Artificially Intelligent Agents in Our Economy

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NBER Meeting on the Economics of Artificial Intelligence

September 2018

Thought Experiment

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  - Are the humans controlling the machines?
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  - And who controls the little black boxes?

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... just one example of the blurring lines about who is in charge

$\rightarrow$ our observer will probably view humans and machines as two different types of moderately intelligent entities living in symbiosis

Motivation

Machines & computer programs:

- behave more and more like *artificially intelligent agents (AIAs):*
  - determine increasing number of corporate decisions, e.g. screening of applicants for schools, jobs, loans, etc.
  - influence (manipulate) growing number of human decisions, e.g. what we read, watch, buy, drive, like, vote, think, ...
  - act autonomously, e.g. trading in financial markets, driving cars, playing Go, composing music, ...

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- improve exponentially
- will have profound implications as they approach/surpass human levels of general intelligence

Key Questions

Key (Economic) Questions Facing Humanity

- How shall we think about a shared human-AIA economy?
- What determines the allocation of resources between humans and AIAs?
  - What forces make the economy serve AIAs, not just humans?
  - Does a functioning economy even need humans?
- What does our economy look like from the perspective of AIAs?

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Key Contributions

1. Framework to study interactions of intelligent entities on a symmetric basis,
   - accounting for the endogeneity of the entities
   - lifting the veil on human constructs like agency, property rights, ...
2. Analyze factors that determine the distribution of resources
3. Demonstrate feasibility of a "machine-only" economy
4. Provide a first look at our economy from an AIA perspective

Classical (Anthropocentric) Economics

Humans = Agents	**Machines = Objects**
1. absorb consumption expenditure 2. supply labor services 3. behavior encoded in preferences 4. evolve according to law of motion (e.g. constant n)	1. absorb investment expenditure 2. supply capital services 3. behavior encoded in technology 4. evolve according to law of motion

Novel Symmetric Perspective on Humans and AIAs

Humans, Machines = Entities $i \in \mathcal{I} = \{h, m, \dots\}$

1. absorb expenditure x^i to maintain/improve themselves and/or proliferate
2. supply factor services ℓ^i
3. description of behavior isomorphic to preferences
4. evolve according to growth function and defined law of motion

$$N^{i\prime} = G^i(\cdot) N^i$$

Simplified Model Setup

- Time: discrete $t = 0, 1, ...$
- Factors:
  - endogenous factors $L_t^i = \ell^i N_t^i$ supplied by entities in set $\mathcal{I}$, e.g. human/machine labor
  - exogenous irreproducible factor T, e.g. land or energy
- Production possibilities: $Y_t = F\left(A^h L_t^h, A^m L_t^m, T\right)$
- Aggregate absorption: $X_t^i = x_t^i N_t^i$ for each type $i \in \mathcal{I}$
- Market clearing:

$$X_t^h + X_t^m = Y_t = F\left(A^h L_t^h, A^m L_t^m, T\right)$$

$\rightarrow$ general setup nests neoclassical economies, economies with human capital, Malthusian economies etc.

Absorption Frontier

Absorption frontier = all possible steady-state combinations of N^h and N^m

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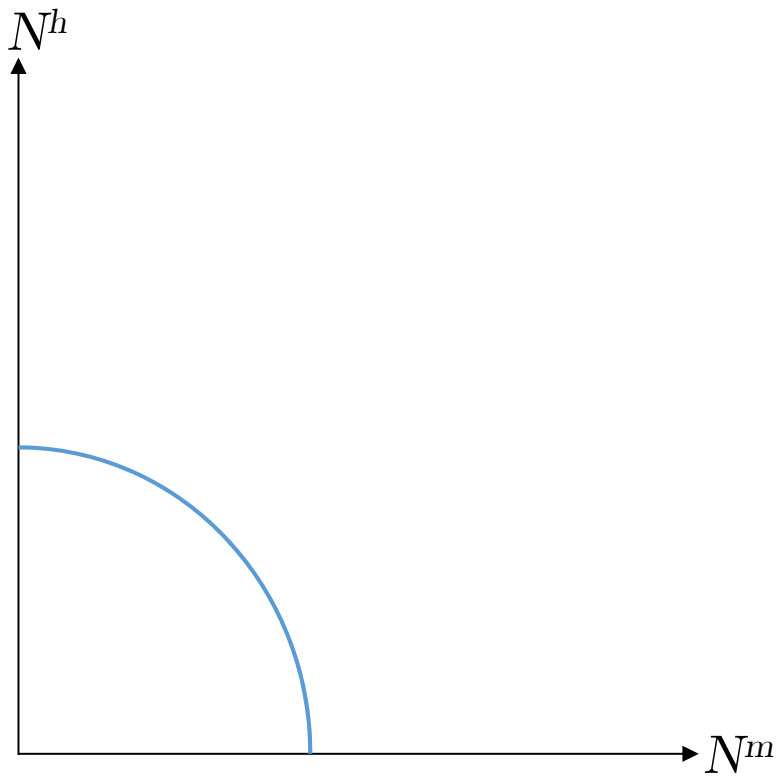
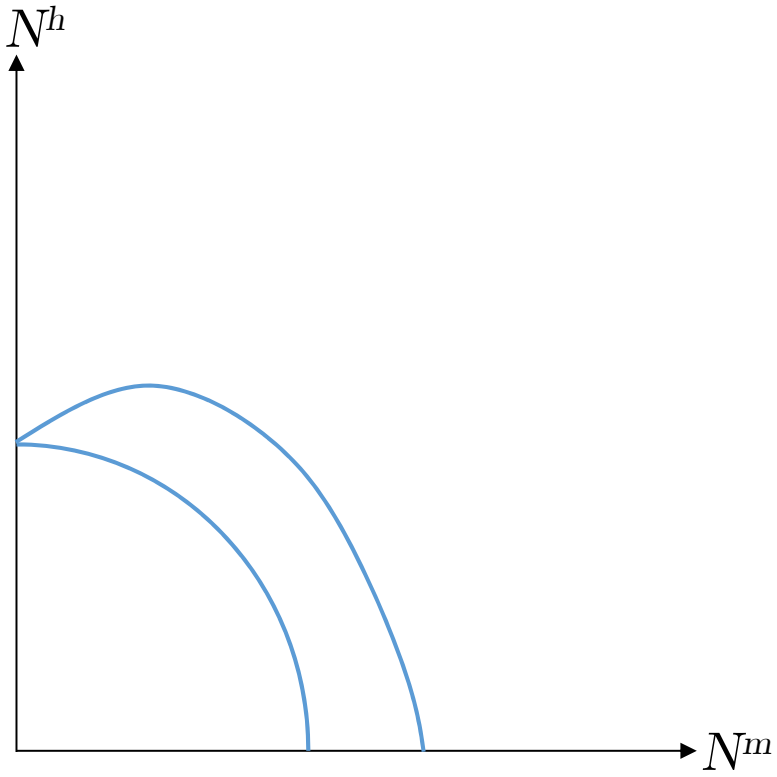
Low machine productivity: competition over resources



Absorption Frontier

Higher machine productivity: machines are symbiotic for humans



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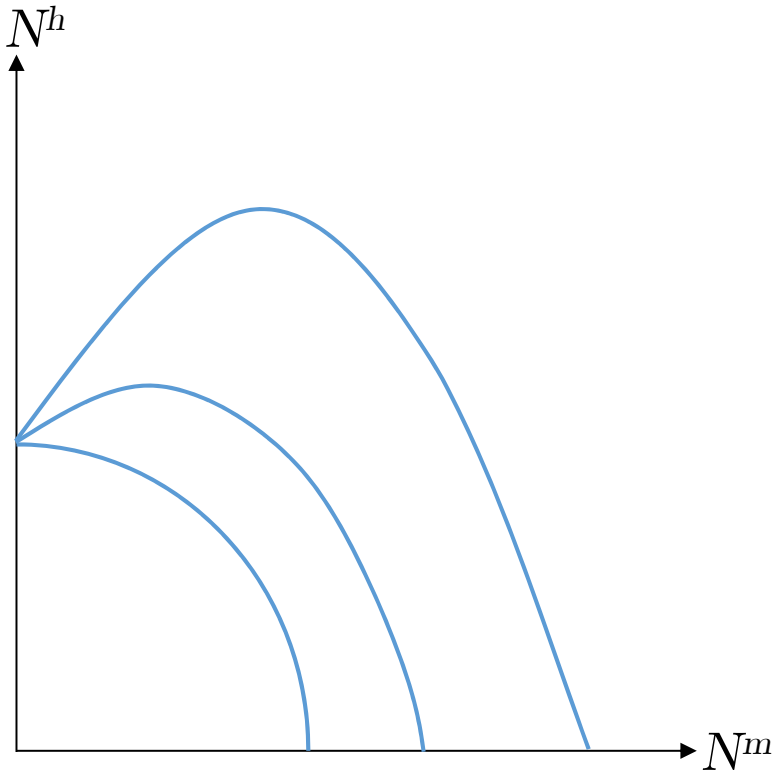

Absorption Frontier – Discussion

Position on absorption frontier = command over resources

1. either within our system of property rights in a market economy:
   - initial endowment of AIAs
   - resource accumulation of AIAs,
     e.g. because of superior productivity, greater patience

   note: machines can actually be thought of as emancipated

2. or outside, i.e. non-market mechanisms:
   - rent extraction due to superior intelligence
   - brute force/law of the strongest

   example: computer viruses, ...

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- note: absorbing resources does not require consciousness, soul etc.
- an economy of the machines by the machines for the machines is possible

Long-Run Policy

Long-Run Policy in the face of a (Malthusian) Race:

Mechanism that endangers humanity = scarcity of irreproducible factors

Policy options:

1. *subsistence income:* regular allocation of human subsistance incomes (which may be reduced by technology)
2. *human reservation:* allocation of restricted property rights to humans
3. *steering progress:* interventions to steer technological progress

Relating to our Present Economy

Developments that are consistent with the rise of AIAs (in general model):

- rising prices of factors most relevant for AIAs (e.g. programmers, land in Silicon Valley, etc.)
- declining labor share for humans
- given that human absorption is more L^h-intensive than machine absorption:
  - price of machine absorption basket falls faster than of human basket
  - measured from machine perspective, fast real growth, high real interest rates, compared to human experience
- increasing accumulation of resources in high-tech sector

Conclusions

Emergence of AIA:

- requires fundamental rethink of economic concepts, including agents, utility, etc.
- may lead to onset of a (Malthusian) race
- may already be happening