



# AI and inequality: How smart machines exacerbate demographic bias and inequality

**A presentation at the Centre for the Study of Living Standards / Centre d'étude des niveaux de vie (Ottawa, Canada)**

**18 Mar 2019**

Kai L. Chan, PhD  
Kai.Chan@alumni.princeton.edu  
www.KaiLChan.ca



# AI and inequality

## How smart machines exacerbate demographic bias and inequality

- How does AI generate riches, redistribute wealth and distort the labour market in multicultural societies?



- How will AI disrupt off-shoring and upend the traditional development model?



- As AI displaces humans from their jobs, economic value will be transferred from labour to capitalists, particularly the "super-elites". In an era where capital is mobile and labour is less so, AI will exacerbate already-high levels of inequality if left unmanaged





“As automation substitutes for labour across the entire economy, the net displacement of workers by machines might exacerbate the gap between returns to capital and returns to labour... This will give rise to a job market increasingly segregated into ‘low-skill/low-pay’ and ‘high-skill/high-pay’ segments, which in turn will lead to an increase in social tensions.”

– *Klaus Schwab, 2016*

“[Economic inequality] is one of the main challenges posed by the proliferation of artificial intelligence and other forms of worker-replacing technological progress.”

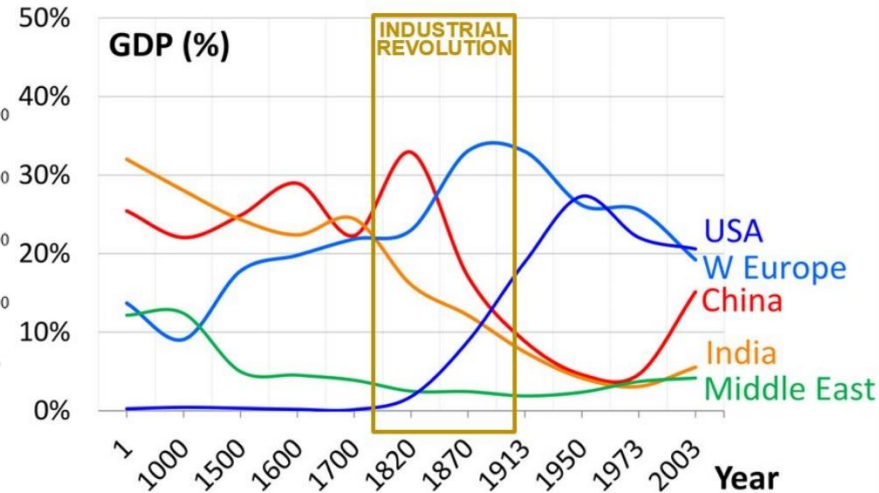
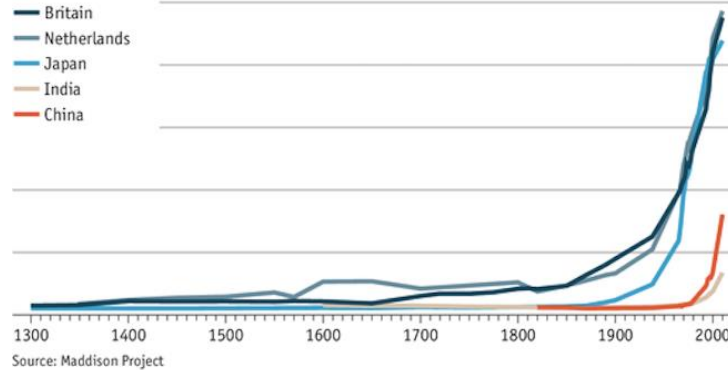
– *Anton Korinek & Joseph Stiglitz, 2017*

# Inequality at the global level

"Great Divergence" b/w the West vs the rest after (1<sup>st</sup>) Industrial Revolution



**The Great Divergence**  
GDP per person, 1990 constant \$

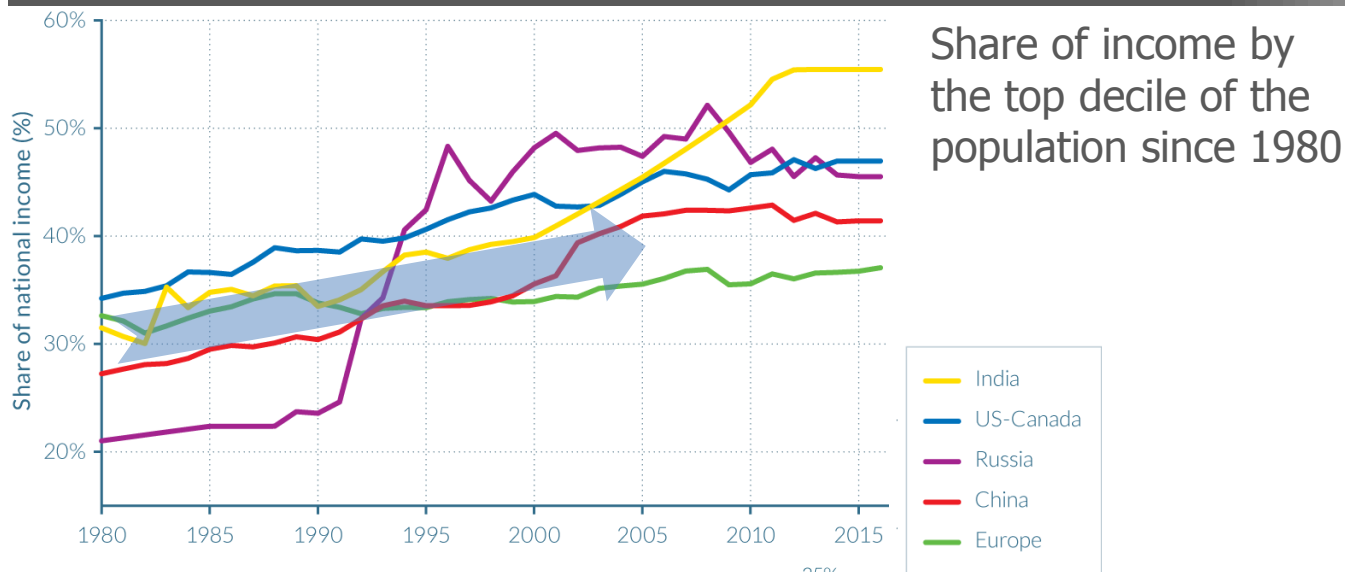


## Number of people by income



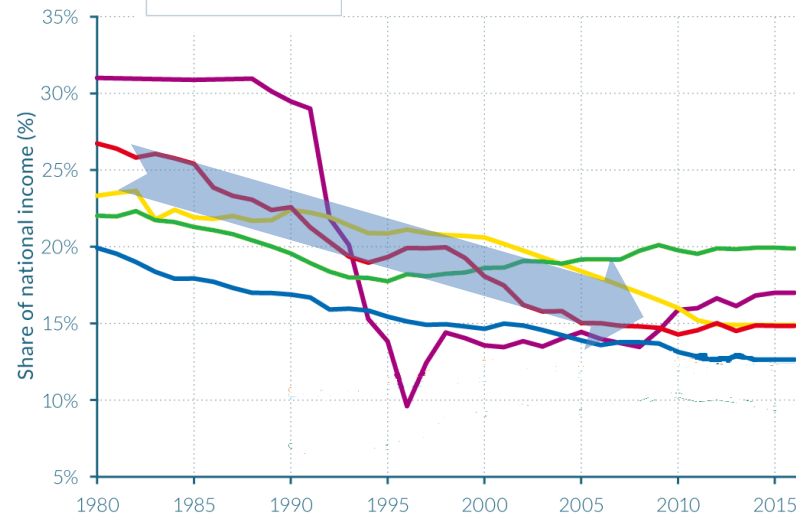
# Inequality at the national level

Inequality is growing in most countries (even as it has fallen globally)



Source: WID.world (2017). See [wir2018.wid.world/methodology.html](http://wir2018.wid.world/methodology.html) for data series and notes.  
In 2016, 47% of national income was received by the top 10% in US-Canada, compared to 34% in 1980.

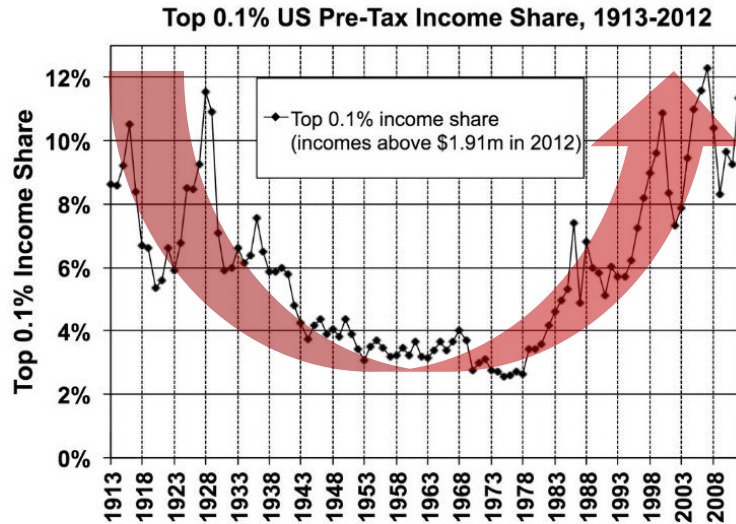
Share of income by the bottom half of the population since 1980



Source: WID.world (2017). See [wir2018.wid.world/methodology.html](http://wir2018.wid.world/methodology.html) for data series and notes.  
In 2016, 12% of national income was received by the Bottom 50% in Sub-Saharan Africa.

# It was not always this way

Inequality low in Bretton Woods era; now back at level of Gilded Ages

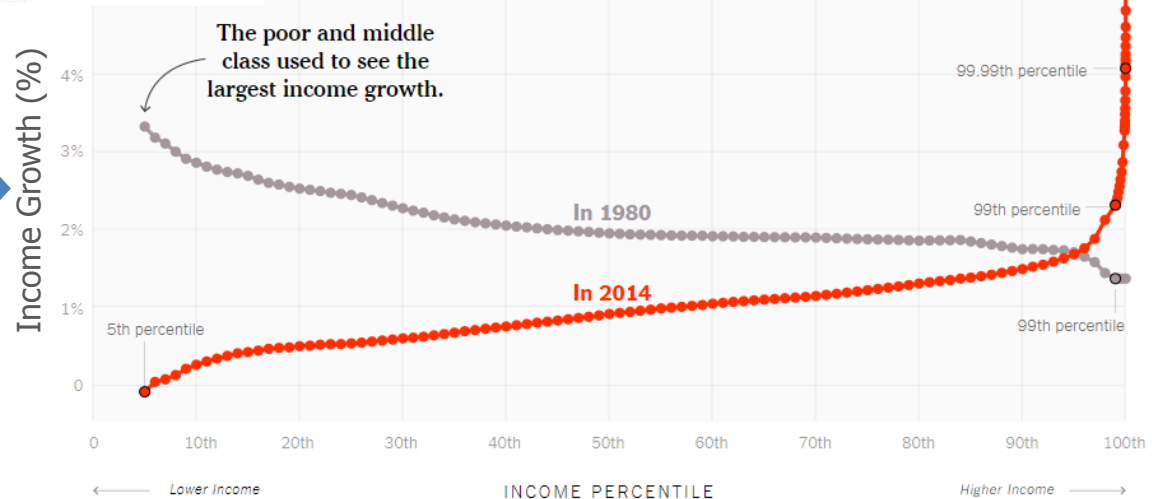


Source: Piketty and Saez, 2003 updated to 2012. Series based on pre-tax cash market income including or excluding realized capital gains, and always excluding government transfers.



Inequality was high just before the Great Depression; then came the golden era led by the welfare state

"Our broken economy, in one simple chart"

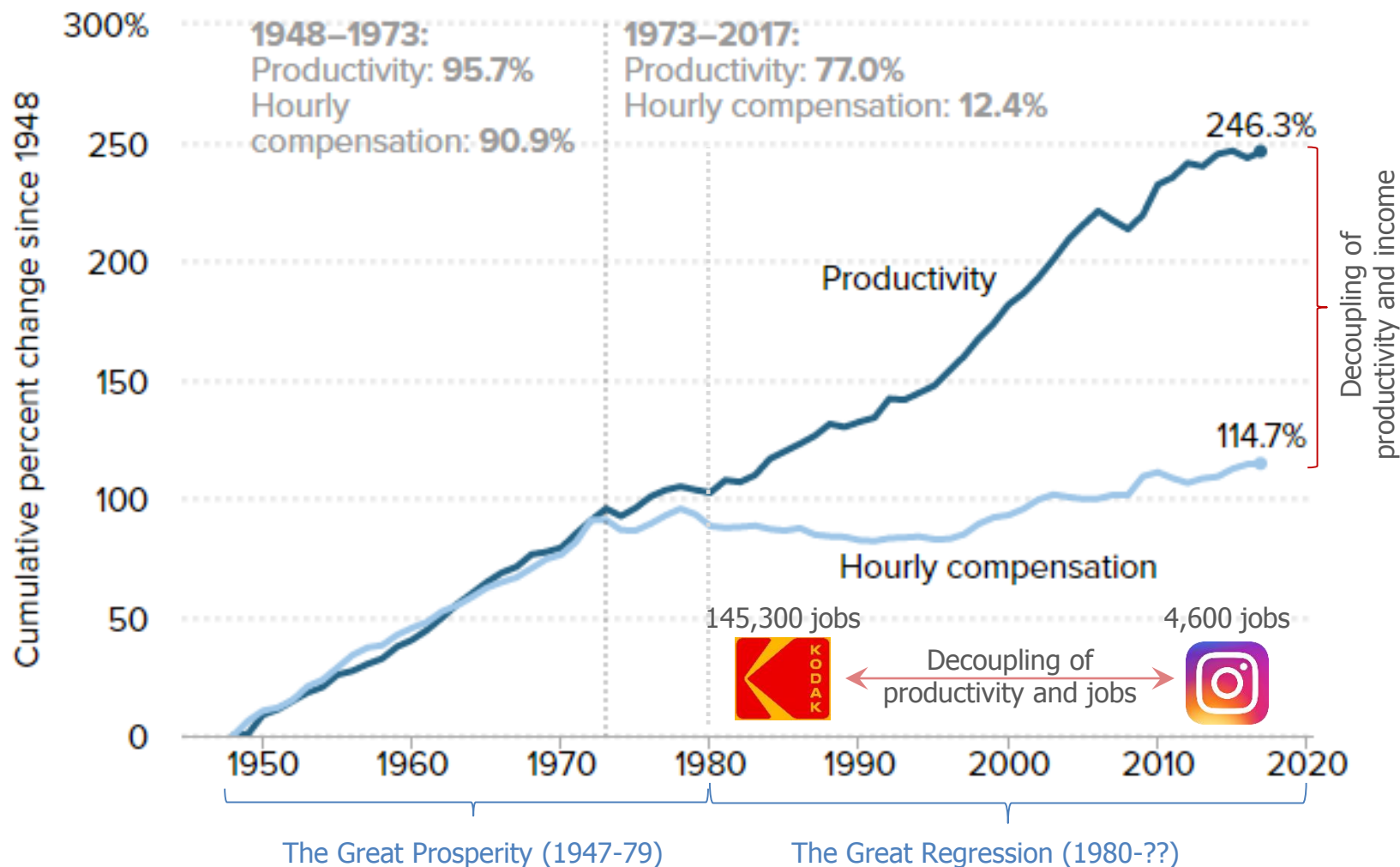


Note: Inflation-adjusted annual average growth using income after taxes, transfers and non-cash benefits.



# Driven (partly) by productivity/labour-wage gap

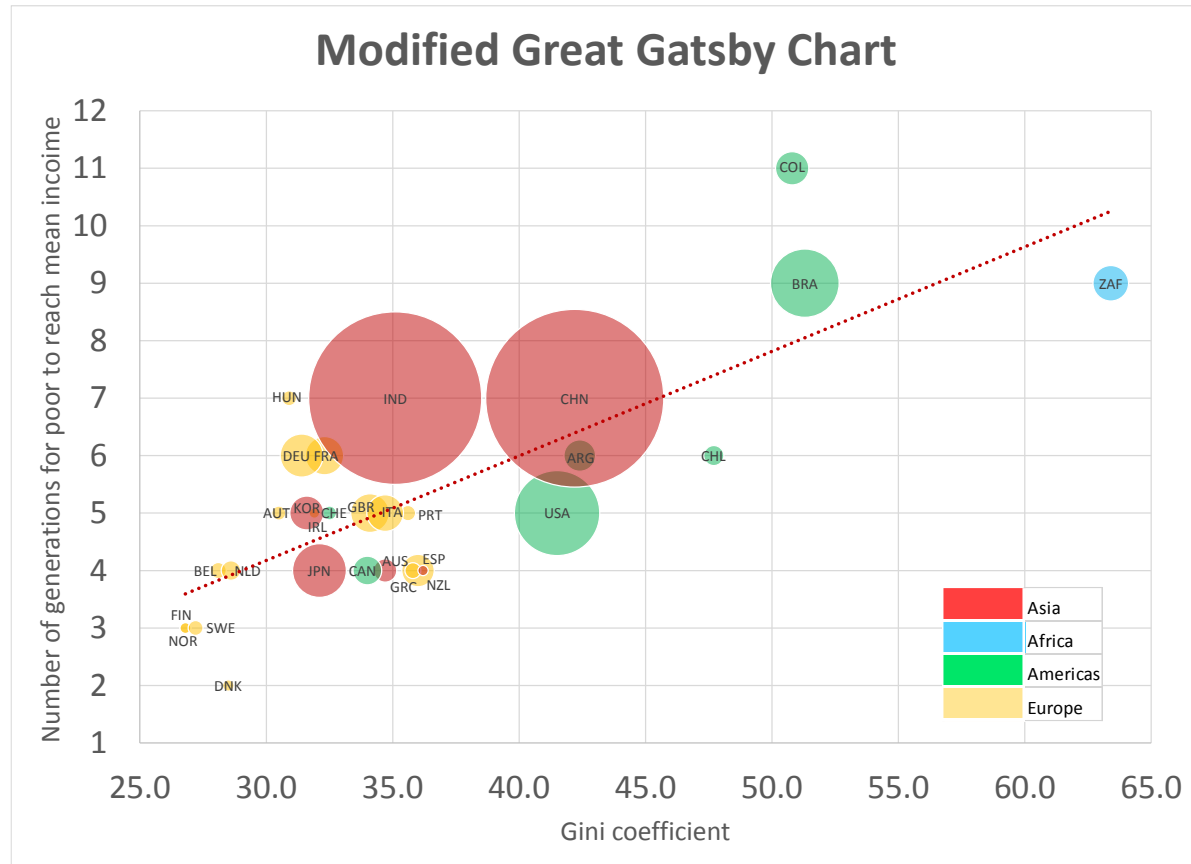
Technology and globalisation → decoupling of jobs and wealth



The real median income of US households has barely changed over the past 2 generations, yet the country is much wealthier now. Where did those gains go?

# Inequality inconsequential if we have mobility

But we have inequality without mobility



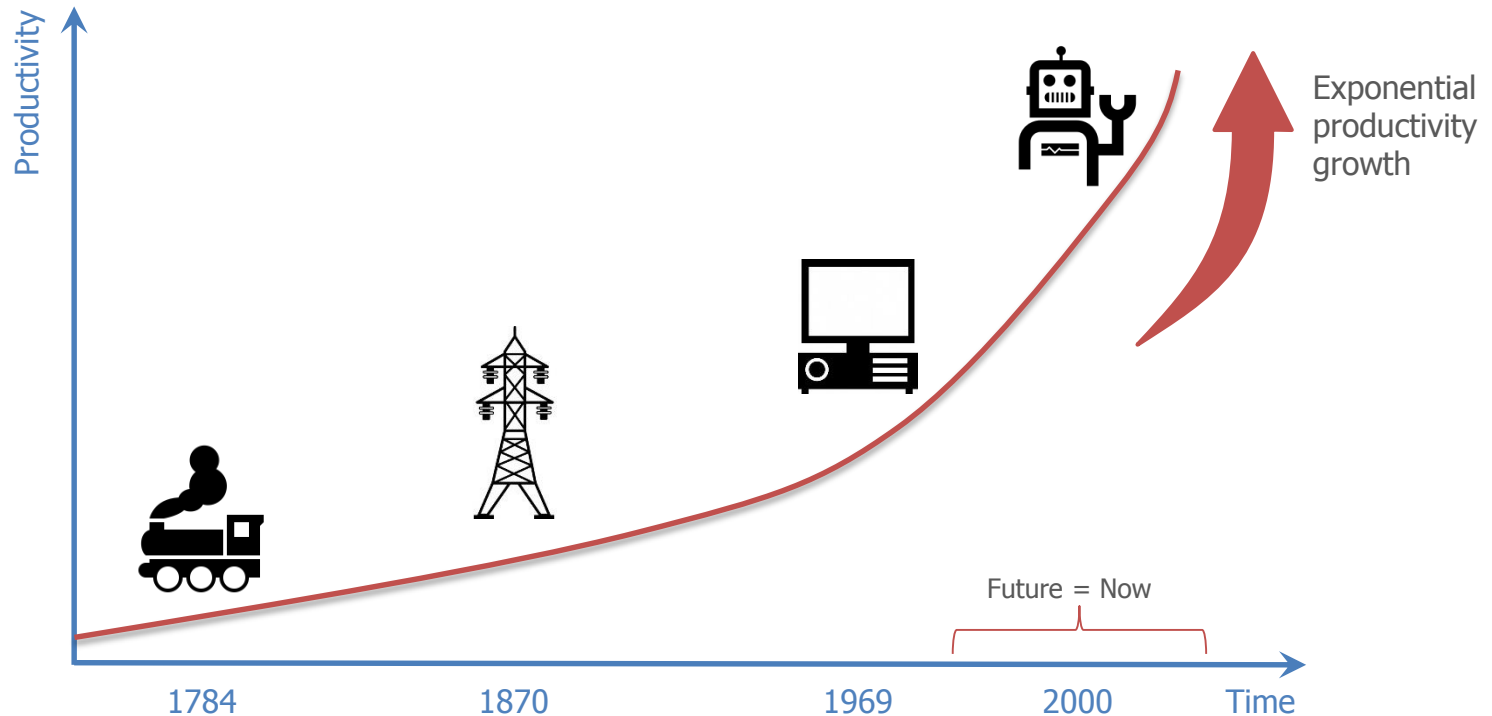
"[I]nequality represents the greatest societal concern associated with the 4<sup>th</sup> Industrial Revolution. The largest beneficiaries of innovation tend to be the providers of intellectual and physical capital – the innovators, shareholders, and investors – which explains the rising gap in wealth b/w those dependent on capital versus labour."

– Klaus Schwab, 2016



# First Industrial Revolution → Great Divergence

We are now embarking on the Fourth Industrial Revolution (AI, BD, robotics)



## 1<sup>st</sup> Ind. Rev'n

- Mechanisation
- Water power
- Steam power

## 2<sup>nd</sup> Ind. Rev'n

- Mass production
- Assembly line
- Electricity

## 3<sup>rd</sup> Ind. Rev'n

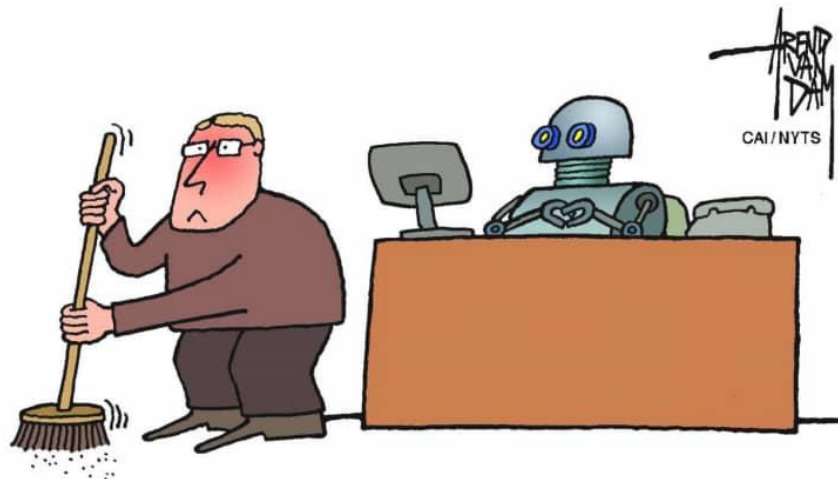
- Automated production
- Electronics
- Computers

## 4<sup>th</sup> Ind. Rev'n

- Artificial intelligence
- Big data
- Robotics

# Robots are supposed to serve us...

But many think they could end up hurting rather than helping us



- Oxford University report suggests that by 2040 up to 47% of jobs (USA) are at risk of automation; similar numbers of job losses in other (developed) countries
- AI and smart machines will lift productivity and allow us to do and consume things previously never possible. But millions of people will need to either switch jobs, upgrade their skills, create their own value or will be forced out of the job market



# The AI job creation/destruction score card

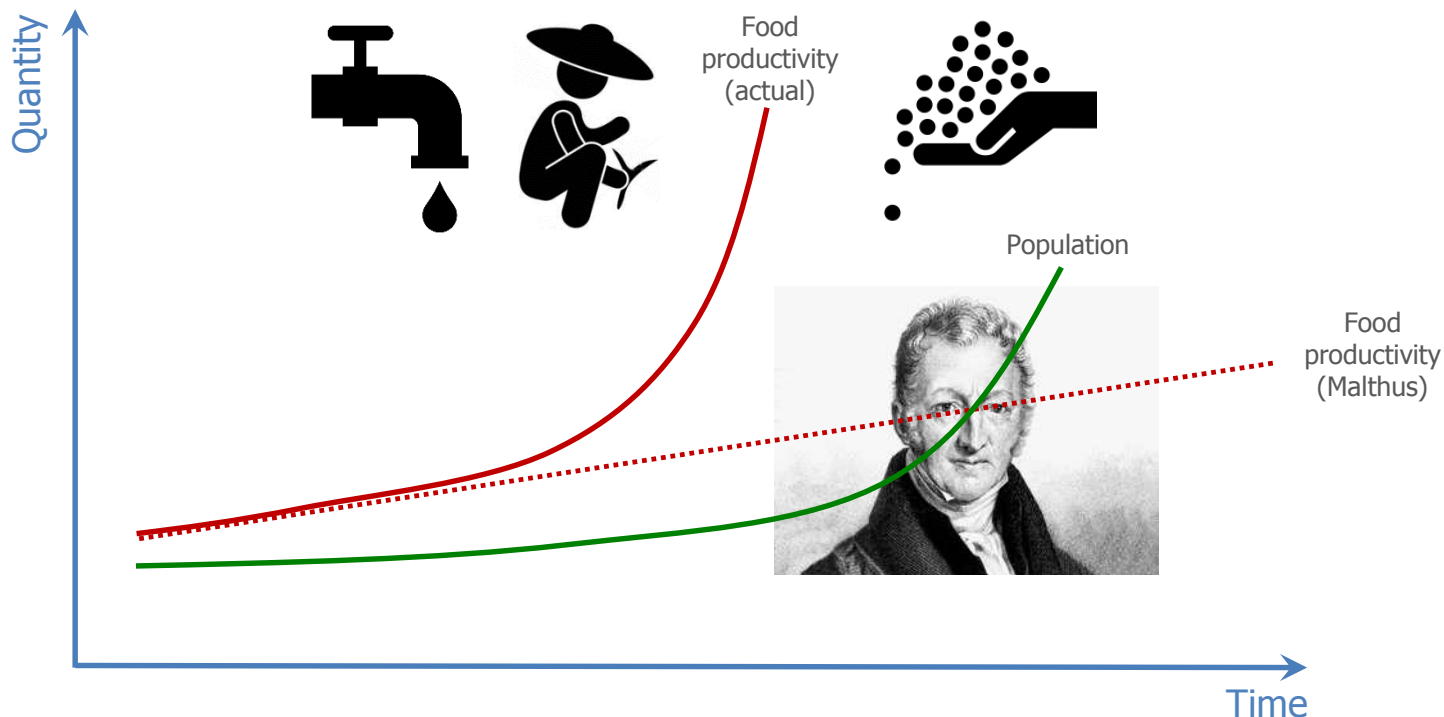
Wide range on expectations, but all are certain of big changes

Date	Geography	Creation	Destruction	Net	Source	Released
2016	Global	900k to 1.5M		N/A	Metra Martech	2013
2018	USA	~3M	~14M	-11M	Forrester	2017
2020	Global	1M to 2M		N/A	Metra Martech	2013
2020	Global	2.3M	1.8M	+0.5M	Gartner	2017
2021	G20+	2M	7.1M	-5.1M	WEF	2016
2021	Global	1.9M to 3.5M		N/A	IFR	2017
2021	USA		~9M (6%)		Forrester	2016
2022	Global		1B	N/A	Thomas Frey	2012
2022	Global	133M	75M	+58M	WEF	2018
2025	USA	~14M	~24M	-10M	Forrester	2016
2025	USA		3.4M	N/A	ScienceAlert	2017
2027	USA	14.9M	24.7M	-9.8M	Forrester	2017
2030	Global		2B	N/A	Thomas Frey	2013
2030	Global	555M to 890M	400M to 800M	-245M to +490M	McKinsey	2017
2030	USA		~58M	N/A	PWC	2017
2035	USA		80M	N/A	BOE	2015
2035	UK		15M	N/A	BOE	2015
~2035	OECD		30%		PWC	2018
~2040	USA		47%		Oxford	2013
N/A	UK		13.7M	N/A	IPPR	2017
N/A	OECD		9%; 14%	N/A	OECD	2016; 2018
N/A	USA		~14M	N/A	OECD	2016

# Is the sky really falling?

Not the first time that we thought humanity's fate was headed for disaster

The Malthusian theory of growth underestimated human ingenuity. In the USA today, 1 farmer is able to feed 154 people. (Or maybe Malthus will be proved right in that technology will not produce enough *jobs* for a growing population?)

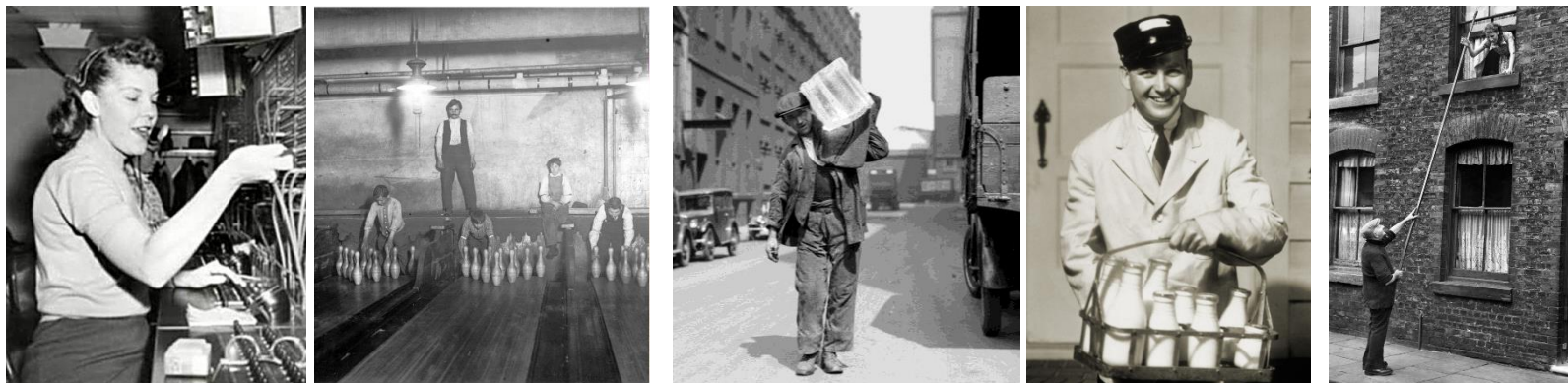


A natural resource-based economy faces scarcity and limitations, but a knowledge-based economy – where data and information are the primary products – has no limit for growth.

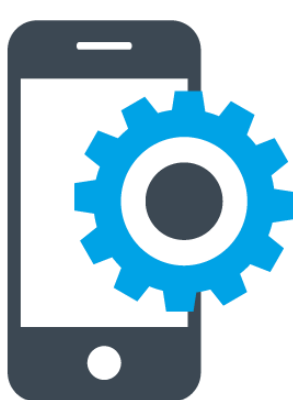


# Technology kills jobs – that is inevitable

But it will also create new ones as part of creative destruction



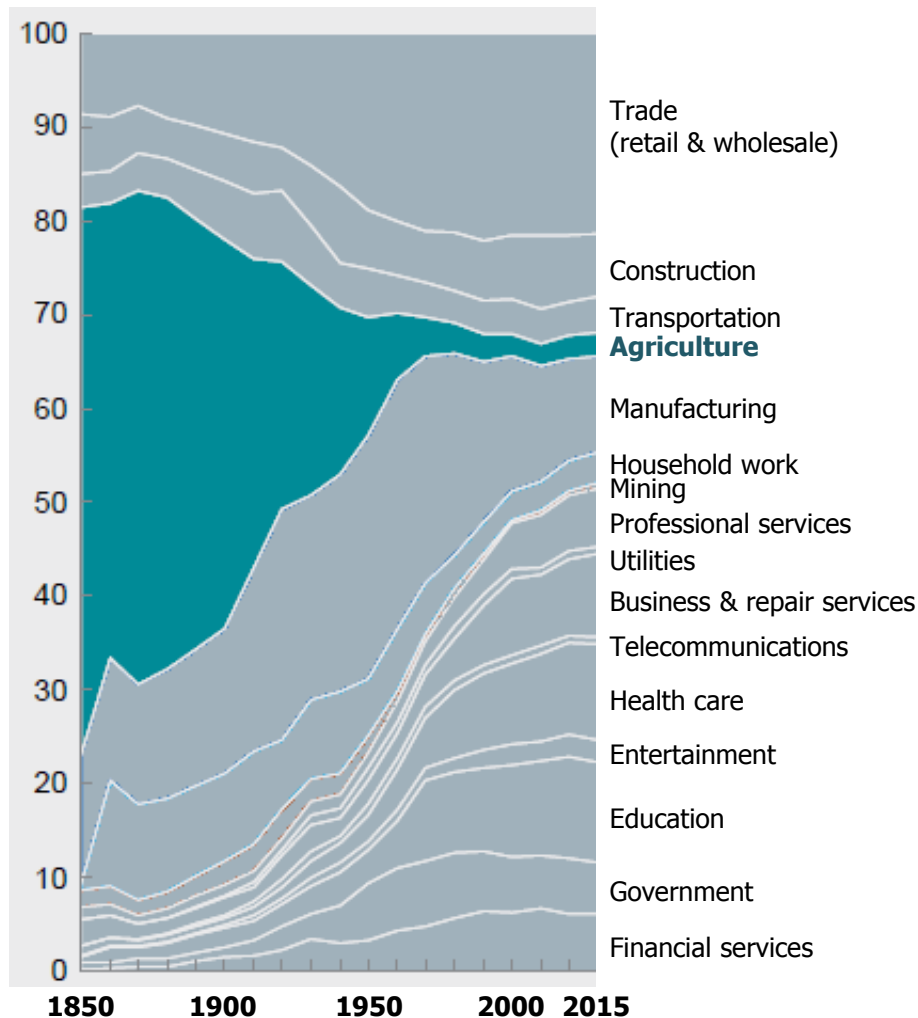
- Many jobs churn within a 60-90 year cycle (Wyatt & Hecker, 2006)
- Will AI be more like alarm clocks (job destroying) or ATMs (job enhancing)?
- Swiss watch industry is an example of a superior technology that threatened jobs (and an entire industry). Instead, the industry re-invented itself and is doing even better than before



# Technological progress has hitherto benefited us

"Displaced" farmers have moved into more productive sectors

## Share of total employment by sector (USA)

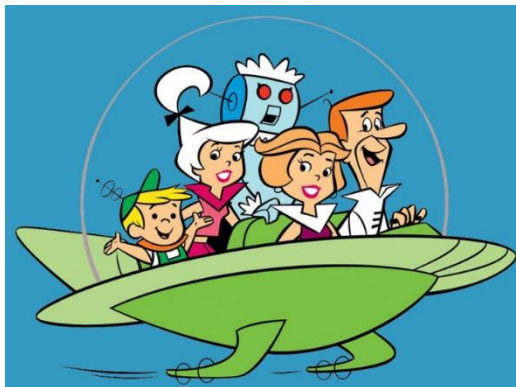


- Even initially after the Industrial Revolution a majority of labour in the USA still worked in the agricultural sector
- Farming was a physical job that relied on strength and the ability to do repetitive tasks on the field
- Because of technological improvements in agriculture now less than 2 percent of the workforce is employed on a farm, yet they produce a surplus of food for the nation
- The "displaced" farm labourers ended up finding more productive and valuable work in the new economy



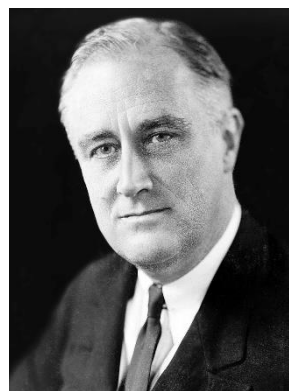
# But is this time different?

Will AI bring the 2-hour workweek or the Apocalypse?



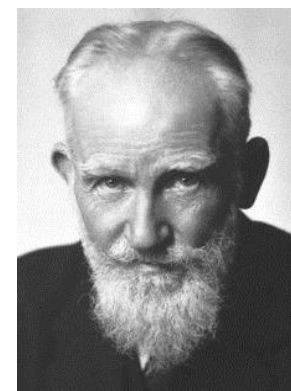
"Prediction is difficult,  
especially about the  
future."

– *Niels Bohr*



"There are about as  
many opinions as there  
are experts."

– *Franklin D. Roosevelt*



"If all the economists  
were laid end to end,  
they'd never reach a  
conclusion."

– *George Bernard Shaw*

# AI's impact on job losses will be uneven

Some jobs are more susceptible to automation

## Probability of job automation by occupation (USA)

Probability	SOC code	Occupation
0.9900	41-9041	Telemarketers
0.9900	23-2093	Title examiners, abstractors, and searchers
0.9900	51-6051	Sewers, hand
0.9900	15-2091	Mathematical technician
0.9900	13-2053	Insurance underwriters
0.9900	49-9064	Watch repairers
0.9900	43-5011	Cargo and freight agents
0.9900	13-2082	Tax preparers
0.9900	51-9151	Photographic process workers and processing machine operators
0.9900	43-4141	New accounts clerks
0.9900	25-4031	Library technicians
0.9900	43-9021	Data entry keyers
0.0028	29-1125	Recreational therapists
0.0030	49-1011	First-line supervisors of mechanics, installers and repairers
0.0030	11-9161	Emergency management directors
0.0031	21-1023	Mental health and substance abuse social workers
0.0033	29-1181	Audiologists
0.0035	29-1122	Occupational therapists
0.0035	29-2091	Orthodontists and prosthetists
0.0035	21-1022	Healthcare social workers

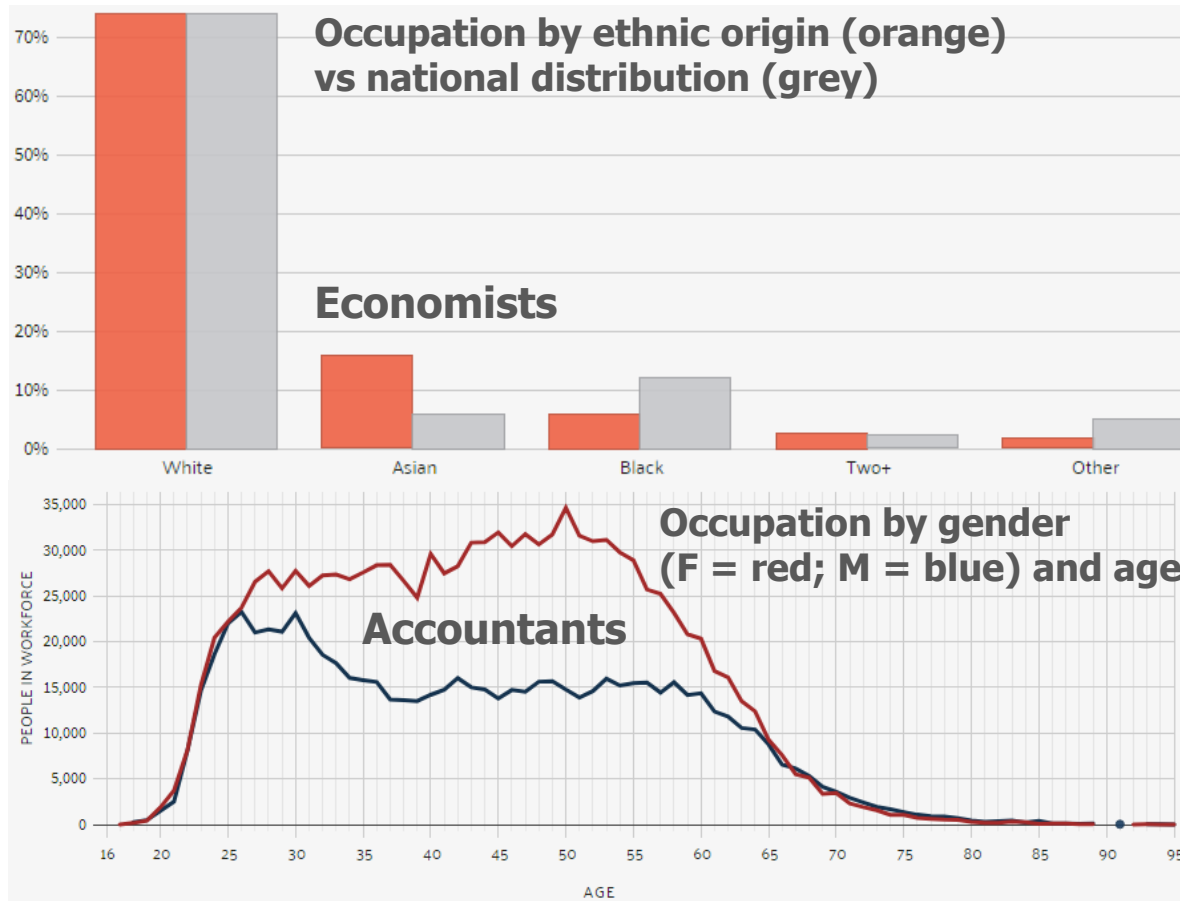
Highly likely to  
be automated  
(rote tasks)

Highly unlikely  
to be  
automated  
(personalised)

In about 3 in 5 occupations, it is expected that at least 1/3 of the associated tasks/activities could be automated, freeing up human labour to pursue other (more valuable) tasks.

# Sectors and occupations have demographic bias

Therefore job losses spurred by AI will have demographic bias



Discussions of the demographic impact of AI have been mute, but there are clear patterns in jobs by race/ethnicity. Employment shocks will thus show bias:

- 1 in 5 nurses in California are Filipino; 1 in 4 overseas nurses is Filipino
- Over 90 percent of truck drivers in Canada are white males; 2/3 of American truck-drivers are white males

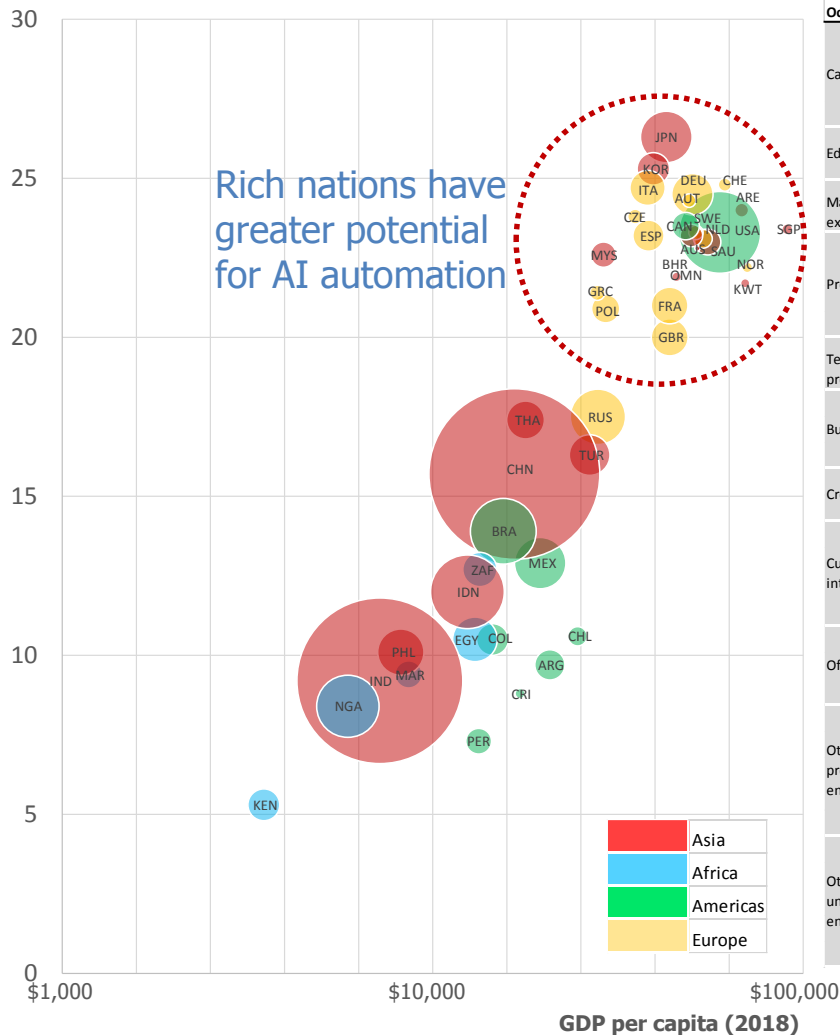
Many occupations have demographic biases in age, gender, ethnicity/race, language, etc. Just as much they may have different educational profiles and fields of specialisation(s) which themselves have a demographic bias.



# AI's impact across countries will be uneven

## Its impact will vary by national income and industry structure

% current work activities displaced by AI  
(2016-30)



		GDP/capita (PPP)					
		7,200	16,600	19,500	42,700	50,200	59,500
Occupation group	Example occupational categories	India	China	Mexico	Japan	Germany	USA
Care providers	Doctors						
	Nurses, physicians assistants, pharmacists						
	Childcare workers						
	Community & social workers						
Educators	School teachers						
	Education support workers						
Managers & executives	Executives						
	Managers						
Professionals	Account managers						
	Engineers						
	Scientists & academics						
	Legal support workers						
Technology professionals	Computer engineers						
	Computer specialists						
Builders	Architects, surveyors, cartographers						
	Construction workers						
	Crane & tower operators						
Creatives	Artists & designers						
	Entertainers/media workers						
Customer interaction	Personal care workers						
	Food servicing workers						
	Sales workers (retail & online)						
	Hotel & travel workers						
Office support	Computer support workers						
	Financial workers						
	Administrative assistants						
Other jobs, predictable environments	Production workers						
	Material machine moving operators						
	Agricultural graders & equipment operators						
	Food preparation workers						
	General mechanics						
Other jobs, unpredictable environments	Specialised mechanics & repair						
	Emergency first responders						
	Machinery installation & repair workers						
	Agricultural field workers						
	Building & ground cleaners						

Key

% change

≤ -35 -25 to -34 -15 to -24 -5 to -14 -5 to +5 5 to 24 25 to 49 50 to 99 ≥ 100

# AI technological change will favour rich countries

Rich nations better prepared to leverage AI technologies



Automation  
Readiness  
Index



Intelligence  
Capital  
Index



- The countries most prepared for the AI revolution are advanced economies, possibly creating a 2<sup>nd</sup> Great Divergence vis-à-vis the rest of the pack as they capture the productivity gains of automation
- The only non-rich nations in the group above are China and India. Both are undergoing rapid growth (catching up to their intrinsic levels) and benefit from a large population (and economy) with high-performing elites
- The AI gold rush will be won by large enterprises (Amazon, Google, Huawei, Microsoft, Tencent) just as much as by powerful nations. But these giants are almost exclusive to either China or the USA

Number of  
AI firms

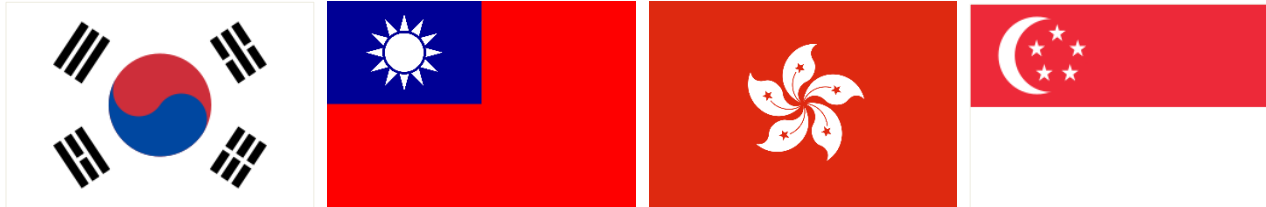


Top AI talent

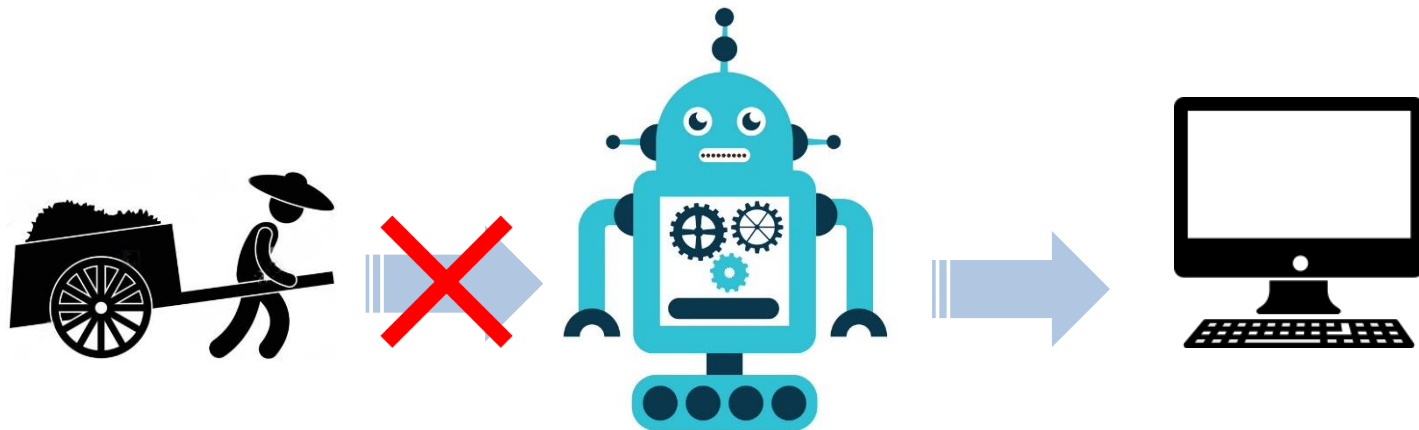


# AI might dampen development opportunities

## Robots may reduce low-cost/low-wage advantage of emerging economies



When multinational corporations were searching for low-cost manufacturing options in the 1960s they helped spur the development of the Asian Tigers

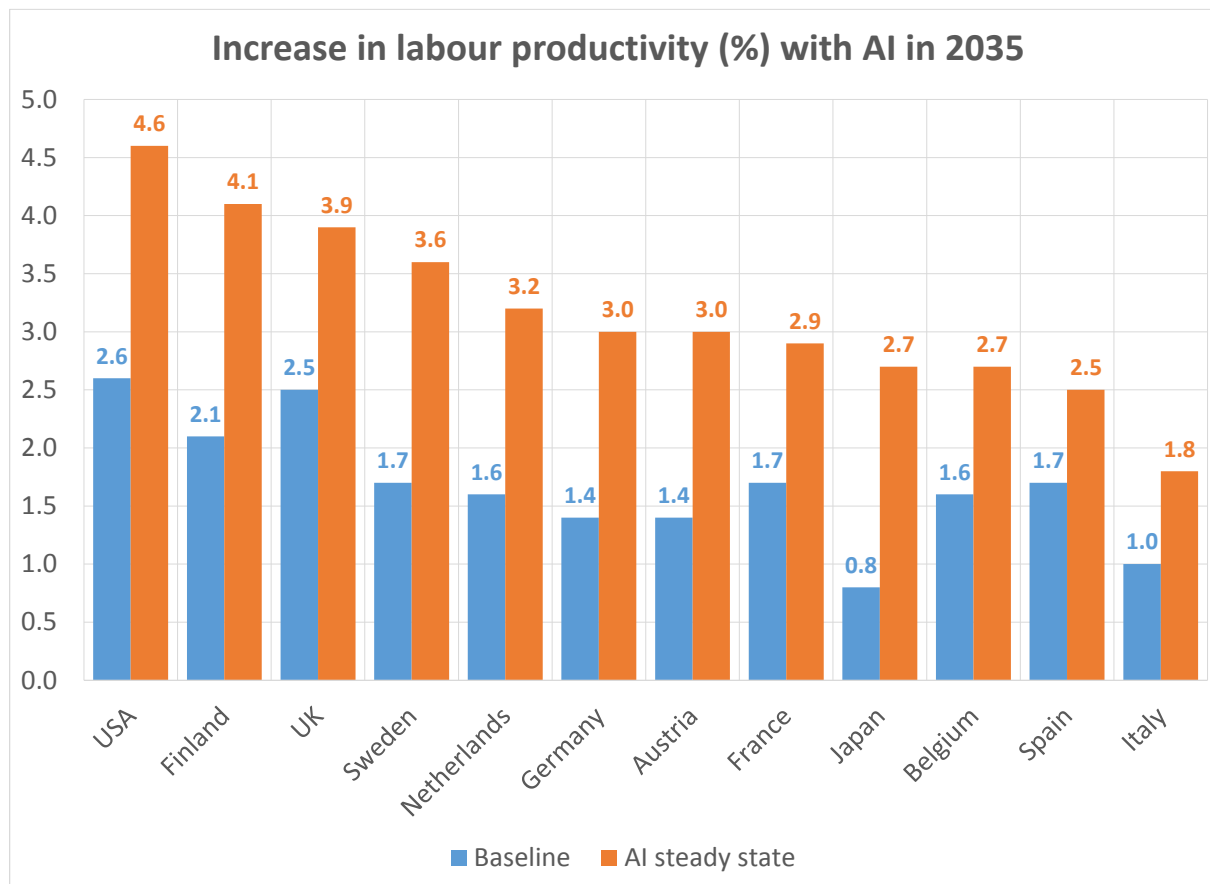


- In the 21<sup>st</sup> century intelligent robots may become cost-effective alternatives to labour in emerging economies, thus diminishing a channel of growth for developing nations
- In fact, smart machines may drive on-shoring of jobs that that had previously been off-shored

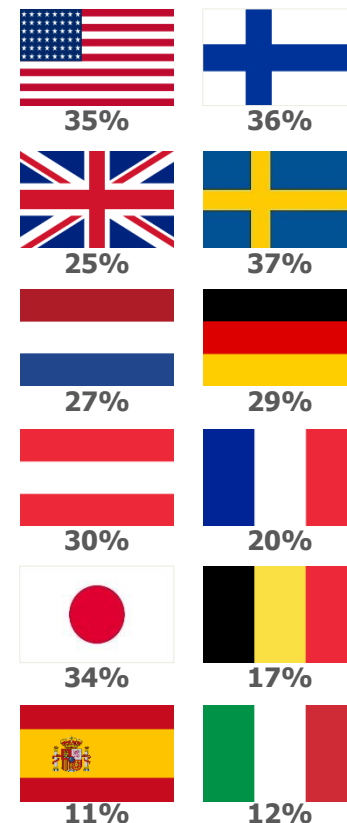


# Rich countries set to reap productivity gains

Bias in favour of rich countries and against EM → Second Great Divergence?



Increase in labour productivity from AI



- Will the Fourth Industrial Revolution see a Great Divergence redux between AI-enabled nations and those that are not?
- Or will it present an opportunity for developing countries to leapfrog to the frontier?



# AI expected to exacerbate migration pressures

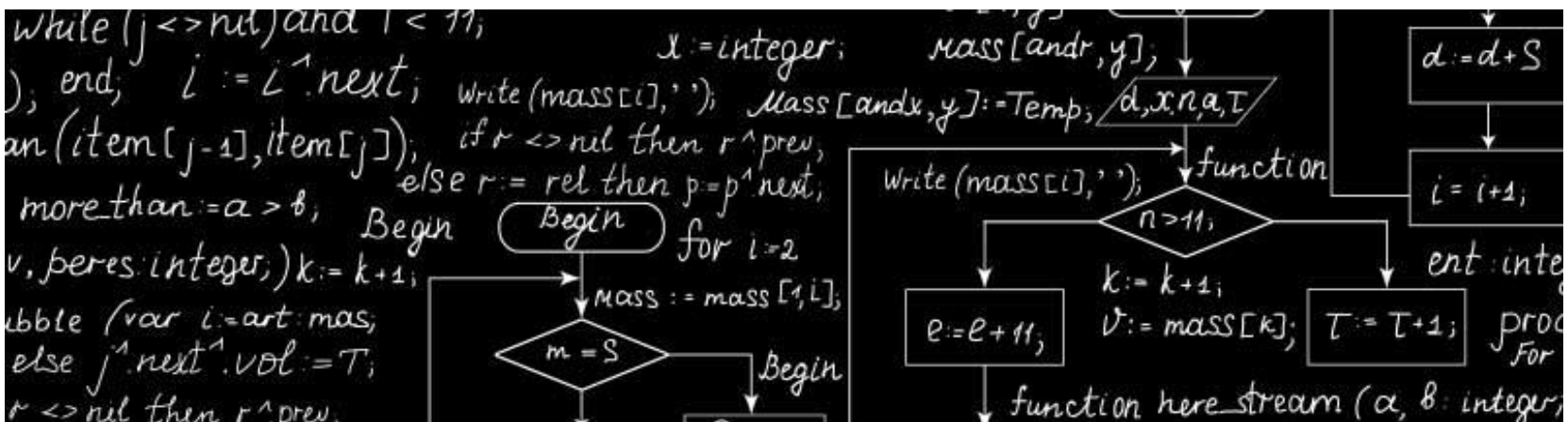
A rising tide of migrants for a world with less jobs for them



- The forces behind international migration will grow over time, fed by both global climate change and the macro inequalities of AI
- Micro inequalities of AI, on the other hand, will stress low-skilled migrants who will find less employment opportunities available for them as low-skill jobs are increasingly done by smart robots. (This is the case in Germany, where many of the migrants who came in do not have the skills required of the German economy.)
- Migration (even when desired by the host) has been fraught with difficulties at the best of times (especially in certain geographies). New dynamics will stoke even more tensions

# AI might exacerbate/perpetuate market biases

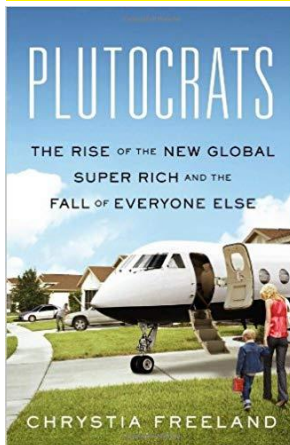
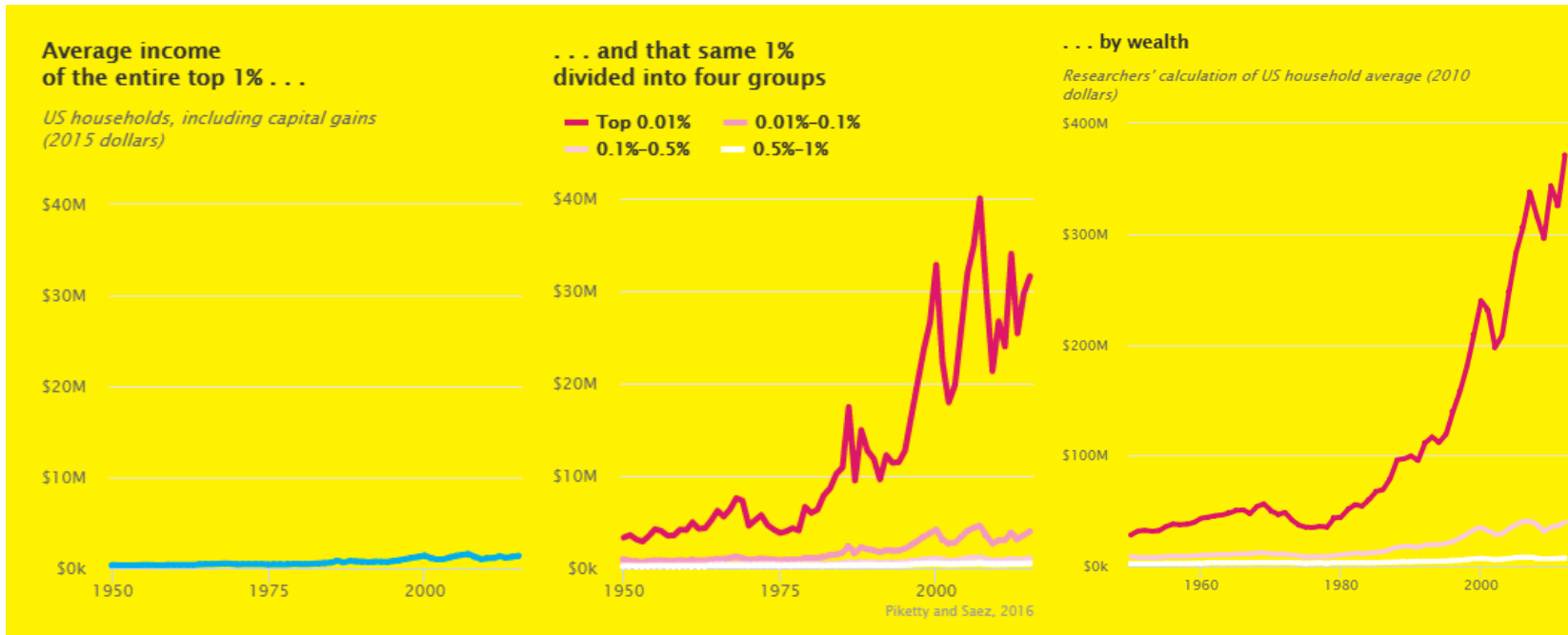
AI only as smart as its human programmers



- AI analytics (Big Data) likely to yield the “valedictorian” solution, rather than to produce game-changing innovation. (Valedictorians rarely are societies’ innovators.\* Would an HR-algorithm ever recommend to hire a dropout?)
- In fact, many of the great innovations/inventions happen by chance and based on seemingly contrarian solutions and chance. For example, no statistical algorithm would have ever suggested Dubai in the 1970s to aspire to become a travel hub and tourist destination. Likewise, all “wise” economic advisers in the 1960s told Korea to pursue its ginseng business and that its ambition to be a leader in heavy industry was foolhardy
- Algorithms may reinforce current biases, especially if they use historical data to infer future outcomes or derive their solutions; they may thus create self-fulfilling prophecies, entrench bias and increase inequality

# Financial benefits of AI captured by super elite

## Huge gains in wealth but they have accrued mostly to the "super elites"



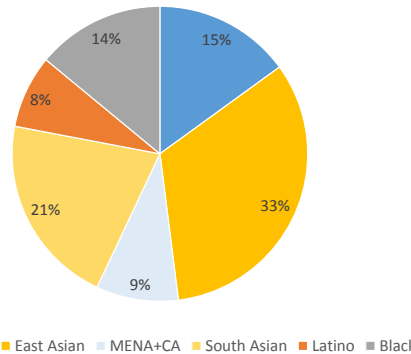
- 3 richest Americans' wealth > the bottom 50% of the country
- 42 richest persons in the world own more wealth than the global bottom half (3.7 billion)
- World's billionaires' (2,208 of them) net worth > GDP of Germany\*
- Surplus from innovations go to innovators (a small group) → large amounts of wealth to a few (e.g. Bezos (\$112B), Gates (\$90B), Zuckerberg (\$71B), Page (\$49B), Brin (\$48B))

# Income & wealth have a demographic bias

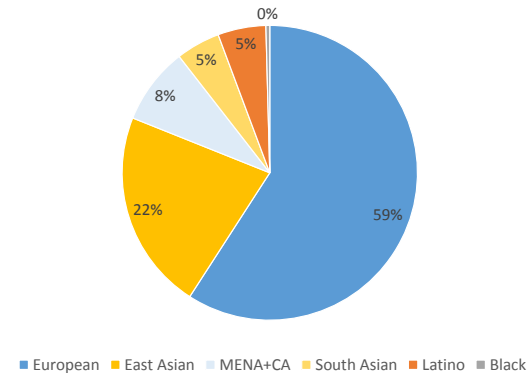
## Demographic bias across and within countries



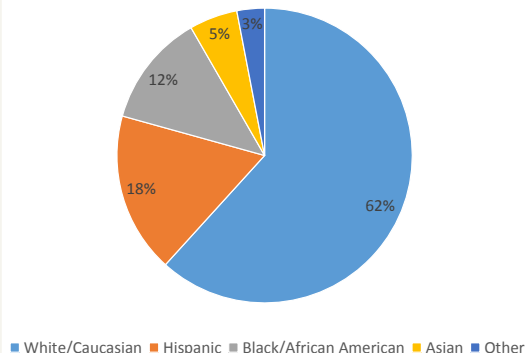
World population by race/ethnicity



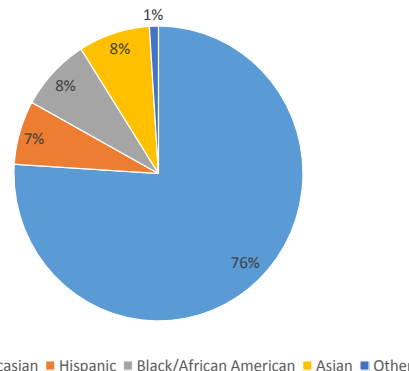
World billionaires by race/ethnicity (Forbes 2013 list)



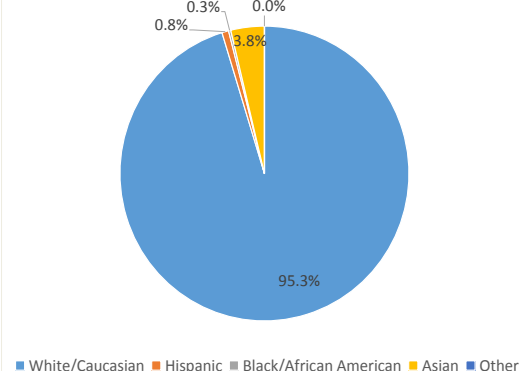
Distribution of US population by race/ethnicity



Distribution of US millionaires by race/ethnicity



Distribution of US billionaires by race/ethnicity



- Super elites are not a reflection of the general society (or even of the “casual elites”) in multicultural societies. They are drawn from a population that is more homogeneous (and who likely have different opinions on redistribution)
- On a global scale, such discrepancies can be overlooked, but when communities live side by side and large discrepancies arise it may engender social discontent



# AI → visible inequality in multicultural societies

## Employment outcomes & gains/losses from AI correlated with background



### Multi-pronged demographic bias of AI:

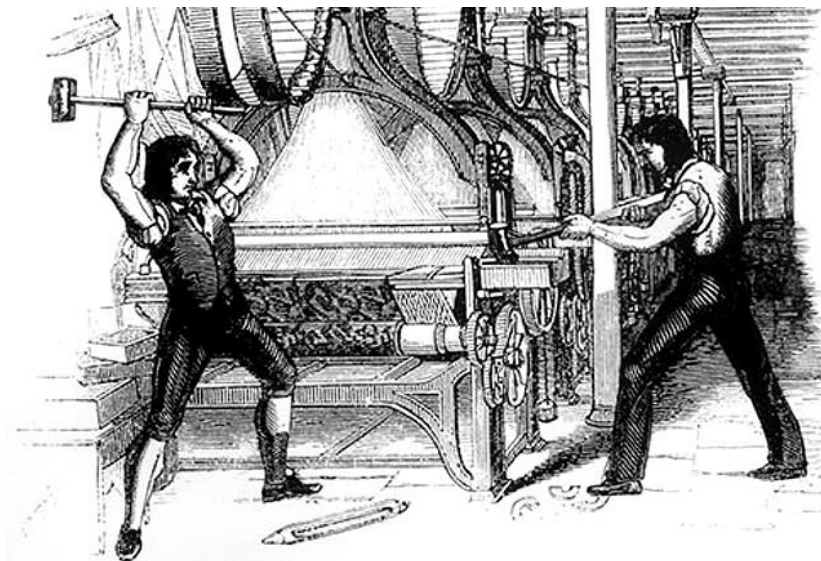
- The jobs that AI will displace (or enhance) have a demographic bias (age, gender, ethnicity, language, etc.)
- AI algorithms risk perpetuating current biases as the algorithms are designed by humans with their own inherent biases, and the algorithms are likely to rely on historical data which will perpetuate historical biases
- Differences in uptake/usage of AI technologies by groups, which are correlated with income and education (Integer Group, 2018)
- A knowledge-based economy favours those with high education and human capital, traits that have sharp differences across communities
- Monetary gains from AI will accrue to capital owners (few), while unemployment will be borne by labour (masses)





# AI technology is not Pareto improving

Although society gains (in productivity), a large segment will be worse off



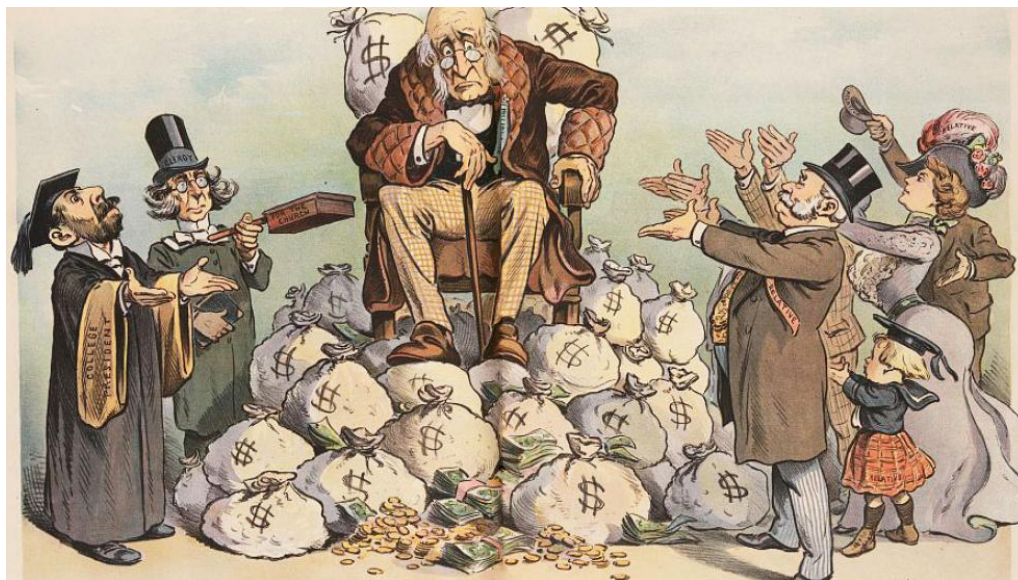
- How to compete with machines that do not sleep, do not require benefits, do not unionize and do their jobs without complaint?
- Is the yellow vest phenomenon a modern-day Luddite movement?
- "There are clear parallels to the situation today in that a significant fraction of the workforce may not have the skills required to succeed in the age of AI... [W]ithout adequate redistribution, it makes sense for workers to resist [AI] innovation."

*Korinek & Stiglitz, 2017*

# Even if AI is Pareto improving...

## Relative outcomes matter

- Pareto improving policies do not make anyone worse off in absolute terms, but they may still represent socially undesirable outcomes that lead to greater relative disparities. Nevertheless, there exists a set of transfers from beneficiaries to losers that makes all better off (at least in theory)
- But we have already seen that winners are reluctant to share their prosperity (perhaps under the misguided lens of our meritocracy), and have enacted laws and implemented institutions to guard their privileged position
- Moreover, any redistribution policy would be fraught with group politics as people fight for their perceived fair share of the pie

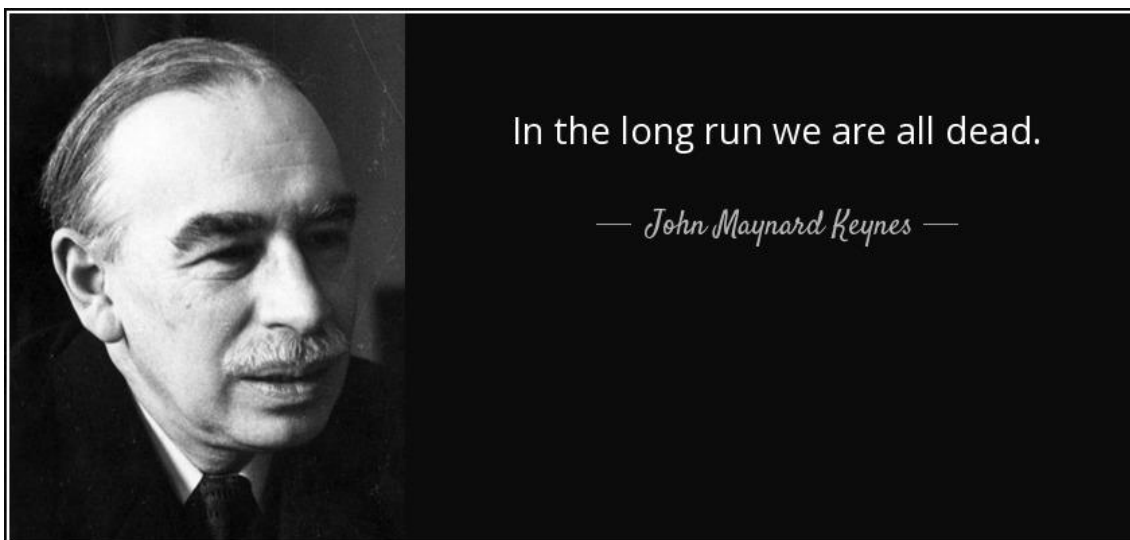




# AI will benefit society in the long run...

"[But] in the long run we are all dead." (John M. Keynes, 1923)

- Cold comfort to those negatively affected by AI that the technology/change benefits society. Not all displaced workers will be able to retrain and transition to other jobs. Moreover, many will transition to a lower-paying job or one with a skills mismatch. In the long run society will move towards a more productive and efficient outcome, but as John Keynes famously said: "In the long run we are all dead."
- "No matter what the long-run implications of AI are, it is clear that it has the potential to disrupt labour markets in a major way, even in the short and medium run, affecting workers across many professions and skill levels."  
-- *Korinek & Stiglitz, 2017*





# Left unmanaged AI will exacerbate inequality

## And the inequality will have a distinct demographic bias



- Technological unemployment is a scary fact and will be a reality for many. The growing and highly visible nature of the inequality that will arise from AI will stoke already-high levels of social discord
- A large population of people with no real prospects in life, especially among men, has invariably been a recipe for disaster (i.e. war) in the past\*
- Populism, anti-globalisation, etc. are all symptoms of discontent by the people. AI, if left unmanaged, will exacerbate these tensions

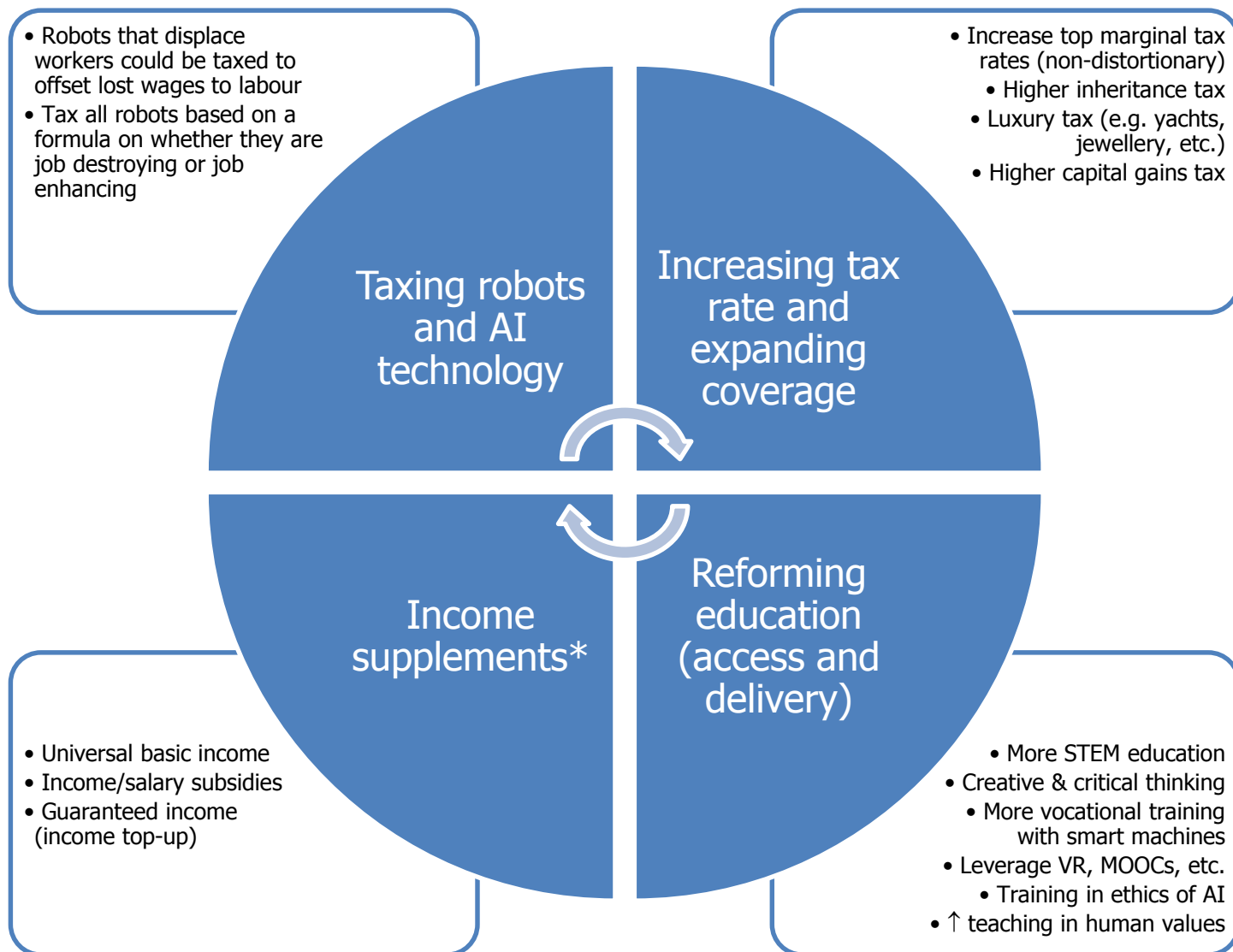
\* "Of men and mayhem: Young, single, idle males are dangerous. Work and wedlock can tame them." *Economist* January 23, 2016





# AI is inevitable and will make society richer

But to avoid its negative externalities will require good policy & management





# Conclusion

AI will exacerbate inequality & demographic bias unless actions are taken

- AI (automation) is the driver of the so-called Fourth Industrial Revolution, which will unleash large productivity gains propelling the world to greater riches
- However, the gains will be uneven, with winners and losers from the technology
- Labour will lose and capitalists will win as AI technology will generate productivity by replacing human labour with computer smarts
- Certain occupations and tasks are more susceptible to AI. Since there are demographic biases in the labour market, the expected AI-generated job displacements will likewise show a demographic bias. These disparities will be highly visible, especially in multicultural societies, and may cause discord
- AI will upend traditional paths of economic development. Low-skill/low-wage jobs are less likely to be offshored and instead done at home by AI technology
- Already-rich capitalists will be the winners from the AI revolution. But the winners are not the so-called 1 percent; rather, they are the “super-elite” 0.01 percent (i.e. the 1 percent of the 1 percent)
- Just as there are demographic biases associated with the jobs prone to AI automation, so too is there a demographic bias in who comprise the super-elites
- AI will exacerbate already-high levels of inequality if left unmanaged. Policy makers need to enact sound strategies to harness its benefits while mitigating its negative facets