

Preparing for the (Non-Existent?) Future of Work

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- Growing concerns that new technologies, esp. AI, may substitute for human labor and lead to “technological unemployment”
- Decades of stagnating wages for lesser-skilled workers in advanced economies, leading to growing political discontent
- Predictions of impending transformative advances in AI (TAI) add new fuel to the question

Main Questions

- Long history of fallacies about technological progress
 - e.g. Luddism and lump-of-labor fallacy
- how do we make sense of predictions about labor becoming redundant?
- should labor be phased out if we approach such a world? and how?
- how to set up institutions for a future in which work may be non-existent?

Main Contributions

- 1 Taxonomy of concerns about the (non-existent?) future of work:
 - 1 labor-saving progress
 - 2 technological substitutability of labor
 - 3 economic redundancy of labor
- 2 Analyze optimal policy in the face of declining MPLs
- 3 Relate to design of real-world economic institutions

Assumptions:

- From the perspective of information theory, the human brain is a computing device
 - it takes inputs and computes outputs
 - this applies no matter what tasks we are engaged in, even if they involve creativity, social & emotional intelligence, etc.
- So do computers – and in their most intelligent form, AI systems
- Many researchers predict that AI will eventually surpass HI – and still continue to advance
- Transformative advances in AI may pose severe challenges for humanity – and economic harms are a major category of TAI risks

1) Labor-Saving Technological Progress:

- since the Industrial Revolution, technological progress has been approximately neutral: all factors have benefited proportionately
→ livings standards of workers have risen in tandem with economic growth
- no economic law that progress must be neutral

Concern 1: technological progress reduces demand for labor at given market prices:

$$w = F_\ell(\ell, \dots) \downarrow$$

- harbinger: progress in recent decades has been biased against labor, and labor-saving for the unskilled (Autor, mult.)

Capturing the Concerns about the End of Labor

1) Labor-Saving Technological Progress (Hicks, 1932):

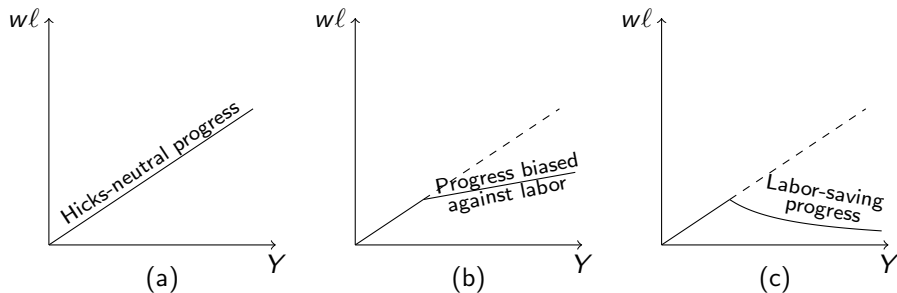


Figure: Varieties of technological progress

2) Technological Substitutability of Labor:

- in the past, labor has been the bottleneck in production
→ scarcity has increased wages over time
- at some point, machines may be able to do everything

Concern 2: Machines can substitute for any type of labor $\ell > 0$ in production

$$\forall \ell > 0, m \exists \Delta m \text{ s.t. } F(0, m + \Delta m) \geq F(\ell, m)$$

- not currently possible, but advances in AI proceeding rapidly
- Concern 1 neither necessary nor sufficient for Concern 2
- But: Concern 2 + Moore's Law \implies Concern 1

Predictions on Technological Substitutability of Labor

- predictions: human-level AI may be reached in coming decade:
 - Ray Kurzweil & Elon Musk: 2029
 - Bostrom (2014) survey of A(G)I researchers: mid-2040s
 - Grace et al (2018) survey of AI researchers: 50% probability by 2060s
 - some people predict: never
- computing power of brain $\approx 10^{15}$ flops
- most powerful supercomputer: Frontier $\approx 2 \times 10^{18}$ flops (at cost of \$600m)
- Moore's Law continuing...

3) Strong Economic Redundancy of Labor:

- in economics, we don't care about technological possibilities but about what's cost-effective
- at some point, machines may be able to do everything *cheaper*
- cheaper than current wages
- and eventually even cheaper than human subsistence

Concern 3: Machines perform any economically valuable task cheaper than humans, valued at their subsistence cost,

$$\forall \ell > 0, m \exists \Delta m \text{ s.t. } F(\ell, m) \leq F(0, m + \Delta m), \Delta m < c_0 \ell$$

- Concern 3 \implies Concerns 1 & 2 ... so it is farther in the future

3') Weak Economic Redundancy of Labor:

- even if some jobs remain for humans, there may not be enough demand for these → look at marginal product of labor

Concern 3': Machines push the competitive wage of human labor below the subsistence cost of humans, or for given economy-wide factor supplies of labor ℓ and other factors m ,

$$F_\ell(\ell, m) < c_0$$

- Concern 3 \implies Concern 3'
- Concern 3' \implies Concern 1 but neither necessary nor sufficient for Concern 2

Wassily Leontief (1983): "the role of humans as the most important factor of production is bound to diminish – in the same way that the role of horses in agricultural production was first diminished and then eliminated by the introduction of tractors."

Objections to Economic Redundancy:

- 1 departs from historical experience
- 2 technologically impossible / human superiority
- 3 ignores new jobs / lump-of-labor fallacy
- 4 ignores lessons from comparative advantage
- 5 economy needs human demand / vs investment
- 6 upgrading of humans
- 7 preference for human service providers (“nostalgic” jobs)

How do we allocate work and income to maximize utilitarian welfare?

1) Case of a single individual

$$U(c, \ell) = u(c - c_0) + v(1 - \ell) \quad \text{for } c \geq c_0 \text{ and } -\infty \text{ otherwise}$$

- subsistence level of consumption c_0
- labor productivity (or wage) w working full-time
- non-labor income (transfer or capital income) T
- (first-best) optimization problem

$$\max_{\ell \geq 0} U(w\ell + T, \ell)$$

Optimally Allocating Work and Income

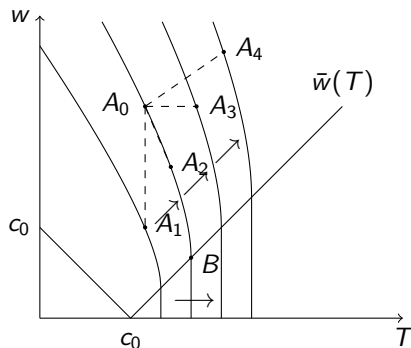
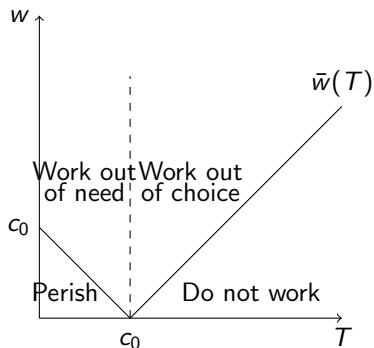


Figure: Regions for labor provision and iso-welfare curves

Proposition (Optimal Labor Provision)

The agent's optimum can be decomposed into the following regions:

- 1 (Perish) If $T + w < c_0$, the agent perishes.
- 2 (Work) If $T + w \geq c_0$ and $w > \bar{w}(T)$, the agent works. $\bar{w}(T)$ is given by

$$\bar{w}(T) := \frac{v'(1)}{u'(T - c_0)} \text{ if } T > c_0 \text{ and } 0 \text{ otherwise}$$

The optimum amount of labor is determined by

$$wu'(w\ell + T) = v'(1 - \ell)$$

An increase in T raises utility, decreases ℓ , and raises \bar{w} for $T > c_0$.

An increase in w increases utility and has ambiguous impacts on ℓ .

If $T < c_0$, labor must satisfy $\ell > (c_0 - T)/w > 0$ to guarantee survival.

- 3 (Don't Work) If $T > c_0$ and $w \leq \bar{w}(T)$, it is optimal to set $\ell = 0$.

How do we allocate work and income to maximize utilitarian welfare?

2) Case of multiple workers who differ in labor productivity w^i :

- optimization problem of utilitarian social planner

$$\max_{\{c^i, \ell^i\}_i} \sum_i U(c^i, \ell^i) = \sum_i [u(c^i - c_0) + v(1 - \ell^i)]$$

s.t. resource constraint

$$\sum_i c^i = Y = F(\ell, m) = F\left(\sum_i w^i \ell^i, m\right)$$

Distributing Labor and Income

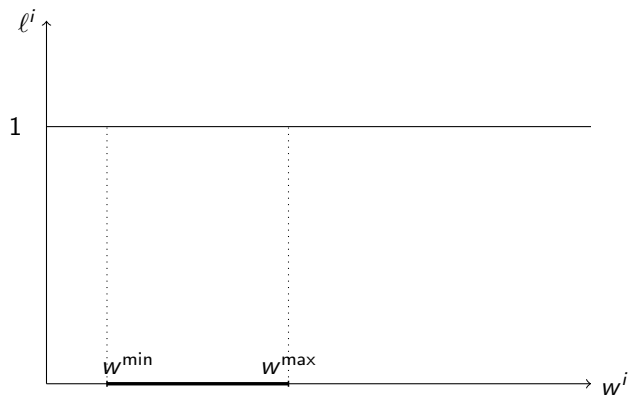


Figure: Optimal allocation of labor l^i as a function of labor productivity w^i

Distributing Labor and Income

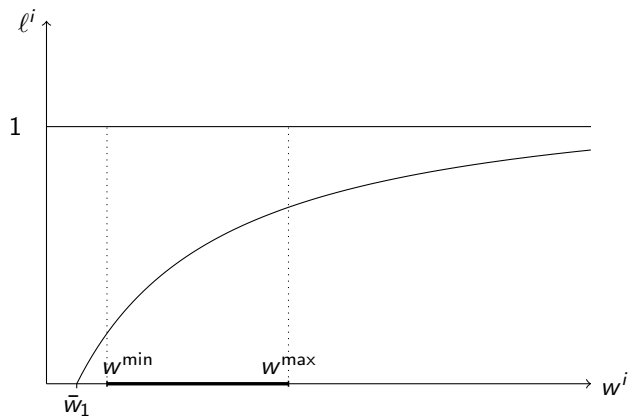


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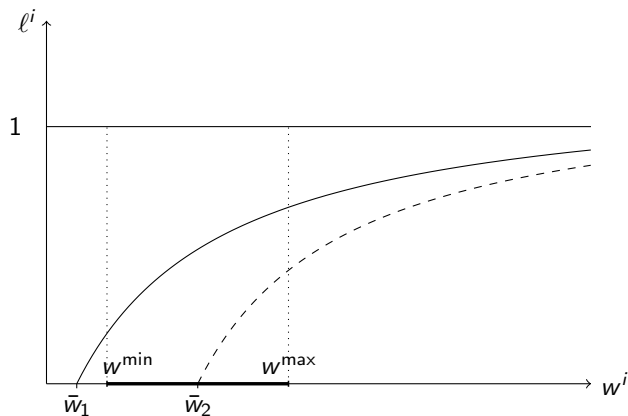


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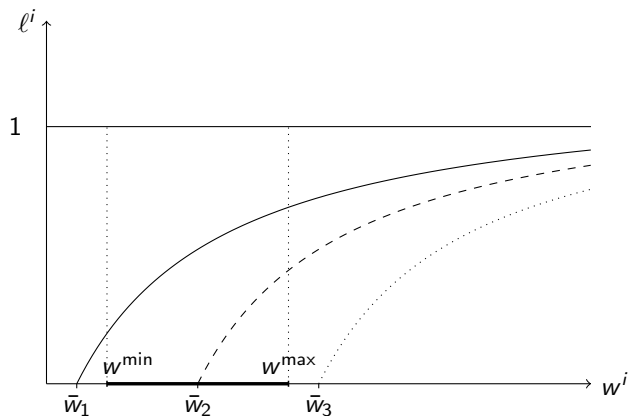


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Proposition (Optimal Allocation With Heterogeneous Productivity)

- ① $\exists \bar{w}$ s.t. $\ell^i = 0$ for all agents with $w^i \leq \bar{w}$, and

$$\ell^i(w^i) = 1 - (v')^{-1} [w^i \cdot F_\ell(\ell, m) u'(\cdot)] > 0$$

for each agent with $w^i > \bar{w}$.

$\ell^i(\cdot)$ is increasing in w^i and F_ℓ , and decreasing in Y .

- ② Everyone works as long as $Y < \underline{Y}$.

The planner starts phasing out work for $Y > \underline{Y}$.

All work is phased out if autonomous output $Y_0 = F(0, m) \geq \bar{Y}_0$.

- ③ The distribution of consumption is independent of productivity,

$$c^i = \bar{c} = \frac{Y}{I} \quad \forall i$$

How do we allocate work, income and amenities to maximize utilitarian welfare?

3) Case of work amenities

Work involves not only giving up leisure for wages:

- work amenities include identity, structure, meaning, social connections, etc – captured by $a^i = \alpha^i \ell^i$ with $\alpha^i \geq 0$

$$U(c^i, \ell^i, a^i) = u(c^i - c_0) + v(1 - \ell^i) + x(a^i)$$

- amenities may compensate for wage income
- compensating differential $z^i \geq w^i \ell^i$ (Rosen, 1986...)
- for some, work may be desirable even if $w^i = 0$
- but 65% of workers are “disengaged/not engaged” from work (Gallup)

Proposition (Optimal Labor Allocation With Amenities)

- 1 \exists frontier of (w^i, α^i) such that $\ell^i = 0$ for sufficiently low w^i and α^i , and $\ell^i > 0$ is increasing in w^i and α^i otherwise
- 2 If $\alpha^i > \alpha_0^i := v'(1)/x'(0)$, then $\ell^i > 0$ even for $w^i = 0$; this is always the case if $z^i > w^i \ell^i$

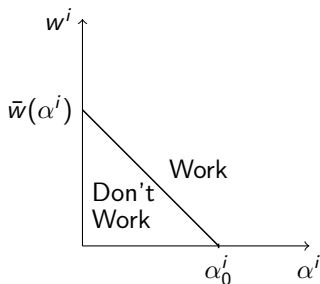


Figure: Optimal labor allocation with amenities

How do we allocate work, income and amenities to maximize utilitarian welfare?

4) Case of internalities and externalities from work amenities

- policy proposals often propose interventions to preserve work without explicitly spelling out the rationale
 - risk of acting out of a “status quo” bias
- economic perspective: let individuals make their own choices (invisible hand) **unless** there are externalities or internalities at work

Internalities and Externalities from Work Amenities:

- 1 work amenities may involve externalities: e.g. social connections (+), political stability (+), commuting/congestion (-)
 - captured by “public amenity” $\bar{a} = \sum_j \bar{\alpha}^j \ell^j / I$ with type j contribution $\bar{\alpha}^j$

$$U(c^i, \ell^i, a^i, \bar{a}) = u(c^i - c_0) + v(1 - \ell^i) + x(a^i) + \bar{x}(\bar{a})$$

- 2 work amenities may involve internalities: e.g. structure (+), workaholism (-)
 - captured by individual mis-perceiving individual amenities as $\hat{a}^i = \hat{\alpha}^i \ell^i$

$$U^0(c^i, \ell^i, a^i, \bar{a}) = u(c^i - c_0) + v(1 - \ell^i) + x(\hat{a}^i)$$

Proposition (Allocation of Labor with Externalities and Internalities)

- 1 \exists frontier $(w^i, \alpha^i, \bar{\alpha}^i)$ such that $\ell^i = 0$ for sufficiently low w^i , α^i or $\bar{\alpha}^i$, and $\ell^i > 0$ and increasing in the three parameters otherwise
- 2 If $\bar{\alpha}^i > 0$ or $\alpha^i > \hat{\alpha}^i$, then $\hat{\ell}^i < \ell^{i*}$, calling for an optimal subsidy (tax) to individual i 's labor of

$$s^i = \frac{\bar{\alpha}^i \bar{x}'(\bar{a}) + [\alpha^i x'(a^i) - \hat{\alpha}^i x'(\hat{a}^i)]}{u'(c^i)}$$

Different Types of Institutions:

- market
- social insurance

Markets Allocating Work and Income:

- perfect free markets: everybody would be perfectly insured → first-best of egalitarian planner (Korinek and Stiglitz, 2019)
 - perfect risk markets unfeasible for the same incentive reasons as perfect social insurance
- in practice we have *free markets with missing insurance markets*:
- large inefficiencies
 - widespread misery
 - esp. if labor becomes redundant

Social Insurance:

- substitutes for missing risk markets
- classic trade-off of efficiency vs redistribution
(but: trade-off mitigated if labor becomes redundant)

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- substitutes for missing risk markets
- classic trade-off of efficiency vs redistribution
(but: trade-off mitigated if labor becomes redundant)
- several categories of transfers:
 - contingent vs uncontingent (e.g. UBI)
 - in-kind vs transfers

One solution: **Universal Basic Income (UBI):**

- it distributes income in a non-distortionary way
 - negative impact on labor supply (due to income effects) is desirable
- it requires large amounts of revenue, imposing costly distortions
 - it is far from implementing the first-best allocation
 - replacing the current system with a UBI *now* would hurt the most needy
 - but it may be the best choice *when labor is phased out*

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Our proposals to prepare for a future in which work may become redundant:

- 1 Introduce a small UBI now
 - which automatically rises if the labor share declines
- 2 Separate provision of social insurance from work

When Is Public Intervention in Labor Markets Desirable?

- individuals should have a choice on whether to work
 - logic of the invisible hand
- work subsidies are desirable when work generates externalities or internalities
 - but these need to be spelled out carefully
- over time, society may develop more efficient ways of providing positive non-wage amenities of work

Raising Revenue when Work does not exist:

- need to tax other factors
 - Pigovian taxes
 - taxes on rents and inelastically supplied factors

Conclusion:

- labor may soon cease to be the most important factor in the economy
- allocation of income needs to be separated from work
 - risk of widespread misery
 - potential for large welfare gains
- institutions to provide social insurance in such a future are urgently needed
- non-material amenities of work will play a growing role