Capitalism in an Age of Robots

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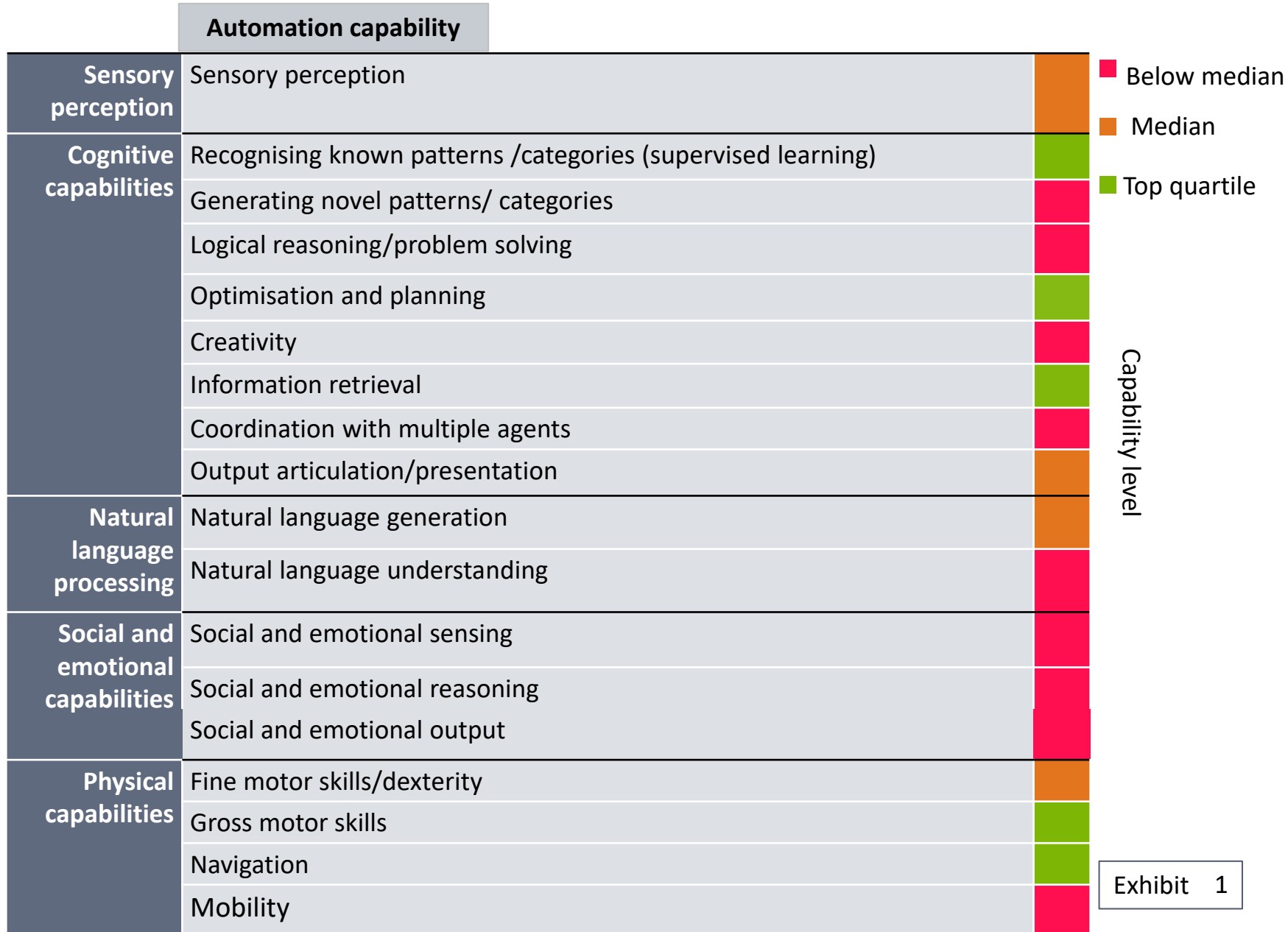Washington DC, 10 April 2018

Current automation capability versus humans performance

	Automation capability	Capability level
Sensory perception	Sensory perception	🟧 Median
Cognitive capabilities	Recognising known patterns /categories (supervised learning)	🟩 Top quartile
	Generating novel patterns/ categories	🟥 Below median
	Logical reasoning/problem solving	🟥 Below median
	Optimisation and planning	🟩 Top quartile
	Creativity	🟥 Below median
	Information retrieval	🟩 Top quartile
	Coordination with multiple agents	🟥 Below median
	Output articulation/presentation	🟧 Median
Natural language processing	Natural language generation	🟧 Median
	Natural language understanding	🟥 Below median
Social and emotional capabilities	Social and emotional sensing	🟥 Below median
	Social and emotional reasoning	🟥 Below median
	Social and emotional output	🟥 Below median
Physical capabilities	Fine motor skills/dexterity	🟧 Median
	Gross motor skills	🟩 Top quartile
	Navigation	🟩 Top quartile
	Mobility	🟥 Below median

Legend:
🟥 Below median
🟧 Median
🟩 Top quartile

Exhibit 1

Automation potential by type of activity

% of time automatable with current technology

	% of time in all US occupations
Predictable physical	81	18
Process data	69	16
Collect data	64	17
Unpredictable physical	26	12
Interface	20	16
Expertise	18	14
Manage	9	7

Source: McKinsey Global Institute, A Future that Works, 2017

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Exhibit 2
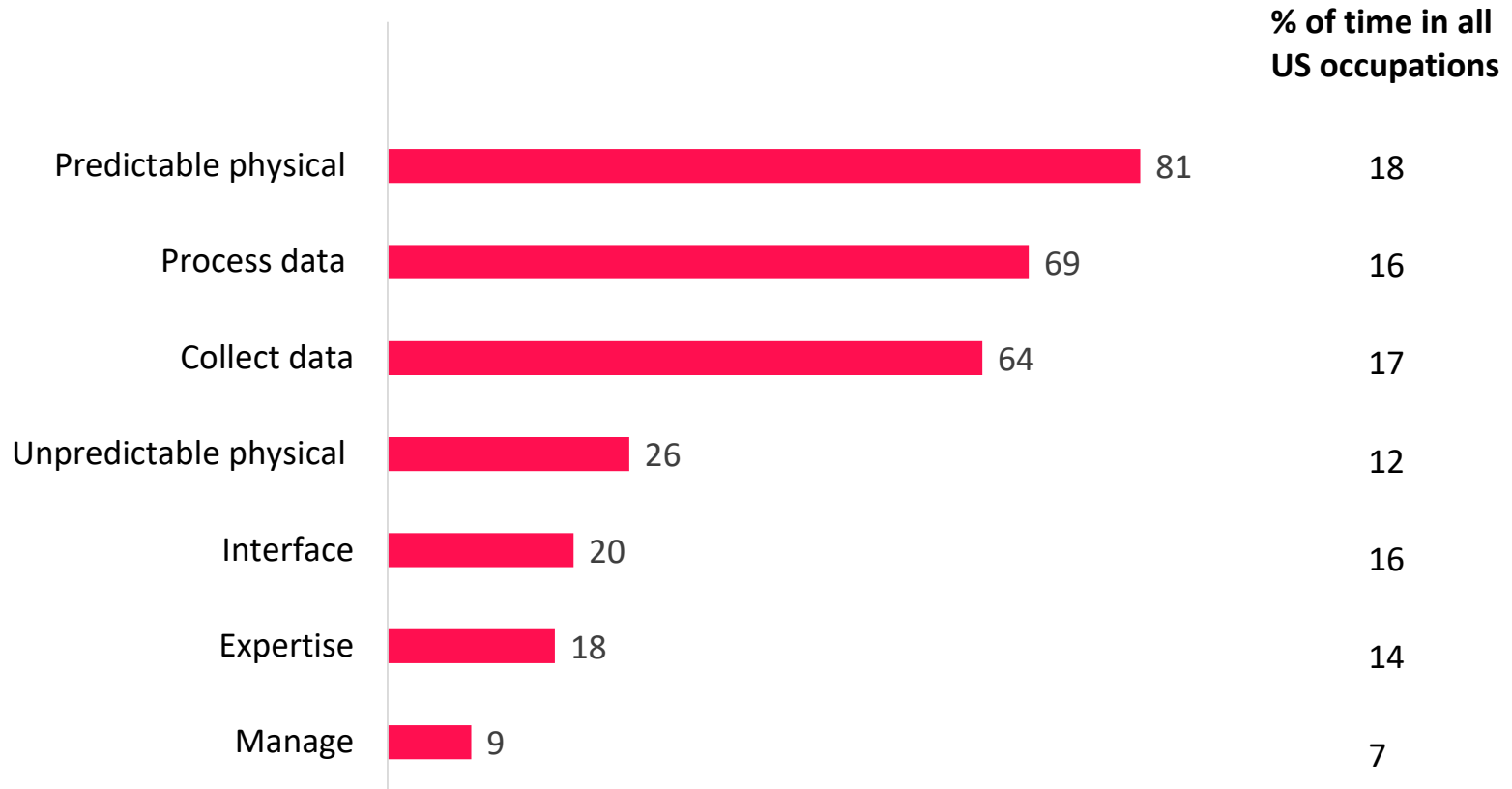
Automation potential by occupation

% of specific activities automatable

Example occupations

Sewing machine operators, graders and sorters of agricultural products	**High** ↑
Stock clerks, travel agents, watch repairers	
Chemical technicians, nursing assistants, Web developers	% of specific roles and time which can be automated
Fashion designers, chief executives, statisticians	
Psychiatrists, legislators	**Low** ↓

Source: McKinsey Global Institute, A Future that Works, 2017

Exhibit 3

Potential to automate by sector

% of time automatable with current technology

Sector	Value
Accommodation and food services	73
Manufacturing	60
Transportation and warehousing	60
Retail trade	53
Construction	47
Finance and insurance	43
Real estate	40
Health and social care	36
Professionals	35
Management	35
Education services	27

Source: US Bureau of Labor Statistics McKinsey Global Institute Analysis

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Exhibit 4

Scenarios for automation

Source: McKinsey Global Institute , A Future that Works, 2017

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Exhibit   5
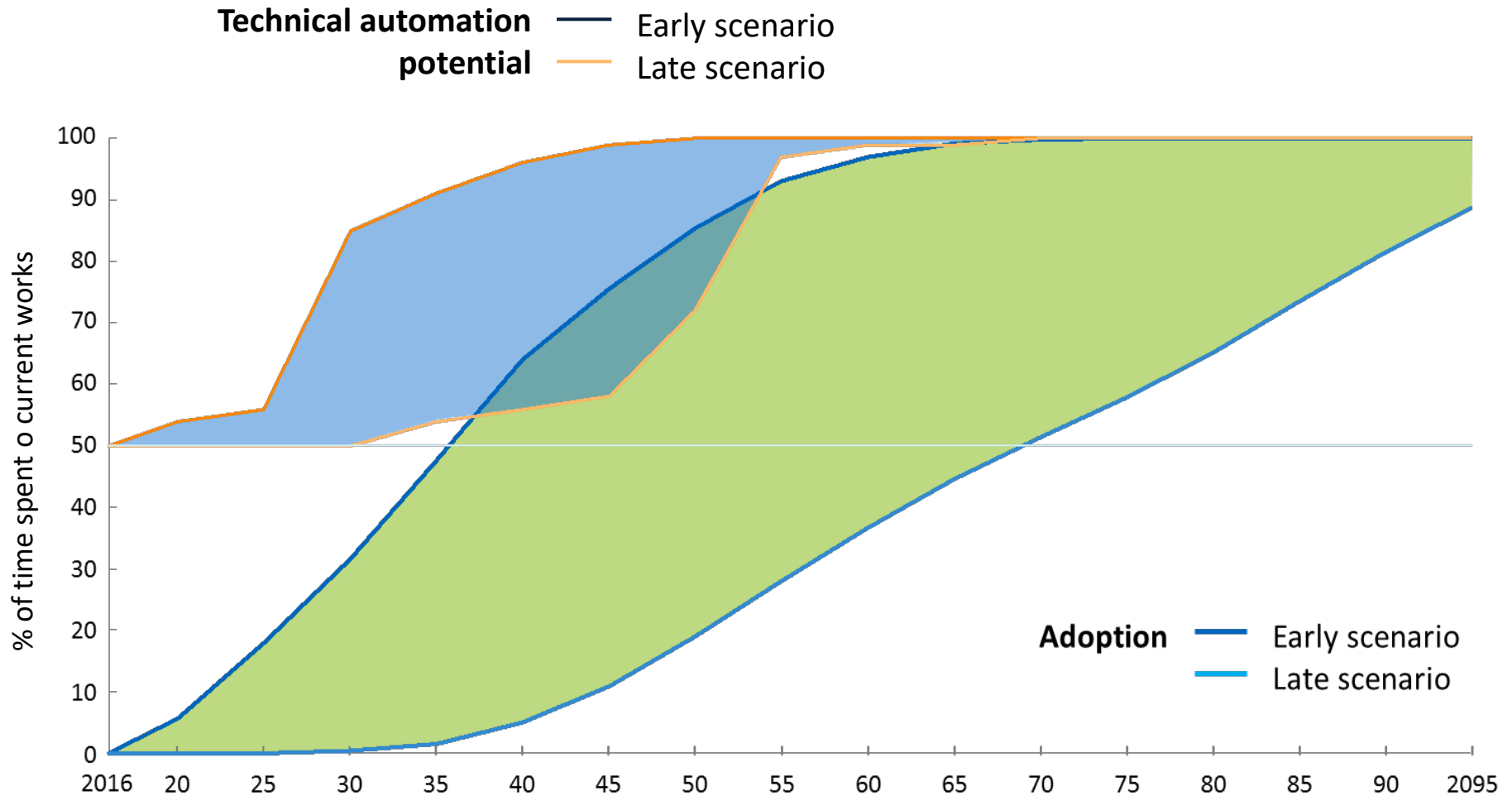
Productivity growth in the US

% per annum

Legend: ■ Output per person ■ output per hour

Chart data:
- 1870-1920: Output per person 1.84, output per hour 1.79
- 1920-1970: Output per person 2.41, output per hour 2.82
- 1970-2014: Output per person 1.77, output per hour 1.62
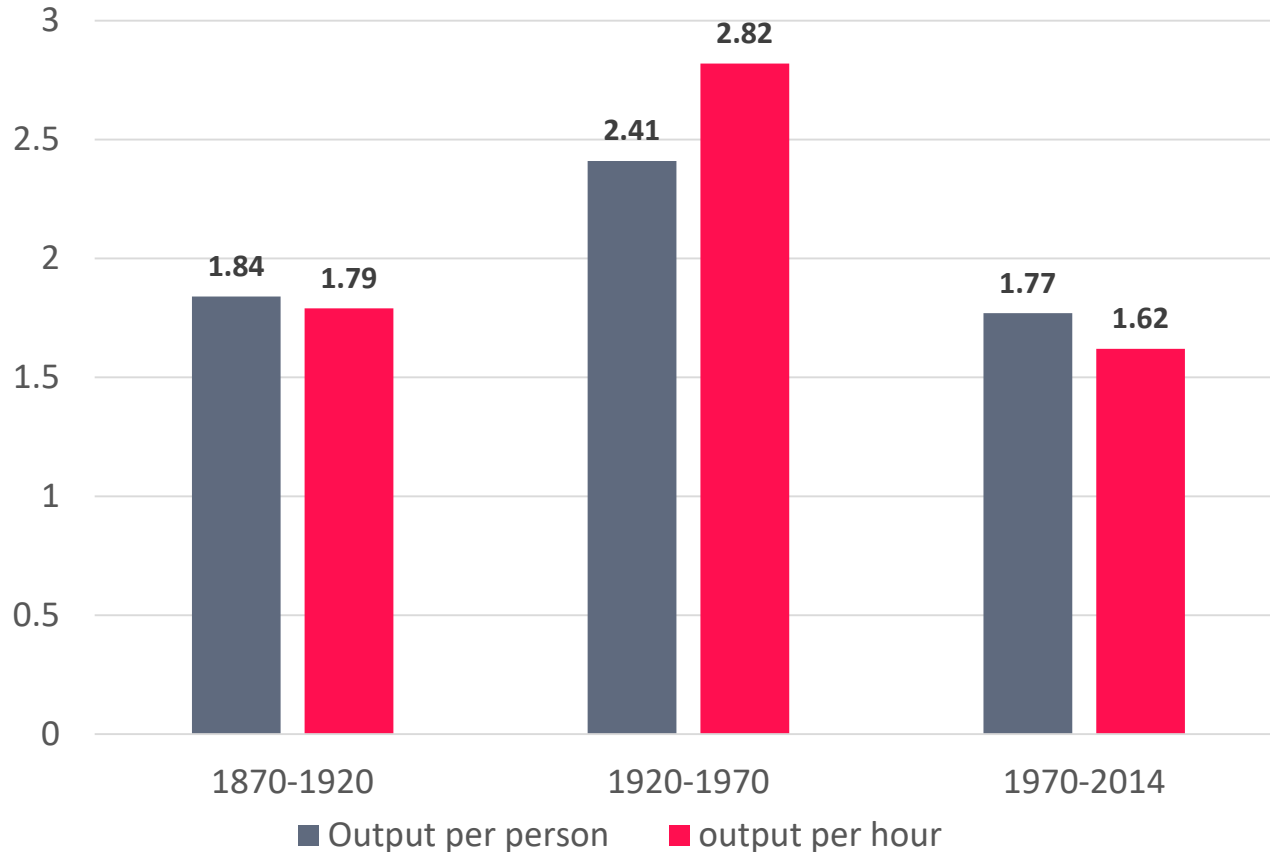
Source: Robert Gordon, *The rise and Fall of American Growth* (Princeton University Press, 2016

Exhibit 6

The standard paradigm

Starting Point

100 self-sufficient farmers produce 100 units of food

Technical progress

New position

50 farmers produce 100 units of food

50 workers produce 100 units of cars, washing machines, televisions, etc.

Measured total economy productivity doubles

Endlessly repeatable progress?

50 farmers produce 100 units of food

50 factory workers produce 100 manufactured goods

Further technical progress

➢ 25 farmers producing 100 food

➢ 50 factory workers producing 200 cars, washing machines, televisions

➢ 15 factory workers producing 60 units of computers, mobile phones and software applications

➢ 10 service workers producing 40 units of healthcare

400 units of value – productivity doubled again

Exhibit 8

The Baumol Effect

100 farmers produce 100 units of food

Technical progress

50 farmers produce 100 units of food

50 domestic servants paid ½ as much produce 50 units of value

- Agricultural productivity doubles

- Total economy productivity increased 50%

Exhibit 9

Asymptotic rather than endlessly repeatable progress

50 farmers produce 100 units of food

50 domestic servants produce 50 services

Double agricultural productivity

25 farmers 100 food

75 servants 75 services

Total measured productivity: +16.6%

Further progress

1 farmer 100 food

99 servants 99 services

Asymptotic limit at +100%

Exhibit 10
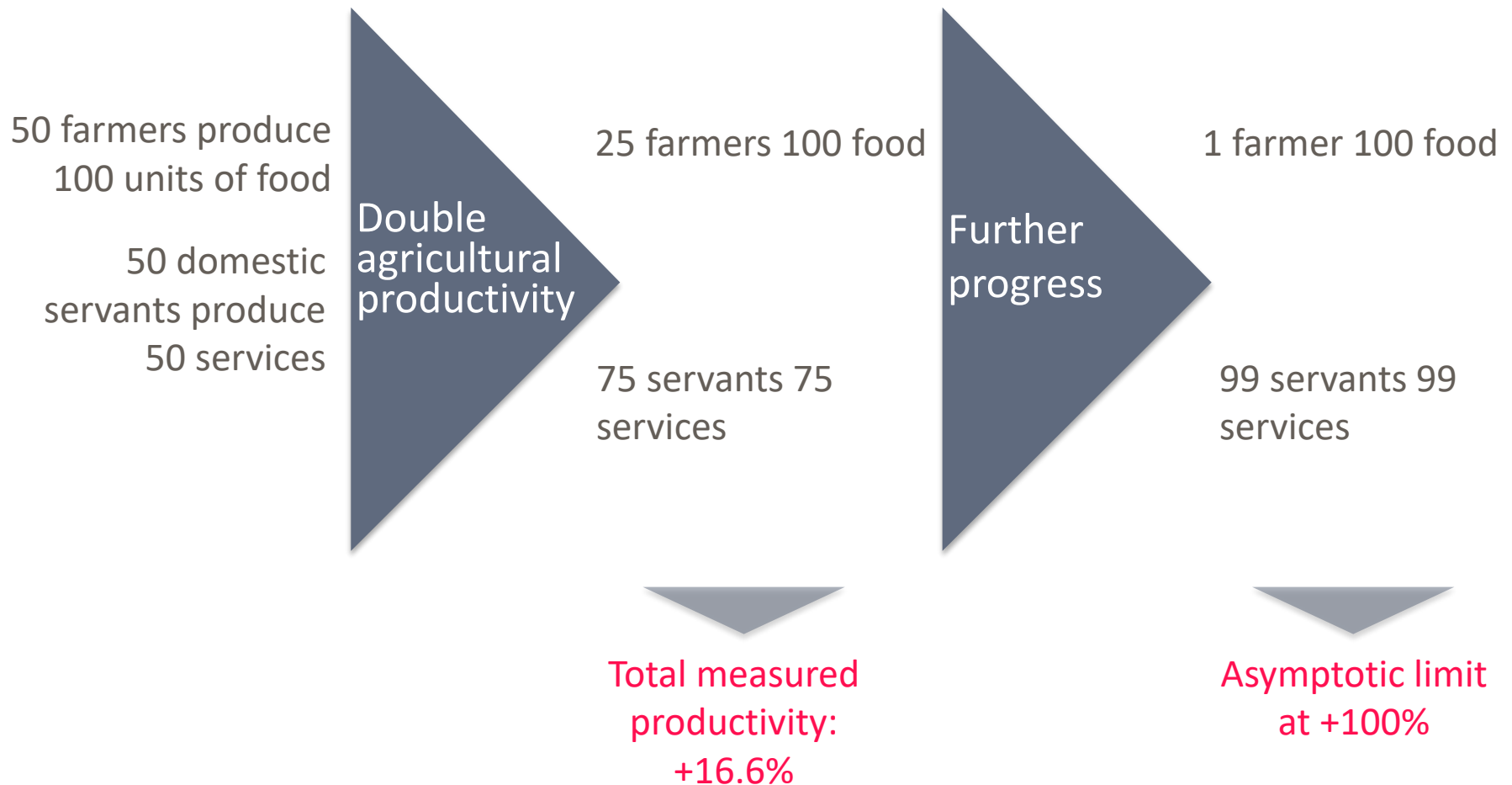
The Baumol Effect with high paid artists

100 farmers produce 100 units of food

Technical progress

50 farmers produce 100 units of food

45 domestic servants paid ½ as much produce 45 units of value

5 artists, singers, entertainers and fashion designers paid twice as much produce 20 units of value

Productivity growth still eventually asymptotes

Exhibit 11

Twenty first century technology
London

US Jobs growth forecast 2014 – 2024

Occupational categories by speed of job growth		Forecast job growth (000s)	Median annual wage May 2014 ($000s)
1	Personal care aides	458	20
2	Registered nurses	439	67
3	Home health aides	348	21
4	Food preparation and serving workers	343	21
5	Retail sales persons	314	18
6	Nursing assistants	262	25
7	Customer services reps	253	22
8	Cooks, restaurant	158	31
9	General and operations managers	151	97
10	Construction labourers	147	31
	Total top 10	**2873 (29%)**	
13	Janitors and cleaners	136	23
14	Software developers, applications	135	95

All sector average: 36

Source: Bureau of Labor Statistics, www.bls.gov; Projections of Occupational Employment, 2014 – 2024

Exhibit 13

The Baumol effect in India:

Automation of tea packing

A manager explains what will happen when he opens the crates:

His job will go. And his over there; and that one's too

But the manager insists that, as in the past, he will somehow find jobs for everyone – as drivers or even watchmen if necessary
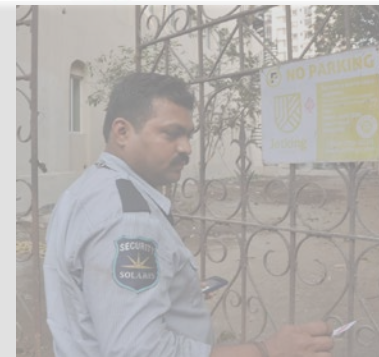
India's Economy: Just the job. **The Economist**, 16 September 2017

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Exhibit 14

Zero-sum activities in the simple model

100 farmers produce 100 units of food

Technical progress

50 farmers produce 100 food

25 criminals

25 police paid same as farmers

- Total measured productivity increases 25%
- But no human welfare benefit of increased consumption

Exhibit 15

Wonder drug contribution to nominal GDP

With private development and patent protection

$
Contribution to
nominal GDP

- Positive if R+D capitalised
- Nil if expensed

Research + Development

Patent protection period

Generic manufacturing with relentless automation

Time ➡
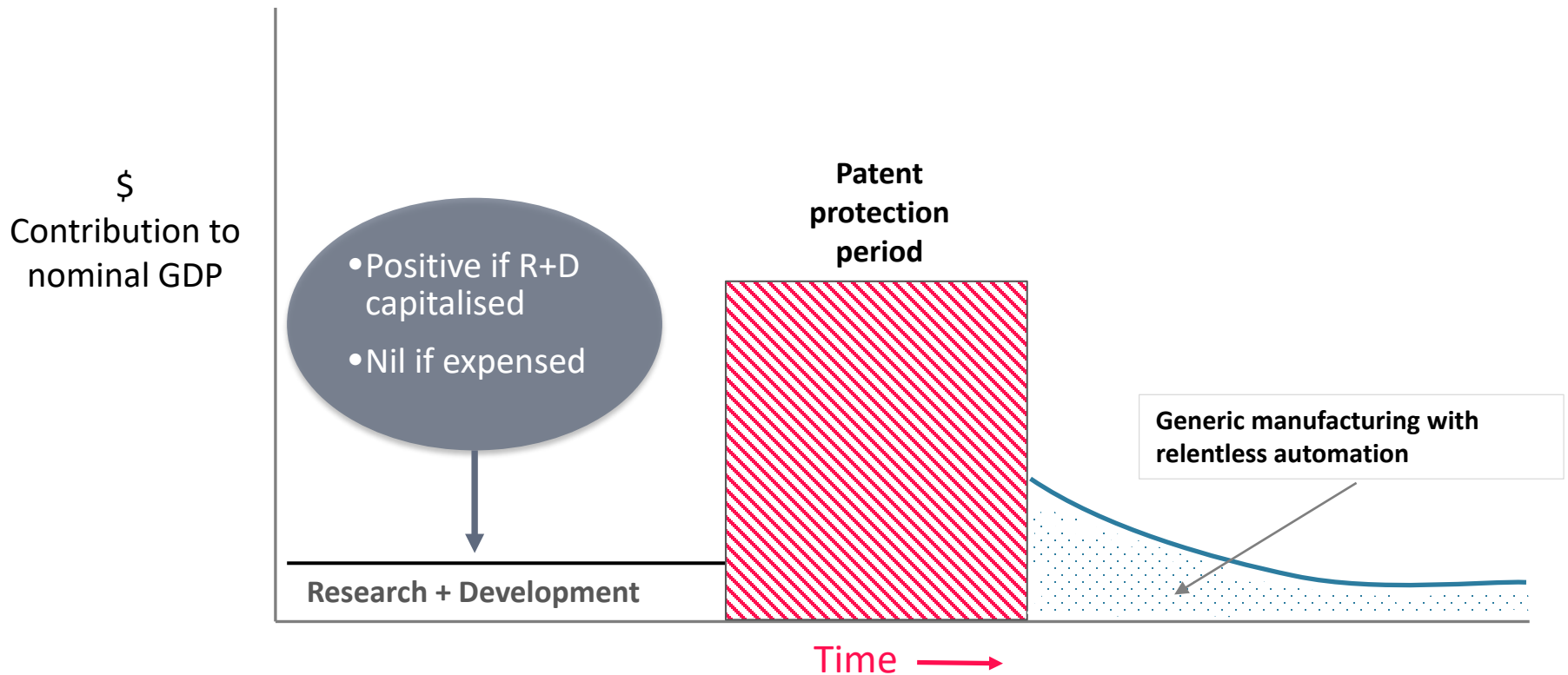
Wonder drug contribution to nominal GDP
If government or charitable development

$ Contribution to nominal GDP

Generic manufacturing with relentless automation

Research + Development

Time →

Exhibit 17
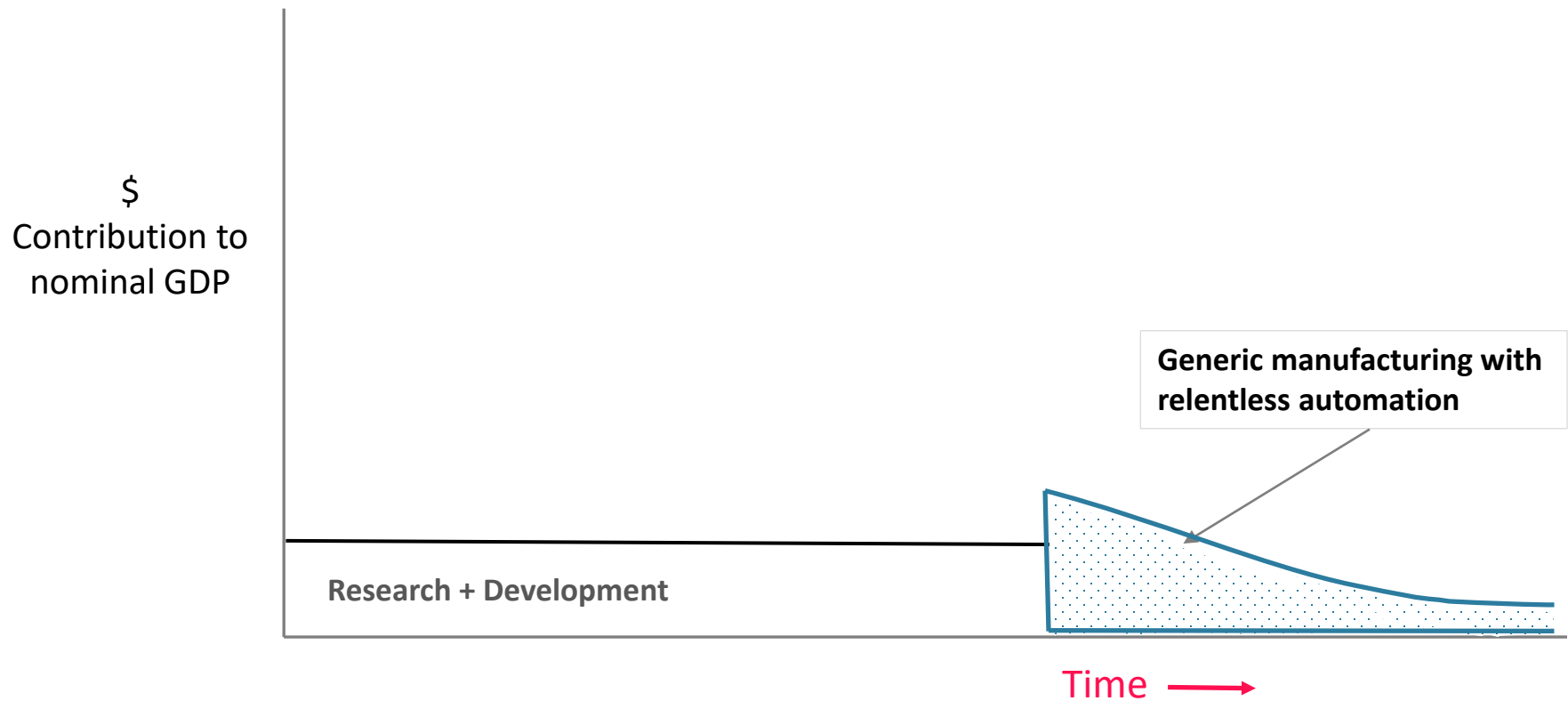
Three effects combined: An illustrative scenario

Assumptions	% of employment
Non-automatable low productivity	10% → 20%
Automatable	90% → 80%
of which:	
Zero-sum	20% → 30%
Non zero-sum	80% → 70%
… with 50% of zero-sum activity in GDP and 50% not	
Productivity growth in automatable sectors: 2% p.a. in 80% of activities 5% p.a. in 20% of activities	
Under-recorded benefits = 33% of growth in the high growth sectors	

Breakdown of Employment

Year 0
- 10
- 18
- 58
- 14

Year 25
- 20 — Low productivity non-automatable
- 24 — Zero-sum activities — 2% productivity growth
- 45 — Non zero-sum activities — 2% productivity growth
- 11 — Non zero-sum — 5% productivity growth
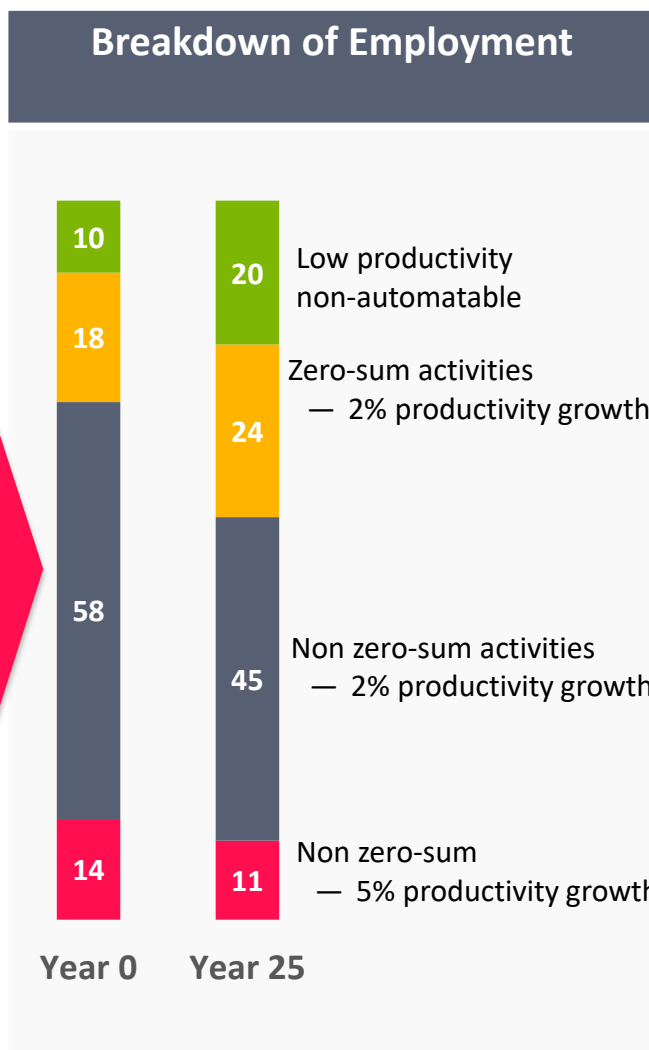
Productivity growth

Of automatable sectors: 2.5% increasing to 2.7%

Of all sectors: constant around 2.05%

Of measured GDP: 1.9% declining to 1.5%

Exhibit 18

The standard assumption

Technological advance drives productivity improvement across the economy

Which shows up in GDP measures of output per hour worked and per capita

Which provides a good measure of improvements in human welfare

Imperfect but adequate assumption in farm → factory transition

… but becomes more imperfect in face of information technology goes and proliferation of zero-sum activities

Imperfect but adequate assumption as income grows from $1000 to $20000 per capita

… but becomes more imperfect as incomes rise and basic needs satiated

Capital in France 1700 – 2010
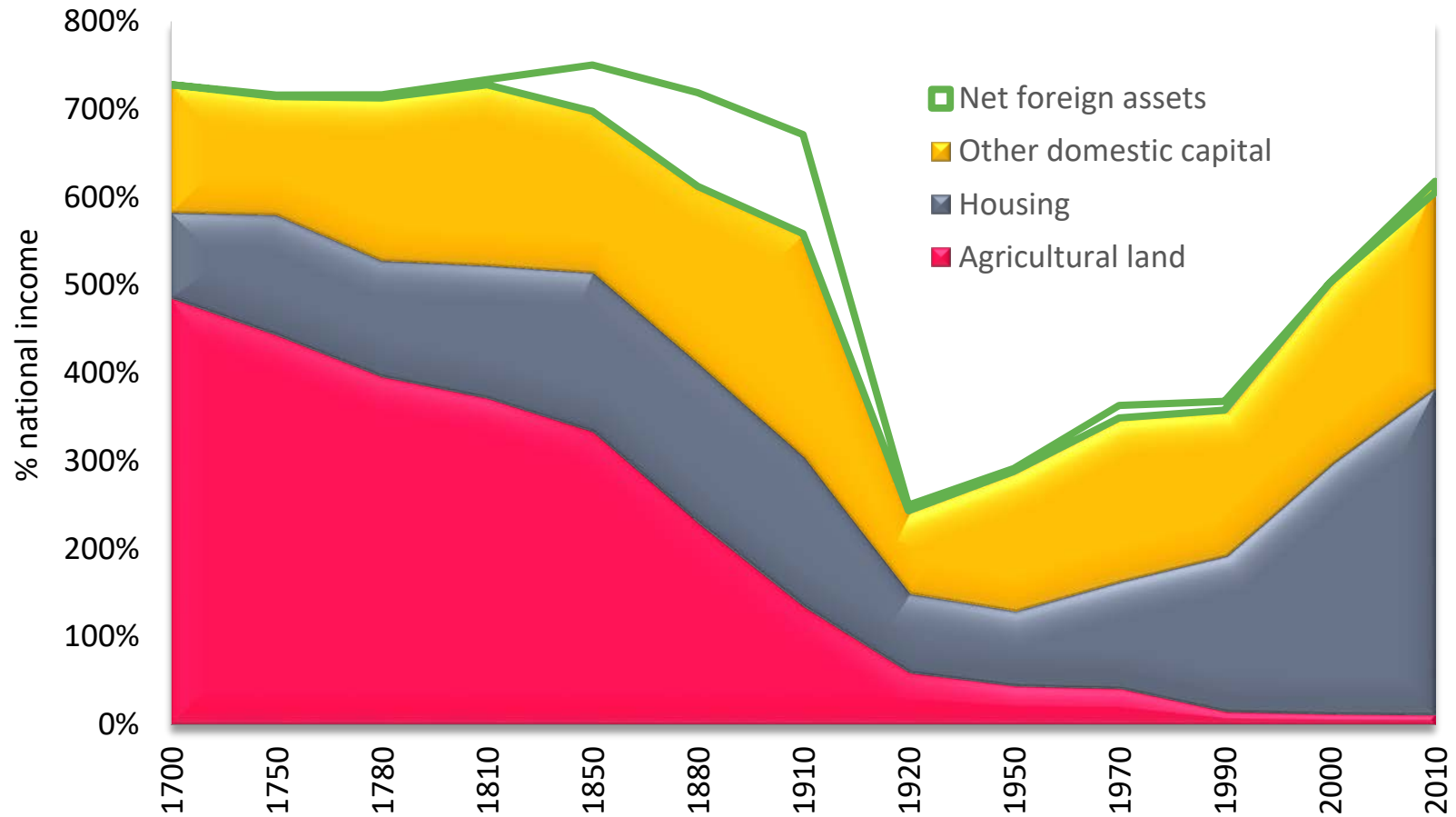
Source: *Capital in the Twenty First Century,* T. Piketty (2013)

Exhibit 20
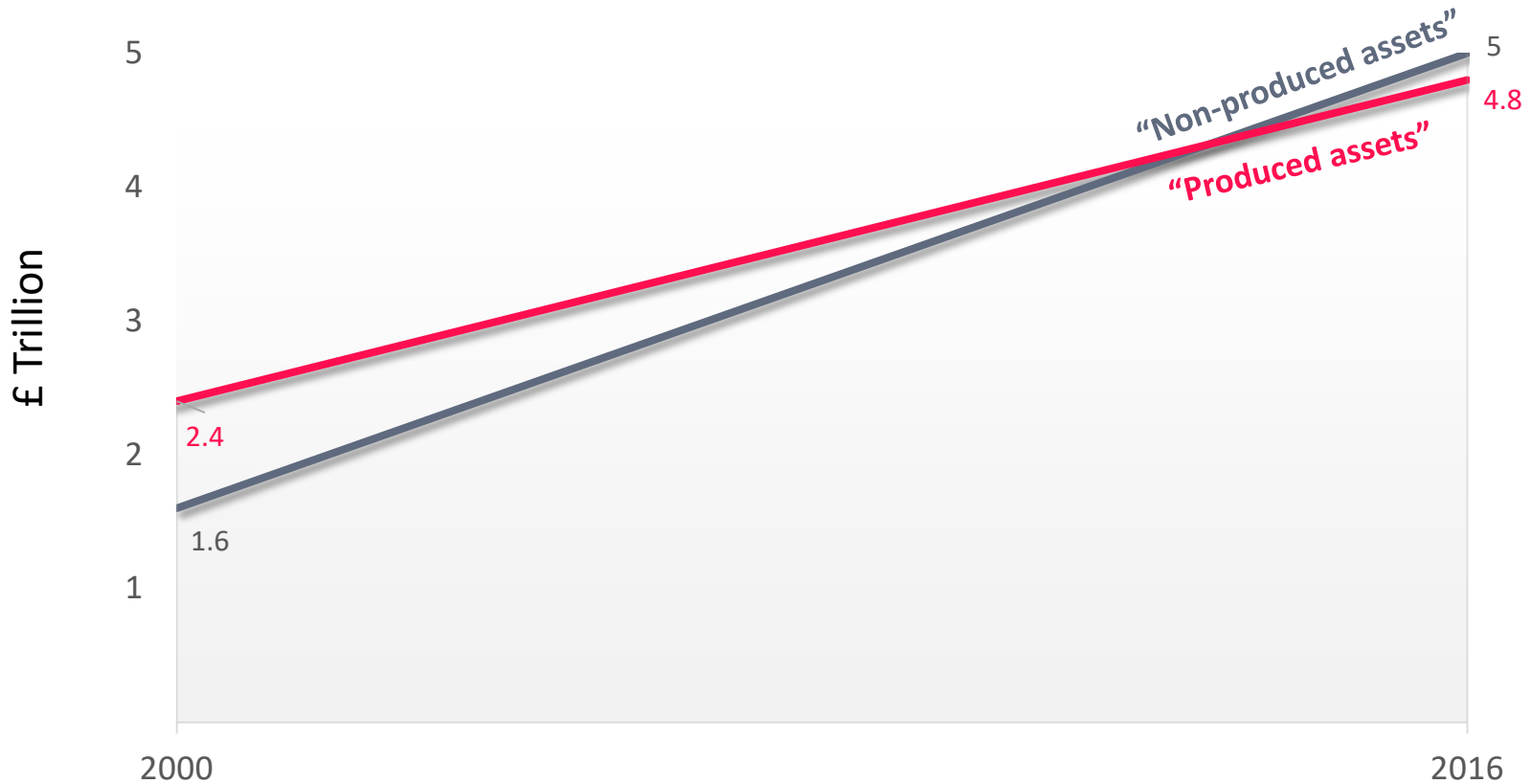
UK Household land and buildings
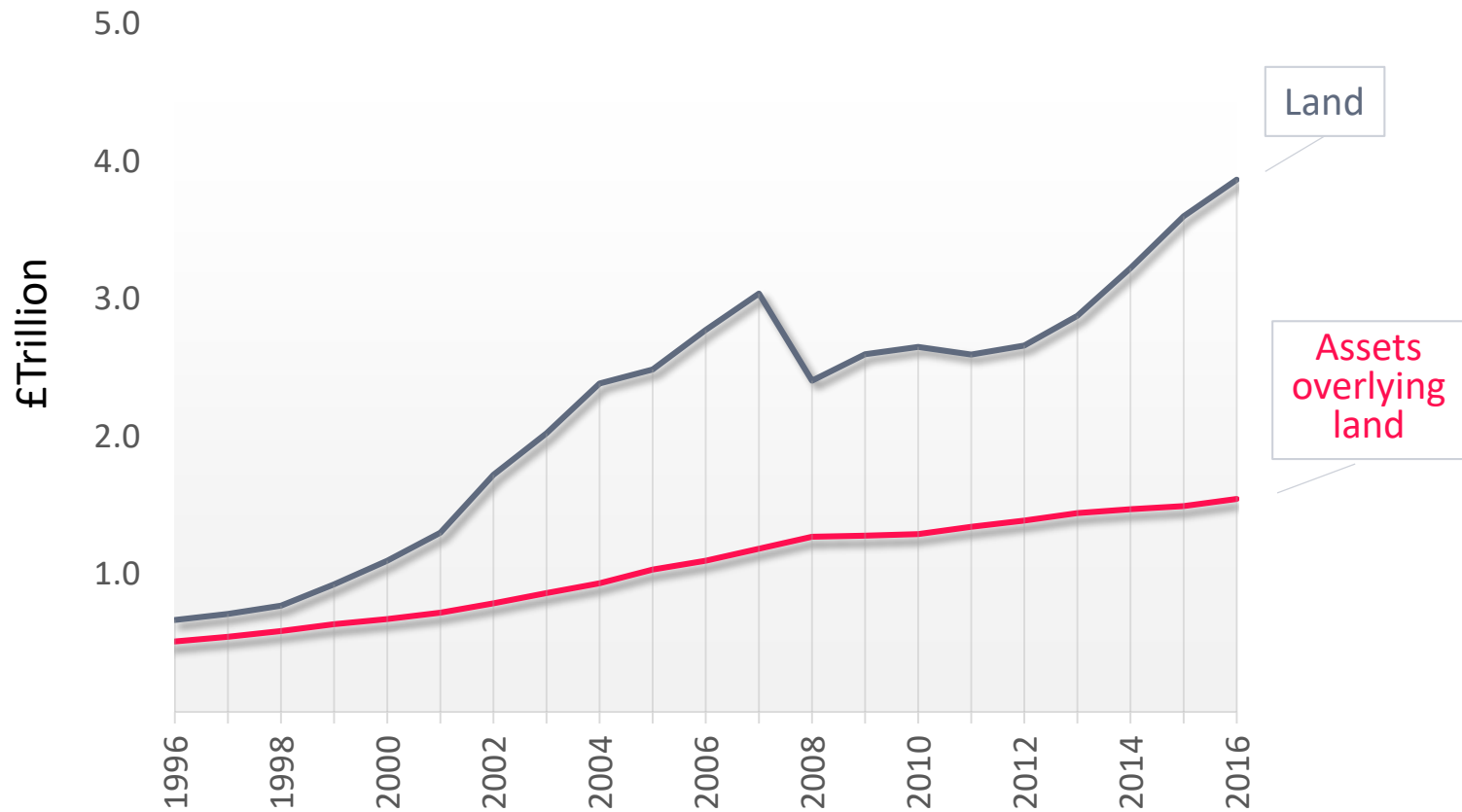
Land

Assets overlying land

£Trillion

5.0
4.0
3.0
2.0
1.0

1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

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Exhibit 22

Average income increases US
(1980=100)
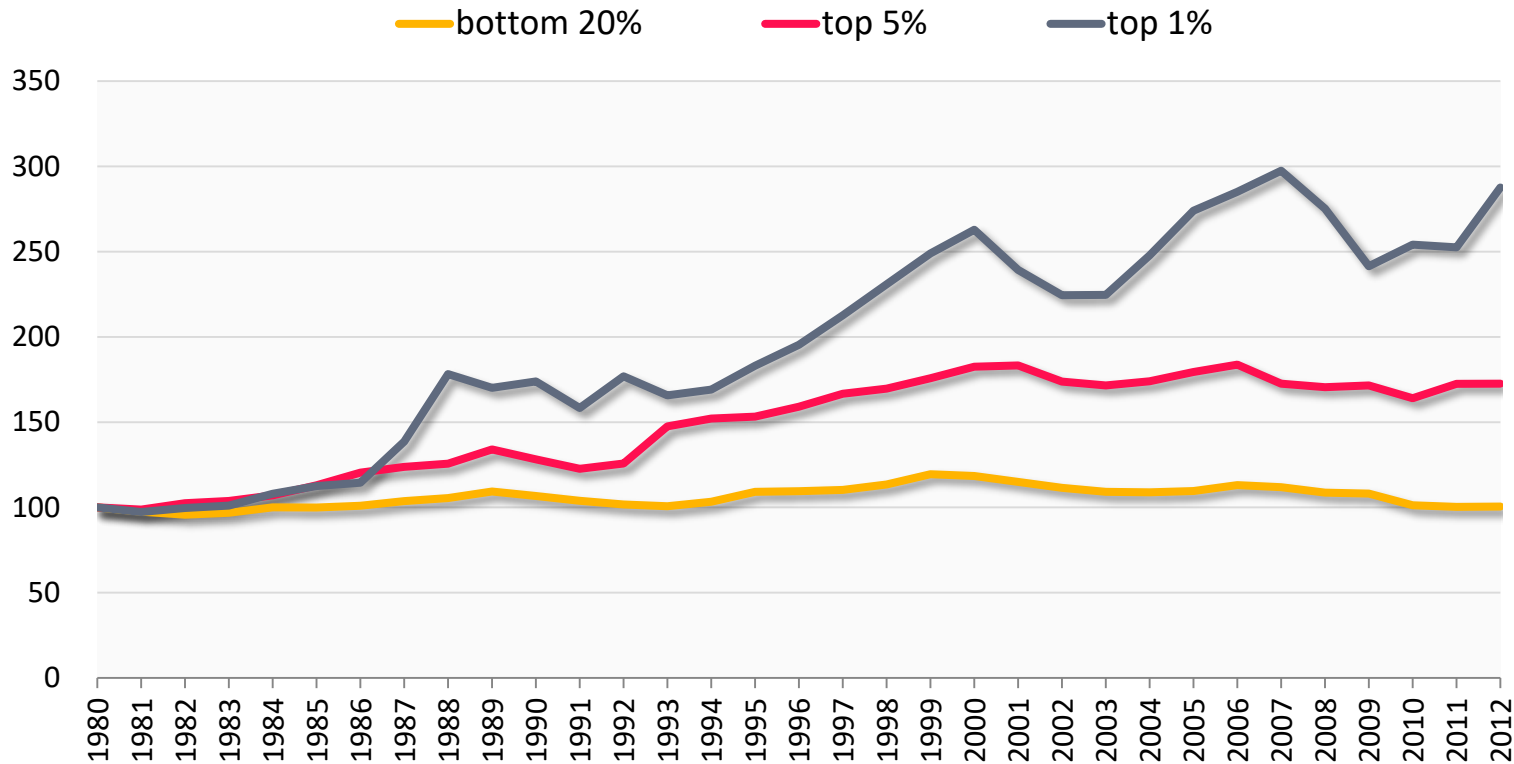
Source: US Census Bureau; World Top Incomes Database

Exhibit 23

Wealth and employment in ICT businesses

	Market Value ($bn) (27 Apr 2018)	Employees (000s) (2017)
Microsoft	736	~ 124,000
Alphabet Google	716	~ 72,000
Facebook	502	~ 25,000
Alibaba Group	455	51,000
Tencent	472	45,000

Exhibit 24

Population aged 20-64
Millions

	2000	2015	Projected 2050	Projected 2100
Japan	79	71	50	35
China	774	928	733	482
Europe	441	454	382	325
Americas	459	582	684	610
India	532	736	1029	867
Africa	352	536	1298	2485

Source: UN Population Database: Medium Fertility projection: 2015. un.org/popin
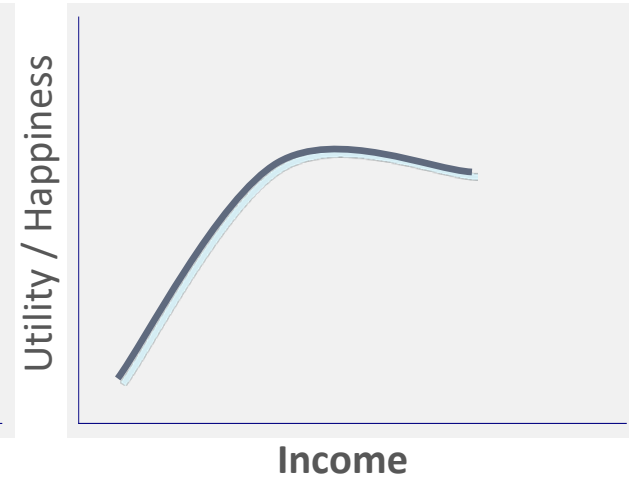
Exhibit 25

Different marginal utility of different "goods"

Good health?

Branded fashion goods?

Congestion and environmental damage?

Exhibit 26