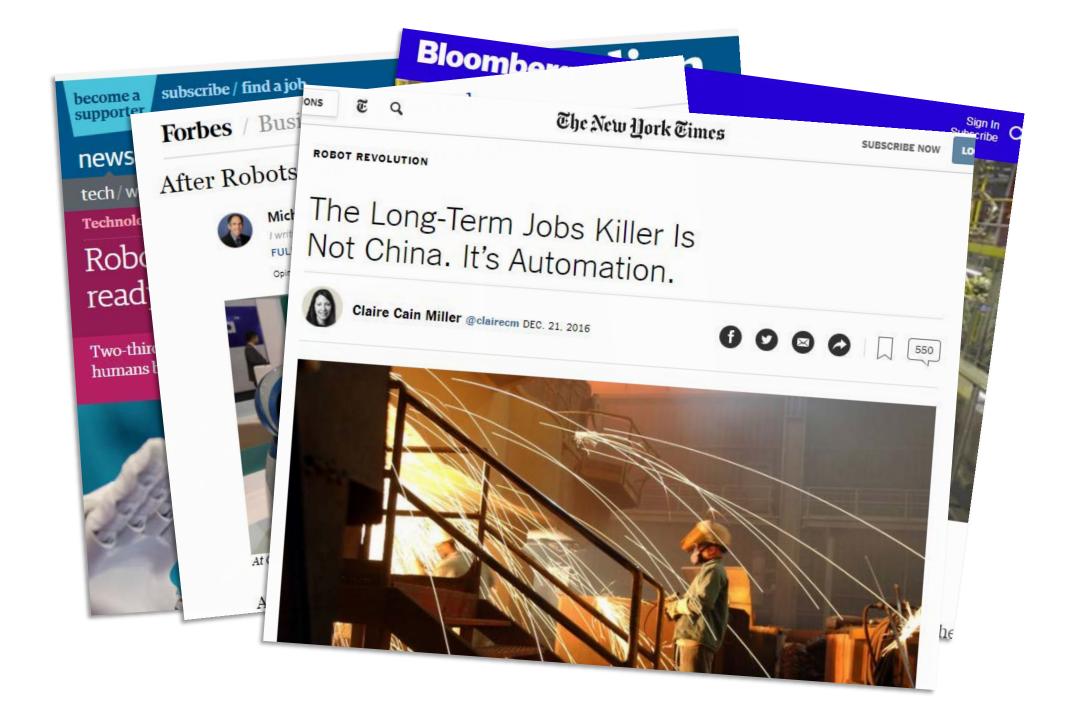
The rise of robots and structural economic change

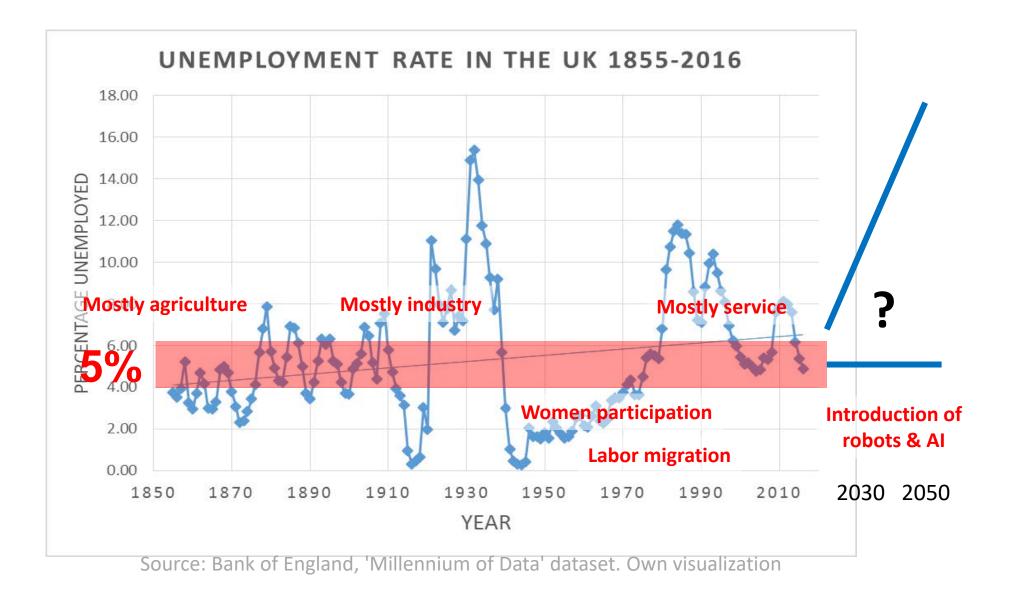
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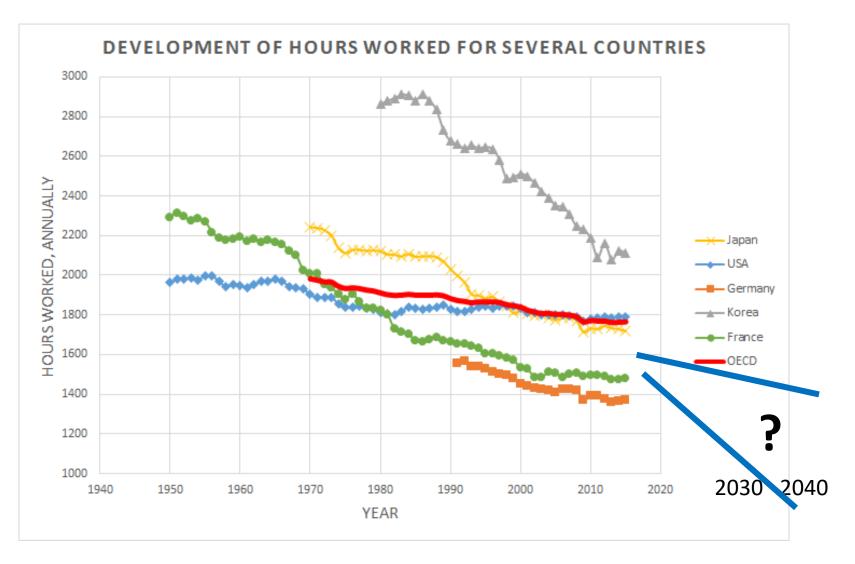
RoboPhilosophy 2018

Mentimeter

From fear-mongering speculation on the future of employment to historical trends







DEVELOPMENT OF HOURS WORKED, ANNUALLY, FOR SEVERAL COUNTRIES (SOURCE: OECD DATA, OWN VISUALIZATION)

What is happening, technologically?

Technological change (Joseph Schumpeter)

Invention

(Conception of new ideas)

Innovation

(Creation of marketable products & processes by entrepreneurs)

Diffusion

(Market demand, societal uptake, imitation by competitors)

Absolute # of "robot*" patent families / year / country

2000 1800 1600 1400 1200 -----KR Nr per year -US 1000 - DE FR 800 -SU —TW 600 ——______SE 400 200 0

Nr patent families per year by country

Source: Visualization of extracted and processed EPO data.

Absolute # of "robot*" patent families / year / country

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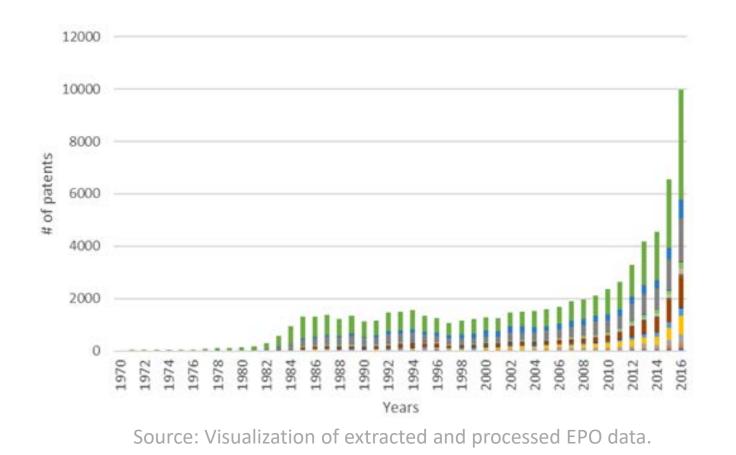
Nr patent families per year by country

Source: Visualization of extracted and processed EPO data.

2000

0

patent families by field (~NACE sector)



Agriculture Personal or domestic articles Separating; Mixing Transporting Chemistry Combinatorial technology Paper Earth or rock Engineering in general Weapons; Blasting Nucleonics Shaping Food Stuff; Tobacco Health; Life-saving; Amusement Printing Microstructural Technology; Nanotechnology Metallurgy Textiles or flexible materials ■ Building Engines or pumps Lighting; Heating Instruments

Electricity

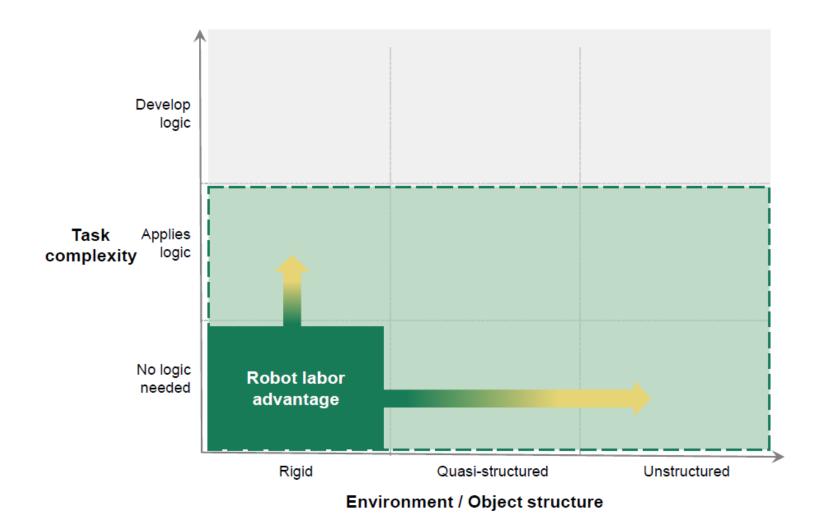
However, it is not just manufacturing...

"Technological profile" of countries

Country	Second specialization	Third specialization	Fourth specialization
China	Health; Life-saving; Amusement	Personal or domestic articles	Engineering in general
China	39,32%	16,90%	14,45%
lanan	Health; Life-saving; Amusement	Engineering in general	Building
Japan	30,12%	18,59%	8,27%
Germany (+ DDR)	Health; Life-saving; Amusement	Engineering in general	Building
Germany (+ DDR)	27,19%	23,50%	11,80%
Popublic of Koroo	Personal or domestic articles	Health; Life-saving; Amusement	Engineering in general
Republic of Korea	41,73%	32,03%	6,61%
US	Health; Life-saving; Amusement	Metallurgy	Personal or domestic articles
05	47,54%	10,58%	8,61%
Sweden	Agriculture	Engineering in general	Weapons; Blasting
Sweden	52,77%	15,63%	7,56%
Great Britain	Health; Life-saving; Amusement	Engineering in general	Personal or domestic articles
Great Britain	38,51%	22,24%	13,26%
Switzerland	Agriculture	Textile or flexible materials	Engineering in general
Switzenanu	32,94%	27,99%	15,84%
Netherlands	Agriculture	Health; Life-saving; Amusement	Building
Nethenanus	80,17%	8,86%	2,72%

Source: Extracted and processed EPO data.

What may change in your job, your tasks?



DOMAIN OF APPLICATION OF ROBOTS IN TERMS OF ENVIRONMENT STRUCTURE AND TASK COMPLEXITY. SOURCE: WOLFGANG, M. (2016). BOSTON CONSULTING GROUP.

What may change?

- Jobs are vanishing: virtually all tasks are taken over by robots / Al
- Jobs are created:
 - Researching, developing & building robots, components, services
 - New fields of application
 - Training people using robots, AI, etc
- Jobs are affected indirectly: disposable income changes (concentrates?) so people spend more/ less on particular discretionary goods like entertainment, leisure, traveling..
- Task content changes: same work but new tools (with higher productivity/ efficiency/ success rate)
- Task set is shifting: some tasks are taken over by robots, allowing emphasis on others (e.g. creative intelligence, social interaction), but also calls for new complementary tasks (e.g. programming, maintaining robot)
- New sectors/ jobs:
 - "Free hands" start providing new services, make new products
 - New technology calls for new skills (yielding even more new technology)

Multisectoral perspective on effects of robotics & AI on employment

		Developing & producing, Supplying & supporting	Applying	Facilitating	Spillover
Existing Transforming	Substitution Exploitation of complementarities & new tools	Increasing employment (higher demand)	Decreasing employment for jobs due to substitution; Increasing employment for jobs with complementarities; Possibly increasing employment due to possibly increasing demand	Increasing employment (higher demand)	Employment depends on dispensable income
Emerging	Exploitation of new skill sets				

Impact "Industry 4.0 technologies" on (NAICS) sectors 2016 - 20260gV (BLS outlook)

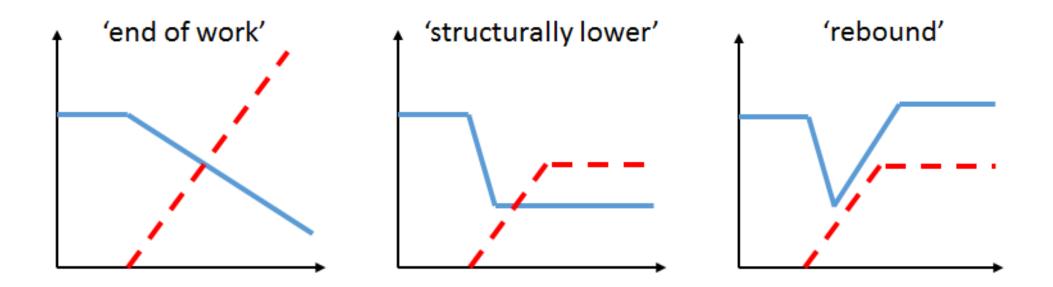
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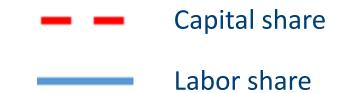
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14031 Catting, punching, and press machine setters, operators, and tenders, metal and plastic 0 -0.4 0 0 0.4 0 0 0.4 0 0 0.4 0.0 0 0.4 0 0 0.4 0 0 0.4 0.0 0.4 0.1	4031 Curting, punching, and press machine setters, operators, and tenders, metal and plastic 0 -0.4 0 0 -0.4 0 0 -0.4 0 0 -0.4 0.2 -0.45 1023 Purchasing gends, except wholesis, well, and fam products -0.1 0.3 -0.1 0.1 0.1 0.1 0.1 0.1 0.2 -0.4 0.2 -0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 0.2 0.4 <t< td=""><td>3-4191 3-4071 3-4071 3-4091 3-5061 3-5061 3-5041 3-5041 3-5041 3-5041 3-5041 3-4022 3-4022 3-4022 3-4022 3-4022 3-4023 3-4122 3-4123 3-4122 3-4123 3-4122 3-5011 3-5011 3-5011 3-5023 3-5011 3-5023 3-9011 3-9011 3-4021 3-901 3-9011</td><td>Hest treating equipment wetwork, operators, and tenders, metal and plastic Foundary mole and communics Destricts plants and system operators Producement cleaks Producement cleaks Producement cleaks Producement wetwork Milling and plants exters, operators, and tenders, metal and plastic Order cleaks Polytog machine setters, operators, and tenders, metal and plastic Cleans adjusters, expensions, and tenders, metal and plastic Weiding, addition, and howeligators Plasting and costing machine setters, operators, and tenders Programs techniciens and workers Mail cleaks and mail machine setters, operators, and tenders Programs techniciens and workers Mail cleaks and mail machine operators Programs techniciens and workers Mail cleaks and building machine tool setters, operators, and tenders, metal and plastic Ell and down cleaks Aircraft tructure, surface, rigging, and systems assemblant Cleansing, politing, and building machine tool setters, operators, and tenders, metal and plastic Ell and downed machine setters Computer coperators Electromechanics leguptoret assemblants Computer coperators Electromechanics leguptoret assemblants</td><td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td></t<>	3-4191 3-4071 3-4071 3-4091 3-5061 3-5061 3-5041 3-5041 3-5041 3-5041 3-5041 3-4022 3-4022 3-4022 3-4022 3-4022 3-4023 3-4122 3-4123 3-4122 3-4123 3-4122 3-5011 3-5011 3-5011 3-5023 3-5011 3-5023 3-9011 3-9011 3-4021 3-901 3-9011	Hest treating equipment wetwork, operators, and tenders, metal and plastic Foundary mole and communics Destricts plants and system operators Producement cleaks Producement cleaks Producement cleaks Producement wetwork Milling and plants exters, operators, and tenders, metal and plastic Order cleaks Polytog machine setters, operators, and tenders, metal and plastic Cleans adjusters, expensions, and tenders, metal and plastic Weiding, addition, and howeligators Plasting and costing machine setters, operators, and tenders Programs techniciens and workers Mail cleaks and mail machine setters, operators, and tenders Programs techniciens and workers Mail cleaks and mail machine operators Programs techniciens and workers Mail cleaks and building machine tool setters, operators, and tenders, metal and plastic Ell and down cleaks Aircraft tructure, surface, rigging, and systems assemblant Cleansing, politing, and building machine tool setters, operators, and tenders, metal and plastic Ell and downed machine setters Computer coperators Electromechanics leguptoret assemblants Computer coperators Electromechanics leguptoret assemblants	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
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14072 Molding, covernaling, and carting methins setters, operators, and tenders, metal and plastic 0 -0.2 0 0 -0.1	4072 Molding covernaling and catting machines setters, operators, and tenders, metal and plastic 0 -0.2 0 0 -0.1 <	3-4194 3-4071 3-4071 3-4094 3-5061 3-502 3-502 3-502 3-4022 3-4022 3-4022 3-4022 3-4022 3-4023 3-4023 3-4023 3-4023 3-4023 3-4023 3-4023 3-4031 3-5011 3-5011 3-4021 3-4031 3	Hest treating equipment extent, operators, and tenders, metal and plastic Foundry mold and commakers Obernical plant and hystem operators Procumered clerks Wholesals and relial buyers, escept farm products Parking enforcement workers Milling and planting machine setters, operators, and tenders, metal and plastic Order clerks Forging machine setters, operators, and tenders, metal and plastic Calins equations extern, operators, and tenders insurance underwriters Tool and dis makers Engine and other machine seamblers Prepress tenhnicians and workers Mail clerks and mail machine operators, except postal services Alacreft structure collection Electromechanical equipment assemblers Computer operations. Computer operators Structure metal backcions and fitters Control discons and fitters Control discons and fitters Control discons and fitters.	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
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Source: Own visualization of extracted & processed BLS OO data

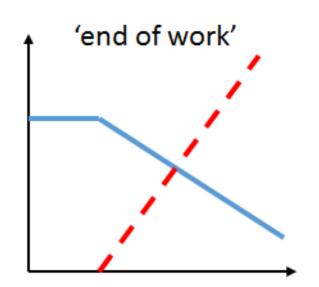
		Producing & developing, Supplying & supporting	Applying	Inhibiting or Facilitating	Spillover
Vanishing occupations	Most tasks substituted for. Few tasks substituted for, several complementary tasks added to exploit substituted tasks.	Robot designer; Robotic system engineer; Robotic system designer; Software engineers; Electrical & electronical engineers	<section-header><section-header> Examiners, investigators, readers, data keyens: Ayers and purchasing agents; Caims adjusters, appraisers, examiners, and investigators; inverse of underwiters; Survey researchers; Parking enforcement workers; Communications equipment operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and account collectors; Dispatchers, except emergency; Meter readers, utilities; Computer operators; Bill and except except emergency; Meter readers, utilities; Computer operators; Bill and account index and end ther machine assemblers; Farmworkers and abores, rop, ursery, and greenhouse; Inspectors, testers, sorters, samplers, and weighers; Graders and sorters; Forest Conversation by there; Millesine and Babricators; </section-header></section-header>	Teachers, lecturers, Lawyers, legal secretary work Incubators [Losing in the vanishing, gaining in the emerging occupations]	Recreation: Recreation Workers; Anters: Anters: Anters: Arters
Transforming occupations	Same occupation but alternative tools, technologies [Higher productivity, higher efficiency, lower failure rate, etc.]	Electrical and Electronics Engineers; Industrial engineers, including health and safety; Mechanical Engineers; Industrial machinery installation, repair, and maintenance workers;	Computer numerically controlled machine tool programmers, metal and plastic Stock clerks and order fillers; Human resource specialists; Customer service representative; First-line supervisors of transportation and material-moving; Receptionists and information clerks Mathematicians; Statisticians; Operations research analyst		
Emerging occupations	New skills, new technology, new specializations [Creation and exploitation of new technologies creating new demand]	 Employm in big-data driven model & system: Big data model designer; Information Systems architect;; Composite Engineer; Smart Management Systems Architect; Employm in robotics & Al in health care: Bioinformatician; Ergonomic designer Medical Equipment designer; Employm in robotics & Al in agriculture: Agricultural Informatics and Engineering Expert; 	In big-data model & system: Telemetric data interpretation engineer; Operating Data Analyst; In health care: Medical Data Manager; Medical Robot Operator Remote Security Coordinator; In agriculture: Automated farming equipment operator; Robot attendant Miscellaneous: 3D printing designer in construction; Smart Travel System Designer; Clothes 3D model programmer;	Robotics Lawyer Robotics teacher	Media Software Designer; Game designer Virtual & augmented reality engineer

Implications for employment at the macro-level?





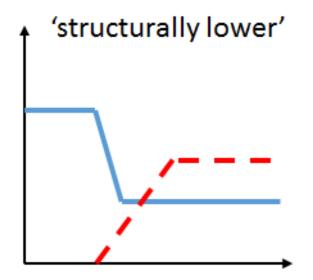
Effect over time: 'end of work' (race against the technology)



Conditions:

- Rate at which humans create new opportunities and can be reeducated and retrained for employment is lower than the rate of technological advancement
- Job *destroying* potential of technology through substitution outpaces the job *creating* potential of technology through complementarities (cf. MacCrory *et al.*, 2014) and creation of new sectors.

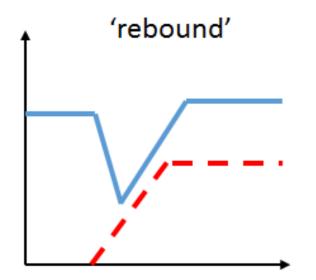
Effect over time: 'structurally lower'



Conditions:

- Rate at which humans can create new opportunities and be reeducated and retrained for employment is equal to the rate of displacement
- 2. Which is the case, if education moderates the pace of technological progress (stronger condition)

Effect over time: 'rebound'



Conditions:

- Education and creation of new sectors moderates the pace of technological progress, but people can catch up faster than technology can progress
- 2. Unemployment returns to a 'regular' rate of frictional unemployment

Measures to direct the effects of robots & AI on employment

- Get 'displaced' people to update skills into new occupations
 - Particularly those predispositioned, low prior educations, geographically immobile.
- How to stimulate people to engage in 'entrepreneurial activities', exploiting new technological opportunities?
- Which policies to stimulate inventiveness, innovativeness & diffusion ("dynamic efficiency")? How to facilitate the creation of new sectors?
- In response to Guy Standing: The measures above seem to curb 'precariatization' of labor. Admittedly, we ignore the "existential stress".

Mentimeter