SIMPLE DSGE MODELS OF "WORK"

MARCH 21, 2017

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- Aguiar and Hurst's (2007 QJE) and Aguiar, Hurst, and Karabarbounis (2013 *AER*) time-use classifications
- Are other uses of time important for macro issues?
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- Rogerson (1988 *JME*) and Hansen (1985 *JME*) issue:
  - Can "indivisibility" in labor (i.e., binary individual labor/leisure outcome) be tractably modeled?
  - **ANSWER: YES** – through "randomization" over WHO actually works

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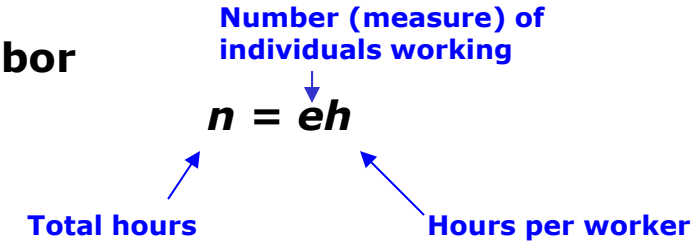
  - **ANSWER: YES** – through "randomization" over WHO actually works
  - **Market structure:** complete Arrow securities in the cross section of agents, to insure away chance of not working
  - **Aggregation result:** representative-agent preferences quasi-linear in labor

Labor Aggregation – Main Results

- **Total equilibrium labor**



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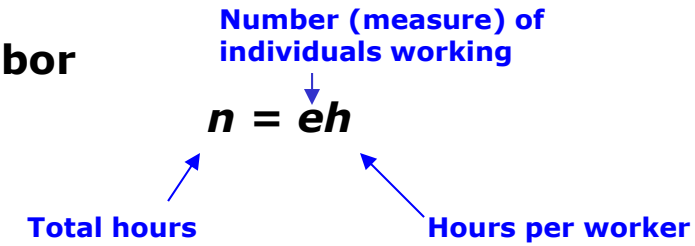

- **Normalize $h = 1$ for employed individuals (so $n = e$)**
- **Suppose non-convexity**
  - **Measure e of individuals work $h = 1$ hours**
  - **Measure $1-e$ of individuals work $h = 0$ hours**
  - **An INDIVIDUAL'S decision problem is NOT convex**
    - **Must choose {0, 1} (work/don't work)**

Terminology:

Indivisible labor (work zero hours or fixed hours)

No intensive margin

LABOR AGGREGATION – MAIN RESULTS

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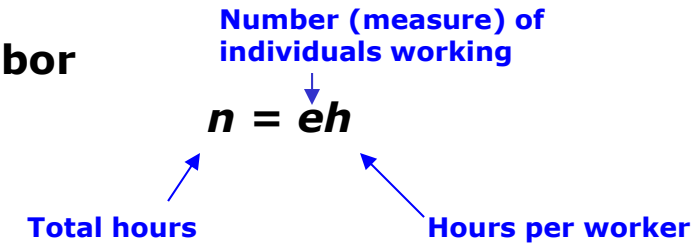

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- **Economy populated by individuals each with** $u(c) + \begin{cases} v(1-n=0) & \text{if work} \\ v(1-n=1) & \text{if don't work} \end{cases}$

equivalent (in terms of aggregate outcomes) to a representative-agent economy with quasi-linear preferences

$$u(c) - An$$

LABOR AGGREGATION – MAIN RESULTS

- **Theoretical attraction: makes "low substitution" (of labor across time periods) economy at the micro level a "high substitution" (of labor across time periods) economy at the macro level**
  - **Which helps make aggregate hours more volatile over time in a DSGE model – can illustrate with two-period model**

- **Interpretation(s)**
  - **Underlying market structure: individuals choose "lotteries" over possibility of being employed, rather than whether or not to work**
  - **Insurance: individuals can (and do) purchase (actuarially fair) full insurance against employment risk**
  - **"Risk-neutrality": representative consumer "doesn't care" how many hours worked in a given period – because of full risk sharing**

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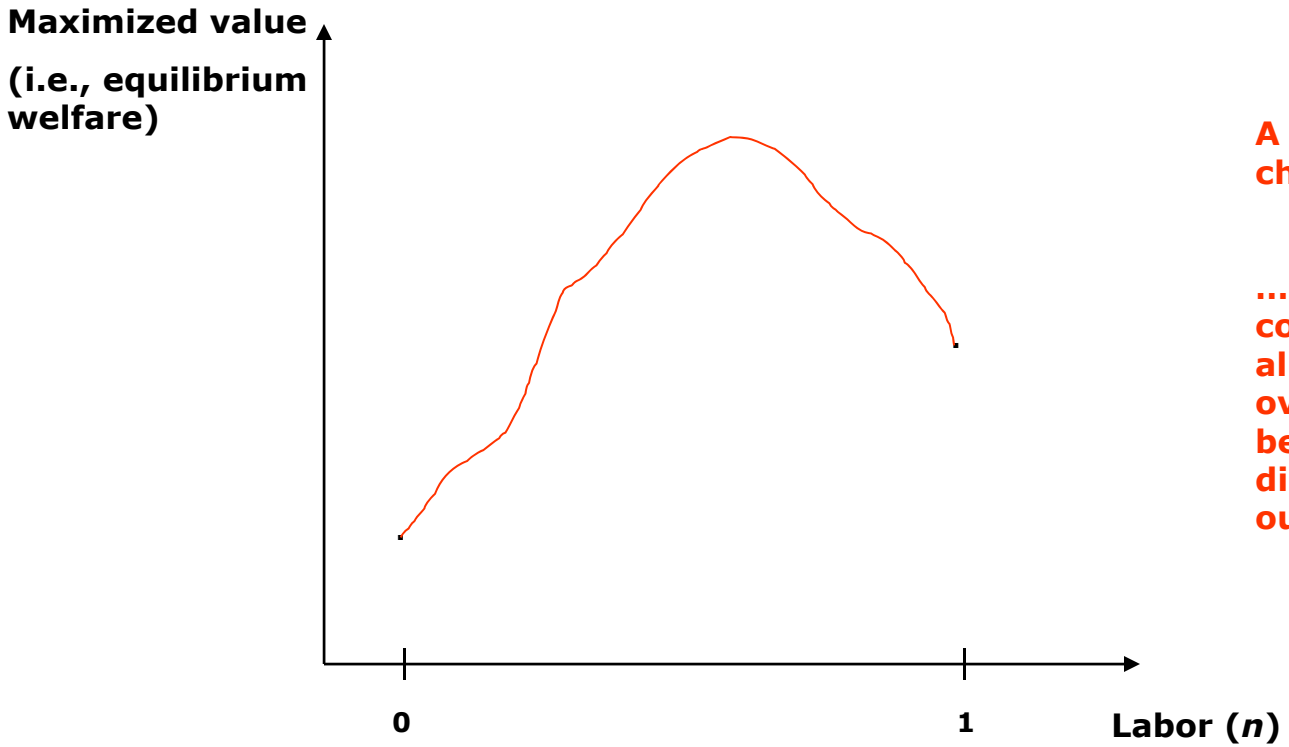
- **Gain in DSGE model performance?**
- **Intuitive plausibility?**
- **Empirical relevance?**

THE SIMPLE MICROECONOMICS



A non-convex choice set…

…can be made convex by allowing choice over lotteries between the discrete outcomes

Introduce lotteries by allowing individuals to purchase insurance (i.e., complete AD assets) against the risk of being unemployed

THE SIMPLE MICROECONOMICS

- **Consider simple static problem**

$$\max_{c_1, c_2, y} e\left[u(c_1) + v(1 - n = 0)\right] + (1 - e)\left[u(c_2) + v(1 - n = 1)\right]$$

Expected utility

subject to

$$c_1 + py = w$$

State 1: work (probability *e*)

$$c_2 + py = y$$

State 2: don't work (probability 1-*e*)

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$$n = e$$

Subject to exogenous randomness

Utility in principle depends on *n*, so would like to optimize on *n*…

…but *n* is trivially exogenous at the optimal choice!

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Probability *e* of working

Equivalently, measure *e* of individuals work

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- **Insurance**
  - **Quantity *y* purchased by consumer**
  - **(Competitive) price *p***
  - **Only pays off (*y* units) in the event the consumer doesn't work**

- **FOCs yield** $u'(c_1) = \lambda_1$ **and** $u'(c_2) = \lambda_2$
  along with $-\lambda_1 ep - \lambda_2 (1-e) p + \lambda_2 (1-e) = 0$

- **Conjecture** $\lambda = \lambda_1 = \lambda_2 \rightarrow \quad c = c_1 = c_2$

THE SIMPLE MICROECONOMICS

- **Perfectly competitive representative insurance firm**

$$\max_{y} py - (1-e)y$$

→ *p* = (1-*e*)

Actuarially fair: competitive price of one unit of insurance that pays off in the event "don't work" = probability of event

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- **Theorem: Risk-averse consumer + actuarially fair insurance contract → consumer will choose to fully insure against loss (*y* = *w* in this case) (See, e.g., Varian (1992) text)**

→ Consumer's TOTAL INCOME/WEALTH (including any insurance payoff) not a function of his employment status

$$\therefore \lambda = \lambda_1 = \lambda_2 \quad \rightarrow \quad c = c_1 = c_2$$ **Verifies conjecture**

A consequence of complete markets:
consumption equated across states
(intratemporal consumption smoothing)

THE SIMPLE MICROECONOMICS

- **Perfect competition in output production → $w = f'(E)$**

- **Labor-market clearing** $E = \int_0^1 h(i)di$
  - **Recall either $h = 0$ or $h = 1$**

***Aggregate* labor hired by firm**

- **Equilibrium: $E = e$ and resource constraint $c = f(e)$**

Use equilibrium results to construct equivalent alternative problem that yields same aggregates

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In particular, use *n* = *e*

$$\max_{c,n} n\left[u(c)+v(0)\right]+(1-n)\left[u(c)+v(1)\right]$$

$$\text{s.t. } nc+(1-n)c+npy+(1-n)py = nw+(1-n)y$$

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aka, complete set of Arrow assets

$y = w$ (fully insure) **$p = 1 - e$ (= 1 – n) (competitive insurance price)**

$$\max_{c,n} u(c)+nv(0)+(1-n)v(1)$$

$$\text{s.t. } c = wn$$

THE SIMPLE MICROECONOMICS

$$\max_{c,n} u(c) + \left[v(0) - v(1)\right] n + v(1)$$
$$\text{s.t. } c = wn$$

Drop $v(1)$ because constant

Define $A = v(1) - v(0)$ (simply a constant)

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Quasi-linear utility:

"risk-neutral" in labor *because* of full insurance

- **Equilibrium: $w = f'(E)$, $E = n$, and $c = f(n)$**
- **Rogerson (Propositions 1 and 2)**
  - **Aggregates (c, n) in this economy identical to those from the indivisible labor economy with lotteries/full insurance**
  - **An application of perfect risk sharing / representative consumer results**

AGGREGATION – RISK NEUTRALITY

$$\max_{c,n} u(c) + \left[v(0) - v(1)\right] n + v(1)$$
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  - **An application of perfect risk sharing / representative consumer results**
  - **If embedded in dynamic model (Hansen 1985), individuals do not care (i.e., are risk neutral with respect to) whether they work more in the present or the future**

BUSINESS CYCLE IMPLICATIONS

- Embed quasi-linear preferences into standard RBC model
- Approximate and simulate
  - Hansen uses LQ (linear-quadratic) approximation

- Hansen results

Table 1

Standard deviations in percent (a) and correlations with output (b) for U.S. and artificial economies.

	Quarterly U.S. time series[a] (55.3–84.1)		Economy with divisible labor[b]		Economy with indivisible labor[b]	
Series	(a)	(b)	(a)	(b)	(a)	(b)
Output	1.76	1.00	1.35 (0.16)	1.00 (0.00)	1.76 (0.21)	1.00 (0.00)
Consumption	1.29	0.85	0.42 (0.06)	0.89 (0.03)	0.51 (0.08)	0.87 (0.04)
Investment	8.60	0.92	4.24 (0.51)	0.99 (0.00)	5.71 (0.70)	0.99 (0.00)
Capital stock	0.63	0.04	0.36 (0.07)	0.06 (0.07)	0.47 (0.10)	0.05 (0.07)
Hours	1.66	0.76	0.70 (0.08)	0.98 (0.01)	1.35 (0.16)	0.98 (0.01)
Productivity	1.18	0.42	0.68 (0.08)	0.98 (0.01)	0.50 (0.07)	0.87 (0.03)

The main successes claimed: in particular, RATIO of S.D. much higher than basic RBC model; but, at 2.7, TOO high

THE VERDICT?

"This description of the employment allocation mechanism strains credibility and is at odds with the micro evidence on individual employment histories."

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Lotteries model predicts an individual's employment status is *iid* over time.

Micro evidence shows it is highly persistent over time.

"Rogerson's aggregation result is every bit as important as the one giving rise to the aggregate production function."

Prescott (2004 *Nobel Lecture* p. 385)

- **"[Not so fast….]"**

Mulligan (2001 *B.E. Journal of Macroeconomics*)

SIMPLE DSGE MODELS OF "WORK" PART II

MARCH 21, 2017

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Both Extensive and Intensive Adjustment

- A major challenge for DGE modeling: elasticity of "labor supply"
  - Intensive margin ("hours supply")
  - Extensive margin ("labor force participation")

- Cho and Cooley (1994)
  - Study RBC economy with both margins operative
  - Extensive margin: "number of days" worked within a period
    - Household pays a cost for each "day" it chooses to work
  - Intensive margin: hours worked per day worked
  - NOTE: No "frictions" in finding jobs

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- Percent of total hours fluctuations accounted for by extensive fluctuations vs. intensive fluctuations
  - Cho and Cooley (1994): 75% extensive, 25% intensive
  - Hansen (1985): 55% extensive (rest from cov term)

STATIC EXAMPLE

- **General utility function** $u(c)-\frac{a}{1+\gamma}h^{1+\gamma}e-\psi(e)e$ — **$\psi(e)$ is fixed cost**

intensive **extensive**

Description of Economy	$\psi(e)$	Elasticity of equilibrium total hours
Both intensive and extensive margins		
Only extensive margin (Hansen-Rogerson)		
Only intensive margin ("typical" RBC model)		

- ***e* denotes "employment rate" – fraction of days worked**
- ***h* denotes hours worked per day**

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intensive **extensive**

Description of Economy	$\psi(e)$	Elasticity of equilibrium total hours
Both intensive and extensive margins	$= (b/(1+\tau))e^{\tau}$	
Only extensive margin (Hansen-Rogerson)	$= b$	
Only intensive margin ("typical" RBC model)	= 0 (also fix $e = 1$)	

- ***e* denotes "employment rate" – fraction of days worked**
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Description of Economy	$\psi(e)$	Elasticity of equilibrium total hours
Both intensive and extensive margins	$= (b/(1+\tau))e^{\tau}$	Intermediate
Only extensive margin (Hansen-Rogerson)	$= b$	High
Only intensive margin ("typical" RBC model)	= 0 (also fix $e = 1$)	Low

- ***e* denotes "employment rate" – fraction of days worked**
- ***h* denotes hours worked per day**

STATIC EXAMPLE

- **Consumer optimization**

$$\max_{c,h,e} u(c) - \frac{a}{1+\gamma} h^{1+\gamma} e - \frac{b}{1+\tau} e^{1+\tau}$$

$$\text{s.t } c \leq whe$$

- **Combine with firm optimization and market clearing**
- **Examining EQUILIBRIUM aggregate hours ("effective L^S")**
  - **Not "labor supply" ("notional L^S")**

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- **Combine with firm optimization and market clearing**
- **Examining EQUILIBRIUM aggregate hours ("effective L^S")**
  - **Not "labor supply" ("notional L^S")**
- **Impose parameter values to capture three different cases**
- **Elasticity equilibrium total hours**
  - **Adjustment only at extensive margin: 4**
  - **Adjustment only at intensive margin: 0.36**
  - **Adjustment at both margins: 1.29**
  - **Recall common compromise value in macro models: ≥ 1**

Business Cycle Implications

- Embed in standard RBC model
- Approximate and simulate
  - Cho and Cooley use LQ (linear-quadratic) approximation
- Cho and Cooley results

Table 2

Calibration results, first parameterization.[a]

Series	U.S.		Model	
	Std. dev.	Corr. with output	Std. dev.	Corr. with output
Output	1.76	1.00	1.76 (0.17)	1.00 (0.00)
Consumption	1.29	0.85	0.53 (0.06)	0.88 (2.49)
Investment	8.60	0.92	5.63 (0.57)	0.98 (0.40)
Capital stock	0.63	0.04	0.47 (0.08)	0.07 (6.73)
Aggregate hours	1.74	0.77	1.06 (0.12)	0.98 (0.56)
Hours	0.46	0.76	0.25 (0.02)	0.98 (1.24)
Employment	1.50	0.81	0.81 (0.08)	0.98 (1.04)
Productivity	1.18	0.35	0.75 (0.08)	0.96 (0.81)
Agg. hrs/Productivity				
in physical units		1.47		1.42
in efficiency units		1.42		1.42

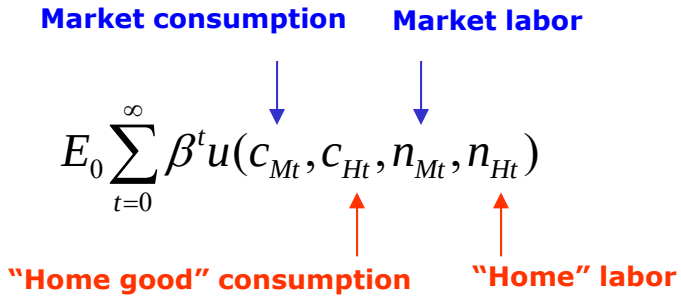
Both intensive and extensive adjustment: 1.06/0.75 = 1.42

HOME PRODUCTION MODELS

- What else do individuals/households do with their time?
  - Aguiar and Hurst (2007 *QJE*) and Aguiar, Hurst, and Karabarbounis (2013 *AER*): over 2 hours per day of nonmarket work (i.e., nonmarket LABOR)
    - Shopping
    - Cooking
    - Cleaning
    - Etc…
- "Household capital" expenditures also sizable
  - Investment in consumer durables and residential investment at least as large as investment in market capital
- "Home production" in RBC model
  - Overview by Greenwood, Rogerson, and Wright (1995)
  - Allow households to accumulate "home capital" and "work" at home (cleaning, cooking, etc.) in order to produce and consume "home goods" (distinct from "market goods")

Basic Home Production Model

- **Preferences**



Basic Home Production Model

- **Preferences**

Market consumption Market labor

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_{Mt}, c_{Ht}, n_{Mt}, n_{Ht})$$

"Home good" consumption "Home" labor

- **Technology**

Market productivity

$$f(n_{Mt}, k_{Mt}, z_{Mt}) \left(= k_{Mt}^{\alpha} (z_{Mt} n_{Mt})^{1-\alpha} \right)$$

Market production function

Market/business capital

$$g(n_{Ht}, k_{Ht}, z_{Ht}) \left(= k_{Ht}^{\gamma} (z_{Ht} n_{Ht})^{1-\gamma} \right)$$

"Home" production function

- Home output can ONLY be used for consumption

"Home" capital

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- **Household Budget Constraint**

$$c_{Mt} + \left[k_{Mt+1} - (1-\delta_M) k_{Mt} \right] + \left[k_{Ht+1} - (1-\delta_H) k_{Ht} \right] = w_t n_{Mt} + r_t k_{Mt}$$

  - Unit relative price between market capital and home capital
  - All income earned through market-factor rental
  - Home consumption not "purchased" – produced at home!

BASIC HOME PRODUCTION MODEL

- **Other model details**
  - **(Constant) labor income and capital income taxation included (for calibration purposes)**
  - **Capital freely-allocatable every period between home and market/business uses**

$$k_t = k_{Mt} + k_{Ht} \quad \forall t$$

  - **Representative (market) firm:** $\max_{n_{Mt}, k_{Mt}} f(n_{Mt}, k_{Mt}, z_{Mt}) - w_t n_{Mt} - r_t k_{Mt}$
  - **See Greenwood, Rogerson, and Wright (1995) for calibration issues**

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  - **Capital freely-allocatable every period between home and market/business uses**

$$k_t = k_{Mt} + k_{Ht} \quad \forall t$$

  - **Representative (market) firm:** $\max_{n_{Mt}, k_{Mt}} f(n_{Mt}, k_{Mt}, z_{Mt}) - w_t n_{Mt} - r_t k_{Mt}$
  - **See Greenwood, Rogerson, and Wright (1995) for calibration issues**

- **Business cycle implications**
  - **Approximate and simulate using "usual" methods**
  - **Main Results**
    - **SD(hours)/SD(productivity) matches data better than basic RBC**
    - **Corr(hours, real wage) matches data (≈ 0) better than basic RBC**
    - **Results rely on ability to substitute between c_{Mt} and c_{Ht} and incentive to do so**

Governed by correlation between z_{Mt} and z_{Ht}

Governed by CES elasticity over c_{Mt} and c_{Ht}

RBC Models and Labor Market Fluctuations

- **Can interpret as micro-foundation for Greenwood-Hercowitz-Huffman (1988) preferences (GHH preferences)**

$$u(c_t, n_t) = \ln\left(c_t - \frac{\psi}{1+\nu} n_t^{1+\nu}\right)$$

  - **Zero income effect on market hours n_t**
  - **Seems inconsistent with balanced-growth facts…**
  - **…unless z_M and z_H are growing at the same long-run rates, in which case there is no reason to substitute between home and mrkt work**

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- **Can interpret as micro-foundation for a preference shifter**

$$u(c_t, n_t) = \ln c_t - \frac{a_t}{1+\nu} n_t^{1+\nu}$$

Exogenous, time-varying process affects (shifts) MRS between consumption and leisure – a mechanism emphasized by Hall (1997)

  - **Change in (endogenous) home outcomes → shift in individual's labor supply schedule in a "reduced-form" model with preference shock**

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  - **Jaimovich and Rebelo (2009 *AER*) modification of GHH**

$$u(c_t, n_t) = \ln\left(c_t - x_t \cdot \frac{\psi}{1+\nu} n_t^{1+\nu}\right)$$

$$x_t = c_t^{\omega} \cdot x_{t-1}^{1-\omega}$$

parameter ω governs how quickly n responds to TFP shock

As $\omega \to 0$, GHH preferences

If $\omega = 1$, KPR preferences

RBC Models and Labor Market Fluctuations

- Standard model (intensive adjustment)
- Indivisible labor model (extensive adjustment)
- Home production model
- Alternative preference specifications
- Consequences of government spending fluctuations
- Overview by Hansen and Wright (1992 *Minneapolis Fed Review*)
- Labor search and matching