# Schumpeterian Growth Theory and the Dynamics of Income Inequality by Philippe Aghion

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# Main Ideas

Aghion (2002) attempts to model

- endogenous technical change with quality improving innovation (Aghion and Howitt 1992) with
- wage dynamics

to study two important puzzles of wage inequality in developed countries.

# The two puzzles

1. The ratio of the "college equivalents" workers to the "noncollege equivalents" was 2.35 % in average between 1940 and 1970 and increased to 3.05 % in average between 1970 and 1995. The ratio of the average weekly wages of college to high school students was falling by 0.11 % per year in 1940-1970 and rose by 25 % in 1970-1995.
   The supply for skilled workers increased while the wage premium for skilled labor increased as well.
2. Within groups wage inequality increased during the 80's, no matter how narrowly we define the groups. Why is that?

# Possible explanations of puzzle 1

- Trade Liberalization (Heckscher-Ohlin): In developed countries, the demand for skilled labor increases and the demand for unskilled decreases, as skilled labor is relatively cheaper and unskilled relatively expensive.
  However, Krugman: US trade with non-OECD countries is less than 2 per cent of the GDP.
- Deunionization
  However, timing puzzle: In UK wage inequality increased before deunionization.

# Possible explanations of puzzle 1-more

- Skill-biased technical change increases the relative demand for skilled labor.
  Note: Acemoglu (2000) finds that the productivity of the skilled labor increased from 0.157 in 1980 to 0.470 in 1990, and the rate of increase is higher after 1980 than before.

# Possible explanations of puzzle 1-more

In line with the skill-biased technical change there are two answers to the puzzle:

1. Katz and Murphy (1992): The 80's increase of the college premium is the result of two effects:
   - skill biased technical change was taking place for 50 years, and
   - the temporary fall in the college premium because of the baby-boom increase in college workers supply in the beggining of the 70's.
2. Krusell, Ohanian, Rios-Rull and Violante (2000), find evidence that the skilled biased technical change accelerated sice the 70's, and this can support the rise in the college premium.

# Possible explanations of puzzle 1-more

Aghion considers this explanation and attempts to give an answer to the first puzzle in two ways:

- The Market Size Explanation: Aghion combines the Schumpeterian growth model with the labor supply changes to get an answer consistent with the empirical evidence.
- The Nonlinear Diffusion Explanation: Then he combines the Schumpeterian growth model with the idea of a major technological change and the assumption that there is nonlinear diffusion of such a change among the firms, to get again consistent results.

# Outline

# The Market Size Explanation

- The final good is produced with two intermediate goods:

$$y = x_S + x_U$$

- which are produced by employing skilled or unskilled labor $l_j$ :

$$x_S = A_S \cdot l_S^a$$

and

$$x_U = A_U \cdot l_U^a$$

where a in (0,1), $A_j$ is the productivity of a specialized machine used by worker i, who produces intermediary good $x_j$.

# The Market Size Explanation- more

- Only one firm knows how to make an innovation. It innovates in sector U or S, by making R&D in that sector. Thus the monopoly rents increase in that sector and we assume that can be extracted for only one period.
- Assume

$$A_{j,t} = A_{j,t-1} \cdot n_{j,t}^{\beta}$$

where $A_{j,t-1}$ denotes the leading-edge productivity in sector j at $t-1$, $n_{j,t}$ is the R&D investment in sector j and $0 < \beta < 1$.

# The Market Size Explanation- more

- The firm chooses employment level $l_{j,t}$ in order to maximize profits

$$l_{j,t} = \left(\frac{w_{j,t}}{A_{j,t} \cdot a}\right)^{\frac{1}{a-1}}$$

- In equilibrium the firm should be indifferent between investing in sector U or S, which gives the no-arbitrage-condition

$$\frac{x_{U,t}}{x_{S,t}} = \frac{n_{U,t}}{n_{S,t}}$$

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- Define as $k = \frac{A_{S,t}}{A_{U,t}}$ , $\omega_t = \frac{w_{S,t}}{w_{U,t}}$ and let $l_U = u$ and $l_S = s$.

# The Market Size Explanation- more

Then:

- $$\omega_t = k_t \cdot (\frac{u}{s})^{1-a}$$

and

- $$k_t^{1-\beta} = k_{t-1} \cdot (\frac{s}{u})^{a\beta}$$

- So if the relative labor supply of skilled workers $\frac{s}{u}$ increases then we have two opposite effects: the skill premium $\omega$ decreases and the relative productivity k increases, which in turn increases the skill premium.
- Then the wage premium decreased in the early 70's as the relative skilled workers supply increased at the late 60's, and then, at the end of the 70's the premium increased reflecting the increase in relative productivity.

# The Market Size Explanation- Problems

- Historical Evidence: Increase in skill labor supply was not always followed by these effects.
- Jones (1995) finds a productivity slowdown in mid 70's.

# The Nonlinear Diffusion Explanation

Some ideas:

- There is a General Purpose Technology, which requires extra skilled labor.
- This GPT takes a lot of time to diffused in the economy.
- The highest amount of skilled labor is required at the stage of acceleration in the diffusion of GPT. At that stage we expect the wage premium to increase, despite the fact that skilled labor supply continues to increase.
- Acceleration occurs because at the beginning of the GPT, individual researchers innovate, with no much coordination and available "templates". Later, when enough firms have used GPT there is going to be a point where even more firms will want to use GPT, learning from the experience of the already GPT users.

# The Nonlinear Diffusion Explanation-more

- The final output y is produced using x(i) according to:

$$y = (\int_0^1 A(i)^a \cdot x(i)^a di)^{\frac{1}{a}}$$

- $A(i) = 1$ in sectors where the old GPT is used and $A(i) = \gamma > 1$ in sectors where the new GPT is used after successful innovation.
- Labor Supply:

$$L_s(t) = L - (1 - s) \cdot L \cdot e^{-\beta t}$$

where $s < 1$ is the initial fraction of skilled labor and $\beta > 0$ measures the speed of skill accumulation.

# The Nonlinear Diffusion Explanation-more

- Assume that to acquire GPT two stages are required: First the experimentation-templates stage - $n_1$
  and then the final acquisition stage - $n_2$.
  So, $n_0 = 1 - n_1 - n_2$ is the fraction of sectors that has not been in any GPT stage yet.
- Let $\lambda(n_2)$ be the Poisson arrival rate of templates which follows a logistic distribution, to capture the nonlinear diffusion.

# The Nonlinear Diffusion Explanation-more

- After the templates come, the firms have to use at least H skilled labor in R&D and experimenting.
- The final stage of using GPT comes with an arrival rate $\lambda_1$.
- $$n_1 = \lambda(n_2) \cdot (1 - n_1 - n_2) - \lambda_1 n_1$$

  and

  $$n_2 = \lambda_1 n_1$$

# The Nonlinear Diffusion Explanation-Conclusions

- Aghion finds that $n_2$ first increases in an increasing rate and then slows down as it approaches 1, with the maximum growth rate in the middle. Also, $n_1$ peaks in the middle.
- When GPT first comes, very few sectors use it and a small amount of skilled labor is required. Much of the skilled labor is working in the sectors without GPT, who pay skilled and unskilled the same. However, as more sectors use GPT, more skilled workers are in sectors with GPT and get paid more.
- The skill premium increases when diffusion accelerates.

# The Nonlinear Diffusion Explanation-Conclusions

- This explanation can be consistent with the historical evidence as an increase in skilled labor supply might not come when the diffusion of GPT accelerates.
- Productivity slowdown might be happening during acceleration, as a lot of resources for restructuring and adjusting the economy and the society.

# Within Group Inequality

- New GPT is coming but only a random fraction of workers adapts it.
- If next period a worker adapts and she had also adapted at the previous period, then she gets a premium in her wage. The distance between the knowledge she has and the knowledge the new technology requires is smaller for such a worker.

# Within Group Inequality-more

- The new technology embodies in machines to produce final output. The machines last for two periods.
- The leading edge technology produces according to:

$$y_t = A_t \cdot x_{0,t}^{1-a}$$

where $x_{0,t}$ is the labor input working with technology t.

- The old technology is:

$$z_t = A_{t-1} \cdot ((1+\eta)x_{1,t})^{1-a}$$

where $x_{1,t}$ is the labor input working with technology $t-1$, and $\eta$ is the premium for learning by doing.

# Within Group Inequality-more

Some assumptions:

- Only a random fraction $\sigma$ of workers can move to the leading edge technology at once.
- A worker who is at the leading edge twice in the row is considered to be supplying $(1 + \tau)$ units of labor, otherwise she supplies one unit of labor, with $\tau < \eta$.

# Within Group Inequality-more

- Each new technology is more productive:

$$A_t = (1+\gamma)A_{t-1}$$

- Labor Demand turns out to be:

$$\frac{\omega_0}{\omega_1} = \frac{1+\gamma}{(1+\eta)^{1-a}} \cdot \left(\frac{x_0}{x_1}\right)^{-a}$$

# Within Group Inequality-more

- Labor Supply is more complicated and it gives three possible results.
- Depending on the solution we pick for the labor supply, we find the equilibrium relative wages. In all cases, we can define a measure of inequality consistent with all three results, the maximum distance between the two wages.

# Within Group Inequality-Conclusions

- The within group wage inequality decreases with $\sigma$ and increases with $\gamma$, the rate of technological progress and with $\tau$, the transferability of knowledge by adaptive workers.
- The empirical evidence shows that both the rate of embodied technical change and the skill transferability has increased since the the mid-70's.

# Conclusions

Three models of Schumpeterian growth are considered which solve two puzzles in modern labor markets:

- Between groups income inequality, and
- Within groups income inequality.

The idea of GPT and the way they diffuse into the economy play and important role in understanding the first one, as at the acceleration stage, demand for skilled labor increases, and inequality increases.
On the other hand, the increase in the diffusion of GPT increases the rate at which new technologies improve productivity and also the skills transferability, increasing within group inequality.