutsky equation.

- We have

$$e_H \geq e_M$$

Frisch Elasticity

- Deriving the Frisch via. the Lagrangian

$$\begin{aligned} \max_{h_1, h_2, C_1, C_2, b} & U + \lambda_1[(1 - \tau)w_1 h_1 + N_1 + b - C_1] \\ & + \lambda_2[(1 - \tau)w_2 h_2 + N_2 - b(1 + r) - C_2] \end{aligned}$$

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- FOC for hours in period 1

$$\frac{\partial U}{\partial h_1} = -\beta h_1^\gamma + \lambda_1(1 - \tau)w_1 = 0$$

such that

$$\log h_1 = \frac{1}{\gamma} \log(\lambda_1) + \frac{1}{\gamma} \log((1 - \tau)w_1) - \frac{1}{\gamma} \log(\beta)$$

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such that

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- and the partial derivative (fixed λ_1)

$$e_F = \left. \frac{\partial \log h_1}{\partial \log w_1} \right|_{\lambda_1} = \frac{1}{\gamma}.$$