Technological Progress and Economic Transformation

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1 Introduction

1.1 Life in the USA, 1800

- Home – 95 % lived in rural areas
  - No running water
  - No central heating
  - No electricity

- Work week
  - 70 hours
    * Men in the fields
    * Women in homes
• Family

  – 7 kids

    * < 7 years of school

    * Worked at home and in the fields

THE CATALYSTS

– Technological Progress in the Market

– Technological Progress in the Home
1.2 Technological Progress in the Market, 1800-2000

- TFP in non-agriculture up 9.25×

- TFP in agriculture up 7.5×
  - 1830 – 250-300 hours to grow 100 bushels of wheat
  - 1890 – 40-50 hours with horse-drawn machine
  - 1930 – 15-20 hours with a tractor
  - 1975 – 3-4 hours with a combine

- Wages up 10×
1.3 Technological Progress in the Home, 1900-2000

- Influx of labor-saving household appliances and products.
  - Pre-electrification – 38 lb. load of laundry
    * Washing – 4 hrs
      - Effort – 3,181 feet
    * Ironing – 4.5 hrs
      - Effort – 3,122 feet
  - Post-electrification, 1945
    * Washing – 41 mins.
      - Effort – 332 feet
    * Ironing – 1.55 hrs.
      - Effort – 333 feet
1.4 The Result, Economic Transformation

● Fertility
  – 1800 – 7 kids per woman
  – 2000 – 2 kids per women

● Labor Force
  – 1800 – 74% in agriculture
  – 2000 – 2.6% in agriculture

● Female Labor-Force Participation
  – 1900
  * 5% of married females worked
  * 58 hours a week on housework
- 1980
  * 50% of married females worked
  * 18 hours a week on housework

- Child Labor
  * 1870 – 13% of children worked
  * 1930 – 4.7%

• Education
  
  - High school education
    * 1870 – 16%
    
    * 1970 – 76%
1.5  Goal

- To show that all of these facts can be explained, both

  *qualitatively*

  and

  *quantitatively,*

  within the context of *standard growth theory.*
2 Fertility

Technological Progress in the Market and Fertility
2.1 Model

- Overlapping generations model
  - Two period-lived agents
  - Small open economy; i.e., fixed interest rate
  - Young
    * Work – one unit of time
    * Choose fertility, $n^y$

- Tastes
  \[
  \phi \ln(c^y + c) + \beta \phi \ln(c^o) + (1 + \beta)(1 - \phi) \ln n^y
  \]
  \[
  c = \text{constant level of household production}
  \]
• Income

  – Market wage, \( w \)
  
  – Gross interest rate, \( r \)

• Cost of children

  \[
  \text{consumption cost} = \frac{\text{wage}}{w} \times \left( \frac{ny}{x} \right)^{1/(1-\gamma)},
  \]

  \( x = \text{productivity in household production (child care)}. \)

### 2.2 Choice Problem

\[
\max_{c^y, c^o, n_y} \left\{ \phi \ln(c^y + c) + \beta \phi \ln(c^o) + (1 + \beta)(1 - \phi) \ln n^y \right\},
\]

subject to

\[
c^y + \frac{c^o}{r} = w - w\left(\frac{ny}{x}\right)^{1/(1-\gamma)}.
\]


2.3 Theoretical Results

- Solution

\[ n^y = \left[ \frac{A}{1 + \beta + A} \right]^{1-\gamma} x \left( 1 + \frac{c}{w} \right)^{1-\gamma}, \]

where

\[ A \equiv \frac{(1 + \beta)(1 - \gamma)(1 - \phi)}{\phi}. \]

**Lemma 1** Fertility, \( n^y \):

1. decreases with market wages, \( w \),

2. increases with technological advance in the home sector, \( x \).
2.4 Equilibrium

- Market Production

\[ o = z k^\alpha l^{1-\alpha}, \]

- Wages

\[ w = (1 - \alpha)^{\alpha/(1-\alpha)} z^{1/(1-\alpha)} r^{-\alpha/(1-\alpha)}. \]
2.5 Example 1 (Fertility, 1800 and 1940)

1. Tastes: $\beta = 0.94^{20}$, $\phi = 0.47$, $c = 2.97$.

2. Technology $\alpha = 0.33$, $\gamma = 0.33$, $r = 1/\beta$

3. Year 1800

   (a) TFP – Normalize $x = z = 1.0$.

   (b) Get

   $$n^y = 3.5 \text{ (Fertility per parent in 1800)}$$

4. Year 1940

   (a) Market TFP – $z = 3.2$

   (b) Home TFP – set $x = 1$

   (c) Get

   $$n^y = 1.2 \text{ (Fertility per parent in 1940, 1.1)}$$
2.6 Example 2 (Fertility, 1960 and 2000)

1. Year 1960 – Baby Boom

   (a) Market TFP – \( z = 4.9 \)

   (b) Home TFP – set \( x = 1.8 \)

   (c) Get

   \( n^y = 1.8 \) (Fertility per parent in 1960, 1.8)

2. Year 2000 – Baby Bust

   (a) Market TFP – \( z = 7.4 \)

   (b) Home TFP – set \( x = 1.8 \)

   (c) Get

   \( n^y = 1.5 \) (Fertility per parent in 2000, 1.0)
3 Extension – Decline of Agriculture

The Decline in Agriculture and the Rise in Skilled Labor
4 Model

- Two changes
  - Two sectors
    * Agriculture – uses unskilled labor
    * Manufacturing used skilled labor
  - Parents care about quality in addition to quantity of kids
    * \( h = \) human capital level \(- h \in [0, 1] \)
    * \( w = \) unskilled wage
    * \( v = \) skilled wage
    * \( \tau = \) cost of birthing a kid as a fraction of income
    * \( \phi = \) cost of educating a kid as a fraction of income
• Tastes

\[ \psi \ln(c^y) + \beta \psi \ln(c^o) + \underbrace{(1 + \beta)\chi \ln n^y + (1 + \beta)\chi \ln [w'(1 - h') + v'h']}_{\text{Quality}} \]

• Technology

  – Agriculture

  \[ o^u = xu^\sigma / \sigma \]

  * \( x = \text{TFP in agriculture} \)

  * \( u = \text{unskilled labor} \)
• Manufacturing

\[ o^s = z s^\sigma / \sigma \]

\* \( z \) = TFP in manufacturing

\* \( s \) = skilled labor

### 4.1 Choice Problem

\[
\max_{c^y, c^o, h', n^y} \{ \psi \ln(c^y) + \beta \psi \ln(c^o) + (1 + \beta) \chi \ln n^y + (1 + \beta) \chi \ln[w'(1 - h') + v'h'] \}
\]

subject to

\[
c^y + \frac{c^o}{r} = (1 - \tau n^y - \phi n^y h')[(1 - h)w + hv + \pi].
\]
4.2 Theoretical Results

Lemma 2 As TFP in manufacturing, $z$, rises relative to agriculture, $x$:

1. human capital, $h$, increases

2. and fertility, $n$, falls.
5 Female Labor-Force Participation

MECHANIZATION TAKES COMMAND

- Mechanization of household tasks began in the middle of the 1800’s.
  - Inventions were mechanical in nature.
  - Success had to wait until the arrival of electricity.
    - Automated washing machine arrived in the 1930s.
    - Refrigerators, 1920s.
    - Frozen foods, 1930s.

- Scientific management – studied domestic task with aim of improving their efficiency.
  - Kitchen, circa 1800’s.
* Large table.

* Isolated dresser.

- Kitchen, circa 1930s.
  * Continuous working services.
  * Built in cabinets.

- Kitchen, circa 1940s.
  * Connected with dining room.
  * Standardized built in appliances.

- Christine Frederick, “Didn’t I with hundred of women stoop unnecessarily over kitchen tables, sinks, and ironing boards, as well as bricklayers stoop over bricks.”

- Bricklayer
  * Old Methods, 120 bricks per hour
* New Methods, 350 bricks per hour
  
  · Adjustable table – no stooping
  
  · Bricks delivered right side up, no turning
  
  · Mortar with right hand, brick with left hand

  – Dishwashing – 3 operations
  
  * scraping and stacking, washing, and drying and putting away

  * computed correct height for countertops

  * drainboard on the left, host to rinse on the right.

* 45 minutes down to 30 minutes.
Kitchen, circa 1900. A kitchen before the home economics revolution spawned by women such as Christine Frederick. Source: Giedion (1948) *Mechanization takes Command.*
Maytag washing machine, circa 1911–butter churn at the back. The automated washing machine was still some years ahead. Source: Lee Maxwell Washing Machine Museum.
Technological Progress in the Home and Female Labor-Force Participation
Daily Housework in Middletown
(Percentage of married housewives in each category)

<table>
<thead>
<tr>
<th>Year</th>
<th>≥ 4 hours</th>
<th>2 to 3 hours</th>
<th>≤ 1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1924</td>
<td>87</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>1977</td>
<td>43</td>
<td>45</td>
<td>12</td>
</tr>
<tr>
<td>1999</td>
<td>14</td>
<td>53</td>
<td>33</td>
</tr>
</tbody>
</table>

Source: Caplow, Hicks and Wattenberg (2001, p. 37)
5.1 Model

- Two types of goods
  - Market Goods, \( c \)
  - Non-Market or Home Goods, \( n \)

- Tastes
  \[
  \mu \ln c^y + (1 - \mu) \ln n^y + \beta \mu \ln c^o + \beta (1 - \mu) \ln n^o
  \]

- Household Production Technology
  \[
  n = \left[ \theta \delta^\kappa + (1 - \theta) h^\kappa \right]^{1/\kappa}, \text{ for } \kappa \leq 1
  \]
  - \( \delta \) = Stock of household capital, lumpy
  - \( h \) = Housework
  - \( q \) = Price of capital – measured in time
  - \( \kappa \) = Degree of substitutability between time and capital
5.2 Choice Problem

\[ U(w, r, \delta, q) = \max_{c^y, h^y, c^o} \{ \mu \ln c^y + (1 - \mu) \ln n^y + \beta \mu \ln c^o + \beta (1 - \mu) \ln n^o \} \]

subject to

\[ c^y + \frac{c^o}{r} = w(1 - h^y) - wq, \]

\[ n^y = \left[ \theta \delta^\kappa + (1 - \theta)(h^y)^\kappa \right]^{1/\kappa}, \]

\[ n^o = \left[ \theta \delta^\kappa + (1 - \theta) \right]^{1/\kappa} \]

- Degree of Substitutability in Household Production
  
  - \( \kappa > 0 \) – \( \delta \) and \( h \) are Edgeworth-Pareto **Substitutes** in Utility
  
  - \( \kappa < 0 \) – Edgeworth-Pareto **Complements** in Utility
5.3 Theoretical Results

Lemma 3

1. An increase in the market wage rate, $w$, will have no effect on housework, $h$

2. An increase in the stock of household capital, $\delta$, will
   (a) cause $h$ to decline when $\kappa > 0$,
   (b) cause $h$ to increase when $\kappa < 0$,
   (c) have no effect on $h$ when $\kappa = 0$. 
5.4 Example 3 (Female Labor-Force Participation, 1900 and 1980)

1. Tastes, $\beta = 0.94^{20}$,

2. Technology, $\theta = 0.33$, $\kappa = 0.5$, $q = 0$.

3. Year 1900

   (a) $\text{FLP} = 5$ percent

   $$1 - h = \frac{\text{male}}{\text{40}} \frac{\text{couple}}{\text{224}} = 0.18$$

   (b) Household capital in 1900 is negligible; i.e., set $\delta = 0$.

   (c) Set $\mu = 0.145$. 
(d) Get

\[ 1 - h = 0.18. \]

4. **Year 1980**

(a) FLP = 50 percent

\[ 1 - h = \frac{40 + .5 \times 40}{224} = 0.27 \]

(b) Set \( \delta = 1.14 \)

(c) Get

\[ 1 - h = 0.27 \]
5.5 Technology Adoption Decision

- New Technology
  - Capital services, $\delta^1$
  - Price, $q^1$

- Old Technology
  - Capital services, $\delta^2 < \delta^1$ (Less capital)
  - Price, $q^2 < q^1$ (Lower price)

- Decision

Adopt new if $U(w, r, \delta^1, q^1) > U(w, r, \delta^2, q^2)$,
Adopt old if $U(w, r, \delta^1, q^1) < U(w, r, \delta^2, q^2)$,
Adopt either if $U(w, r, \delta^1, q^1) = U(w, r, \delta^2, q^2)$. 
5.5.1 Theoretical Result

Lemma 4 \( \kappa > 0 \) then

\[
U(w, r, \delta^1, q^1) > U(w, r, \delta^2, q^2) \ (\text{adopt})
\]

implies that

\( h \) declines.
5.6 Extension – Nondurable Household Products and Services

- Year 1900
  - 92 percent of baked goods made at home
  - 1/2 ton of bread made at home a year
  - 96 percent of vegetables were unprocessed

- Year 1965
  - 22 percent of baked goods were made at home
  - 30 percent of vegetables were unprocessed
Time-Saving Products

1. 1810 – tin can

2. 1880 – toilet paper & 1909 paper towels

3. 1909 – instant coffee

4. 1930 – frozen food

5. 1947 – tupperware

6. 1949 – cake mix

7. 1954 – MacDonalds

8. 1961 – disposable diaper – Pampers
9. 1965 – microwave oven

10. 1971 – food processor
• Tastes

\[ \mu \ln c + (1 - \mu) \ln n, \]

• Home production technology

\[ n = [\theta \sum_{i}^{N} (d_i)^{\kappa} + (1 - \theta) h^{\kappa}]^{1/\kappa}, \text{ for } \kappa \leq 1, \]

- \(d_i\) = purchases of the \(i\)-th household product
- \(p_i\) = price of the \(i\)-th household product
- \(N\) = number of household products
5.7 Theoretical Results

Lemma 5 An expansion in the number of household products and services, $N$, will cause

1. house work, $h$, to decrease

2. market work, $1 - h$, to increase.

Lemma 6 A decline in the time price of the $i$-th household product, $p_i/w$, will cause

1. housework, $h$, to decline when $\kappa > 0$,

2. housework, $h$, to increase when $\kappa < 0$,

3. have no effect on housework, $h$, when $\kappa = 0$. 
Elizabeth Cady Stanton

“Is it, then, consistent to hold the developed woman of this day within the same narrow political limits as the dame with the spinning wheel and knitting needle occupied in the past? No, no! Machinery has taken the labors of woman as well as man on its tireless shoulders; the loom and the spinning wheel are but dreams of the past; the pen, the brush, the easel, the chisel, have taken their places, while the hopes and ambitions of women are essentially changed.”

Source: "Solitude of Self," Address before the Congressional Judiciary Committee, January 18, 1892