Artificial Intelligence, The Collapse of the Middle Class, and Oligarchiy

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September 11, 2024

Introduction

- Historically, automation thought to be skilled-biased.
- More recently, it has been observed that artificial intelligence may also substitute for skilled workers.
    - "Good news"?
        - Reduced inequality
        - Higher GDP/Growth
- Automation favors capital at the expense of (both skilled and unskilled) labor.
    - Lower GDP labor share
    - But capital is accumulable
    - And people benefit from greater returns to capital over life cycle.

A bleaker scenario

- Automation may trigger a general economic collapse
  - workers harmed
  - (many) capitalists harmed
- Consumer society disappears for lack of a large enough middle class
- Obtained in a world with nonhomothetic preferences and increasing returns
  - based on Saint-Paul (2023); which builds on Murphy et al. (1991).
- Key assumption: artificial intelligence replaces skilled workers
  - middle class disappears
  - popular demand for "necessities" only
  - other goods only consumed by capitalists

Policy responses

- Oligarchs have all the political power
- But they vanish if nobody purchases their products
- Would they voluntarily implement redistribution so as to maintain their consumer base?
  - Universal basic income (UBI)
- Would they voluntarily block AI so as to maintain a critical mass of skilled middle class consumers?
  - Post-Fordism (PF)
- These are the issues addressed in this paper

Model: Preferences

- Hierarchy of needs as in Saint-Paul (2023)
- Goods are indexed by j and ordered from $j = 0$ to $j = +\infty$.
- One consumes one unit of each good, starting from the lower ranked goods.
- Consumers indexed by $i \in [0, 1]$, density $f(i)$.
- Endowed with l units of labor, price 1
- Consume n goods and acquire skill s,price ω
- Utility

$$U(n, s, i) \equiv n - c(i, s),$$

- $c()$ such that s grows with i

Consumer behavior

- Lump-sum transfer $z(i)$ from government, financed by profit tax τ
  - Hence, $y = z + l + \omega s$
  - Cost of consuming n goods

$$P(n) = \int_0^n p(j)dj.$$

- An agent with income y
  - consumes

$$n(y) = P^{-1}(y).$$

  - supplies

$$s(\omega, z, i) = \arg\max_s n(z + l + \omega s) - c(i, s).$$

- Aggregate skilled supply

$$S(\omega) = \int_0^1 \int_z s(\omega, z, i) f(i) g(z \mid i) dz di.$$

Technology

- Old technology: unit raw labor requirement c_O
- New technology:
  - which uses $c_N < c_O$ raw labor per unit
  - m skilled labor.fixed overhead cost
- For each good j, a unique oligarch ownd the modern CRTS technology

Pricing

- Since good is inframarginal for most consumers, price elasticity of demand close to zero
- Monopolist drives price up to competitive fringe, i.e. $p = c_O$.
- Competition ensures that $p = c_O$ if modern technology not in use
- Consequently,

$$p(j) = c_O, P(n) = c_O n,$$

and

$$s(\omega, i) = \arg\max_s \omega s / c_O - c(i, s). \tag{1}$$

The role of AI

- Overhead skilled workers replaced with software
- This can only be done by the oligarch who owns the modern technology.
- Not possible for an entrant
  - $\rightarrow$No barrier to entry motivation to block AI

Equilibrium without AI

- A consumer consumes good j if and only if $z + l + \omega s(\omega, i) \geq c_O j$.
- Given ccdf $G(. \mid i)$ of z, demand for good j :

$$x(\omega, j) = \int_0^1 (1 - G(c_O j - l - \omega s(\omega, i)))f(i)di.$$

- Modern technology used for good j iff

$$\pi(\omega, j) = x(\omega, j)(c_O - c_N) - \omega m \geq 0.$$

  - Critical industrialized good $j^*(\omega)$

$$j^*(\omega) = \inf\{j, \pi(\omega, j) \leq 0\}$$

- Equiibrum in the market for skills:

$$mj^*(\omega) = S(\omega). \tag{2}$$

- Government budget constraint

$$\tau \int_0^{j^*(\omega)} \pi(\omega, j)dj = \int_0^1 \int_z zf(i)g(z \mid i)dzdi.$$

Political decisions

- Only oligarchs have power
- Rules out pure appropriation motives for UBI, and pure luddite motives for blocking IA
- Research question: is it in the interest of oligarchs to preserve the middle class?
  - Henry Ford versus Panem and circenses
- Two paradigms:
  - Decisive oligarch (median voter)
  - Lobbying (menu auctions)

AI+UBI

- Demand for skills falls to zero: $\omega = 0$.
- All workers have income $l + z$,
- All the goods consumed by the workers are industrialized.
  - They have full market share:

$$j^* = \frac{l + z}{c_O} \tag{3}$$

- Profit of firm such $j \leq j^*$

$$\tilde{\pi}_j = (c_O - c_N)(1 - \tau).$$

- The budget constraint of the government is

$$\tau(c_O - c_N)j^* = z.$$

Solution

$$z = \frac{\tau(c_O - c_N)}{c_O(1-\tau) + \tau c_N} I, \tag{4}$$

$$j^* = \frac{I}{c_O(1-\tau) + \tau c_N}. \tag{5}$$

- "multiplier"

$$\frac{dz}{d\tau} = \frac{\partial z}{\partial \tau} + \frac{\partial z}{\partial j^*}\frac{dj^*}{d\tau} = (c_O - c_N)j^* + \tau(c_O - c_N)^2 \frac{I}{(c_O(1-\tau) + \tau c_N)^2}.$$

- Additional transfer income triggers further industrialization

The decisive oligarch's choice

- DO picks τ subject to GBC and fiscal capacity constraint, $\tau \leq \bar{\tau}$
- Optimal to be the last industrial sector, $j^* = j$
- Hence

$$\tau_j = \min(\max(\frac{c_O}{c_O - c_N} - \frac{I}{j(c_O - c_N)}, 0), \bar{\tau}).$$

- Clearly, tax rate is increasing in j

Computing profits

- $\tau_j = 0$ for $j < I/c_O$.
  - If $j_d < I/c_O$, then
    - $\tau = 0$
    - AI not blocked
- On the other hand, if

$$j > \frac{I}{\bar{\tau} c_N + c_O(1 - \bar{\tau})} = j_A^+(\bar{\tau}),$$

  decisive oligarch disappears even at $\tau = \bar{\tau}$
- Profits if $j_d \leq j_A^+$:

$$\pi_A(j_d) = \min(\frac{I}{j_d} - c_N, c_O - c_N).$$

The PF economy: The two-skill case

- Two skill levels, 0 and b, with cost
$$c(i,b) = \gamma i^{-\frac{1}{\sigma}}.$$
- Agent i becomes skilled iff
$$b\omega / n_O \geq \gamma i^{-\frac{1}{\sigma}}, \Longleftrightarrow i \geq \left(\frac{\gamma c_O}{b\omega}\right)^{\sigma} = h\omega^{-\sigma}.$$
- Agents types are uniformly distributed $f(i) \equiv 1$.
    - Therefore
$$S(\omega) = b(1 - h\omega^{-\sigma}). \tag{6}$$
- Two income classes:
    - Unskilled, mass $h\omega^{-\sigma}$, earn l, consume the first l/c_O goods.
    - Skilled, mass $1 - h\omega^{-\sigma}$, earn $l + b\omega$, and consume the first $(l + b\omega)/c_O$ goods.
- All goods beyond $j = (l + b\omega)/c_O$ are only consumed by an infinitesimal amount of oligarchs
    - Produced using old technology

Equilibria

- Type 1: $j^* < I/c_O$, $\pi_j = 0$, $\forall j$
- Type 2: $j^* = I/c_O$, $\pi_j = 0$, $\forall j > I/c_O$
- Type 3: $I/c_O < j^* < (I + b\omega)/c_O, \pi_j = 0$, $\forall j > I/c_O$
- Type 4: $j^* = (I + b\omega)/c_O$, $\pi_j > 0$, $\forall j \leq (I + b\omega)/c_O$
- Since $\pi_j < \pi_A(j)$ for $j \leq I/c_O$, only type 4 is interesting.

Equilibrium conditions for type 4

- Skills market equilibrium

$$m\frac{l+b\omega}{c_O} = b(1-h\omega^{-\sigma}) \tag{7}$$

- Critical good's profits are non negative:

$$0 \leq \pi(\omega, j^*) = (c_O - c_N)(1-h\omega^{-\sigma}) - m\omega.$$

Proposition 1 – Suppose the set of parameters satisfies the following condition:

$$h < \left(1 - \frac{ml}{bc_N}\right)\left(\frac{l}{b}\frac{c_O - c_N}{c_N}\right)^{\sigma}. \tag{8}$$

Then there exists an equilibrium of type 4.

UBI dominates unless there are limits to redistribution

Proposition 2 – Assume a type 4 equilibrium exists such that $\omega = \omega^*$. *Let*

$$\tilde{\tau} = \frac{b\omega^*}{l + b\omega^*} \frac{c_O}{c_O - c_N}.$$

Then:
(i) $0 < \tilde{\tau} < 1$
(ii) If $\bar{\tau} \geq \tilde{\tau}$, *any oligarch such that* $j_d \leq j^*$ *is strictly better-off under AI*
(iii) If $\bar{\tau} < \tilde{\tau}$, *there exists* $j_{\min} \in \left(\frac{l}{c_O}, j^*\right)$ *such that any* $j_d \in \left(j_{\min}, j^*\right]$ *is strictly better-off under PF. Also,* $j_{\min} = j_A^+(\bar{\tau})$, *implying that any such* j_d *would earn zero profits under AI.*

Interpretation

- Number of skilled workers from skilled demand side $= mj^*/b$
- Number of silled workers = market size for any good $j > l/c_O = y_j$
- Profitability implies $y_j > \frac{\omega m}{c_O - c_N} \iff$

$$\frac{b\omega}{j^*} < c_O - c_N.$$

- LHS = Average cost of one extra skilled worker in the economy, per oligarch
- Additional skilled worker would increase sales of any good $j \in (\frac{l}{c_O}, j^*]$ by one unit
- RHS = benefit to those firms of one extra skilled worker in economy
- If $j_d \in (\frac{l}{c_O}, j^*]$, decisive oligarch is better off by raising size of the middle-class
- Therefore, he would like middle-class to be equal to 1
- But this situation is mimicked by UBI+AI situation with $z = b\omega$.

The PF economy under continuum of skills

- Assume that skills are continuous and cost skill s for agent i is

$$c(i,s) = \gamma i^{-\sigma/\lambda}(s-b)^{1+1/\lambda}.$$

$$\Longrightarrow s(\omega, i) = b + h\omega^{\lambda} i^{\sigma},$$

- Uniform distribution, implying

$$S(\omega) = b + \frac{h\omega^{\lambda}}{1+\sigma}.$$

- Consumer i consumes a range

$$n(\omega, i) = \frac{I + b\omega + h\omega^{\lambda+1} i^{\sigma}}{c_O}.$$

- Consequently, the market size for good j is equal to

$$y_j = 1 - \left[\max\left(c_O j - I - b\omega, 0\right)\frac{\omega^{-\lambda-1}}{h}\right]^{\frac{1}{\sigma}}.$$

Profits and equilibrium conditions

- Profits:

$$\begin{aligned}
\pi_j &= y_j(c_O - c_N) - \omega m \\
&= (c_O - c_N)\left(1 - \left[\left(\frac{c_O j - l - b\omega}{h}\right)\omega^{-\lambda-1}\right]^{\frac{1}{\sigma}}\right) - \omega m, \\
\frac{l + b\omega}{c_O} &\leq j \leq j^* \qquad (9) \\
&= (c_O - c_N) - \omega m,\ j \leq \frac{l + b\omega}{c_O}. \qquad (10)
\end{aligned}$$

- Equilibrium in the market for skilled labor:

$$mj^* = S(\omega) = h\frac{\omega^\lambda}{1+\sigma} + b. \qquad (11)$$

- Zero profit condition for j^* :

$$\frac{\omega m}{c_O - c_N} = y_{j^*} = 1 - \left[\frac{c_O j^* - l - b\omega}{h}\omega^{-\lambda-1}\right]^{\frac{1}{\sigma}} \qquad (12)$$

Again, PF preferred under limited fiscal capacity only

Proposition 3 – Assume $\bar{\tau} = 1$. In equilibrium, any oligarch with a full market share, if decisive in the AI world, is better off under AI than under PF.
Proposition 4 – In equilibrium, the following inequality holds

$$j^* < j_A^+(1) = l/c_N.$$

That is, if $\bar{\tau} = 1$, then in equilibrium any oligarch with positive profits will also have positive profits under AI, if decisive.
Corollary – If $\bar{\tau} = 1$, there exists a range of goods $[j_0, j^*]$ such that all oligarchs in this range prefer AI, if decisive.
Proof – Immediate from the continuity of the above defined profit function and the fact that $\pi_{j^*} = 0$.

Remarks

- Note that the results provided by Propositions 3 and 4 are incomplete.
- Numerical simulations fail to find support for PF for $I/c_O < j_d < j_0$.
- Intuitively, the wage bill transferred to the skilled workers under PF is higher than the tax receipts one would need under AI, so as to just support mass consumption of the decisive oligarch's product.
- Again, though, this may need high tax rates that may exceed state capacity
- If $j_d < j^*$, the range of industrialized goods under AI will, be lower than under PF, despite UBI.

Menu Auctions

- Each oligarch offers contingent contributions to the policymaker.
- Try to construct an equilibrium which sustains a PF status quo
- Previous literature shows that this amounts to maximizing aggregate payoffs of the organized sectors
- We assume only operating oligarchs are organized under PF
    - True if fixed cost of organizing + borrowing constraints

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Menu Auctions: Setup

- Firm j offers x_j for PF status quo and y_j for AI is authorized.
- If AI is blocked, equilibrium is the preceding one
- If not, some tax rate τ prevails
  - j^*, z, determined by above and if $j \leq j^*$ then

$$\pi_{Aj} = (1-\tau)(c_O - c_N).$$

- Policymaker maximizes total private rents.

Equilibrium definition (BW,GH)

Definition 1 – A menu auction politico-economic equilibrium is a x-uple $(P, Q, \{x_i\}, \{y_j\}, D)$ *such that*
(i) P is an equilibrium allocation in the sense of Section **??**, *and Q and equilibrium allocation in the sense of Section* **??**. *x and y are piece-wise continuous mappings from* $[0, P.j^*]$ *to* $\mathbb{R}^+$, $D \in \{P, Q\}$.
(ii) If $D = P$ *(resp.Q) then*

$$\int_0^{\mathcal{P}.j^*} y_j dj \leq \int_0^{\mathcal{P}.j^*} x_j dj (\text{resp.} \int_0^{\mathcal{P}.j^*} y_j dj \geq \int_0^{\mathcal{P}.j^*} x_j dj).$$

Equilibrium definition (BW,GH), ctd

(iii) $\forall j$,

$$(x_j, y_j) \in \arg\max_{(x,y)} I_j(x,y).(\mathcal{P}.\pi_j - x) + (1 - I_j(x,y))(\mathcal{Q}.\pi_j - y), \quad (13)$$

where $I_j(x,y)$ *is an indicator function defined as follows:*

$$\begin{aligned}
&(1) \text{ if } \int_0^{\mathcal{P}.j^*} y_j dj \; < \; \int_0^{\mathcal{P}.j^*} x_j dj, \text{ then } I_j = 1 \\
&(2) \text{ if } \int_0^{\mathcal{P}.j^*} y_j dj \; > \; \int_0^{\mathcal{P}.j^*} x_j dj, \text{ then } I_j = 0 \\
&(3) \text{ if } \int_0^{\mathcal{P}.j^*} y_j dj \; = \; \int_0^{\mathcal{P}.j^*} x_j dj \text{ , then } I_j(x,y) = I(y - y_j \leq x - x_j) \\
&\quad (\text{resp. } I_j(y - y_j \; < \; x - x_j)) \text{ if } D = \mathcal{P} \text{ (resp. } D = \mathcal{Q}).
\end{aligned}$$

The structure of equilibrium

Proposition 5 – Assume the following

$$\exists j \leqslant \mathcal{P}.j^*,\ \mathcal{Q}.\pi_j > \mathcal{P}.\pi_j$$

Assume there exists a MAPEE such that $D = P$, *then*
(i) $\int_0^{\mathcal{P}.j^*} y_j dj = \int_0^{\mathcal{P}.j^*} x_j dj > 0$
(ii) $\forall j \leqslant P.j^*,\ x_j y_j = 0$
(iii) $y_j = 0 \Longrightarrow P.\pi_j - x_j \geq Q.\pi_j$
(iv) $y_j > 0 \Longrightarrow y_j \geq Q.\pi_j - P.\pi_j$

Remarks

- Total contributions for each policy must be equal
  - Otherwise contributors to the winning PF outcome could reduce their offers.
- Firms who lobby in favor of AI must offer all their rents from switching to AI
  - Otherwise it would be rational for them to force the AI outcome by offering a marginally higher reward.
- This forces contributions to be **revealing**
- Consequently, equilibrium policy maximizes aggregate profits

Proposition 6 – Let P be a post-fordist allocation and Q be an AI allocation. A MAPEE exists such that $D = P$, if and only if aggregate profits of the organized oligarchs are higher under the status quo, that is

$$\int_0^{\mathcal{P}.j^*} \mathcal{Q}.\pi_j dj \leq \int_0^{\mathcal{P}.j^*} \mathcal{P}.\pi_j dj \tag{14}$$

AI dominates if taxes are not too large

Proposition 7 – (i) For any $\bar{j}$*, the expression*

$$\Pi_A(\bar{j}, \tau) = \int_0^{\bar{j}} \mathcal{Q}.\pi_j dj$$

is a continuous, decreasing function of τ *such* $\Pi_A(\bar{j}, 1) = 0$
(ii) For any equilibrium allocation P*, the following inequality holds:*

$$\Pi_A(\frac{l}{c_O}, 0) = \Pi_A(\mathcal{Q}.j^*, 0) > \int_0^{\mathcal{P}.j^*} \mathcal{P}.\pi_j dj$$

(iii) Consequently, there exists a unique $\hat{\tau} \in (0, 1)$ *such that A MAPEE exists such that* $D = P$*, if and only if* $\tau \geq \hat{\tau}$.

Remarks

- PF preferred only if τ exceeds a minimum
- Overturns the results under decisive oligarch
- Decisive oligarchs needs enough redistribution for enough consumers to buy his good
- But aggregate profits under AI fall with taxation, despite greater number of industrial good
  - A dollar given to the people cannot generate more than a dollar of additional profit
- There is a tax that transfers the same amount to the middle-class under UBI as through wages under PF
- Consequently, aggregate profits must be higher for taxes lower than that
- If τ is low, producers of goods with a low j are willing to contribute more to implement AI than producers of goods with a high j can pay for the post-fordist status quo.

AI: Setting UBI through menu auctions

- Claim (i) in Proposition 7 shows profits are decreasing in τ
- Hence, under MA, one expects $\tau = 0$ under IA $=>$ **No UBI**
- We can prove this, provided we impose truthfulness on functional reward structure (as in GH 94)

Equilibrium concepts

- Discrete menu of policy choices $\tau = n/k, i = 1, ..., k$.
- Interval $[0, j_O]$ of oligarchs is organized
- Each organized oligarch offers $x_j : \{1, ..., k\} \longrightarrow \mathbb{R}^+$
  - $x_j(n)$ rewards $\tau = n/k$.
- $\mathcal{Q}(\tau) =$ UBI allocation

Definition 2 – A MAPEE is a tax rate $\tau^* = n^*/k$ and a collection of mappings $x_j()$, for $j \in [0, j_O]$, such that
(i) $n^* \in \arg\max_n \int_0^{j_O} x_j(n)dj = M$
(ii) $\forall j, \forall \tilde{x}_j() : \{1, ..., k\} \longrightarrow \mathbb{R}^+, \forall p \in \arg\max_{n \in M} \tilde{x}_j(n) - x_j(n)$,
$Q(\frac{p}{k}).\pi_j - \tilde{x}_j(p) \leq Q(\tau^*).\pi_j - x_j(n^*)$.

Truthfulness

Definition 3 – A **truthful** *MAPEE is a MAPEE such that*

$$\forall j, n,\ x_j(n) \geq 0,\ \text{and}\ (\mathcal{Q}(\tau^*).\pi_j - x_j(n^*) - \mathcal{Q}(\frac{n}{k}).\pi_j + x_j(n)) \geq 0,\ \text{WALOE}$$

Corollary – If $x_j(n)x_j(n') > 0$, *then* $Q(\frac{n}{k}).\pi_j - x_j(n) = Q(\frac{n'}{k}).\pi_j - x_j(n')$

Race to the bottom

Definition 4 – A MAPEE is **minimal** *if*

$$n^* = \min M$$

Lemma – Any MAPEE is minimal
Proposition 8 – Any truthful MAPEE is such that $\tau^* = 0$.

Existence values

- AI equilibrium has far fewer industrialized goods than AI+UBI and PF
- Yet, aggregate profits are higher
- Full market size + Zero overhead costs
- Results can be qualified if some oligarchs derive a fixed rent from their firm just operating
- Menu Auction equilibrium may then enforce PF status quo
- ASSUMPTION: For $j < j^*$, the payoff is $\tilde{\pi}_j = \pi_j + v$ instead of π_j.
- Proposition 9 shows that PF dominates under a condition on parameters ((15))
- It is easy to construct equilibria such that (15) holds

PF may survive under existence values

Proposition 9 – Assume $v < c_N$. *Let* $x = 1 - \frac{\omega m}{c_O - c_N} \in (0,1)$. *Assume the PF allocation is such that the following condition holds:*

$$c_O < x^{\sigma}\left((1+\sigma)c_O - \sigma x(c_O - c_N)\right) \tag{15}$$

Then:
(i) The function

$$\tilde{\Pi}_A(\bar{j},\tau) = \int_0^{\bar{j}} \mathcal{Q}.\pi_j dj + \min(\bar{j}, j_A^+(\tau))v.$$

is continuous, strictly decreasing in τ, *strictly increasing in* $\bar{j}$ *for* $\bar{j} \leq j_A^+(\tau)$, *and constant in* $\bar{j}$ *for* $\bar{j} > j_A^+(\tau)$
(ii) There exists $\hat{v} \in (0, c_N)$ *such that if* $v > \hat{v}$ *then the following inequality holds:*

$$\max \tilde{\Pi}_A = \tilde{\Pi}_A(\frac{l}{c_O}, 0) < \int_0^{\mathcal{P}.j^*} \mathcal{P}.\tilde{\pi}_j dj$$

(iii) Consequently, for any $v > \hat{v}$, *for any* $\tau \in (0,1)$, *A unique MAPEE exists such that* $D = P$.