The Labour Market Impact of New Technology

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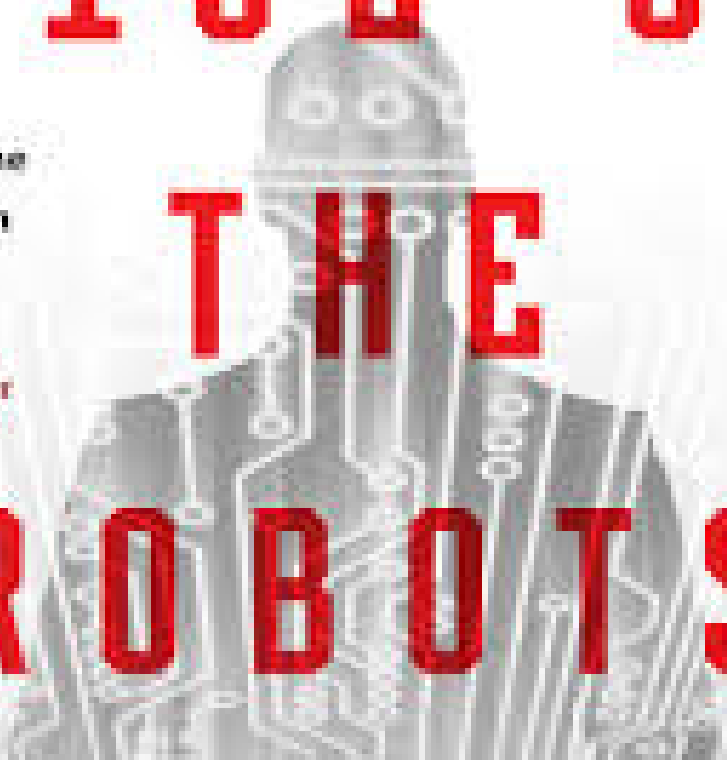
There are widespread fears about the labour market impact of new technology

- Some think this is the end of work – there will be mass unemployment
- Some think there will be massive shift in income from labour to capital
- Some think there will be massive increases in wage inequality as demand for some types of labour rises, other types fall
- This has captured the popular imagination e.g. Martin Ford's 'Rise of the Robots'

RISE OF THE ROBOTS



"No one who cares about the future of human dignity can afford to skip this book."

— Jaron Lanier
Author of You are Not a Gadget and Who Owns the Future?

TECHNOLOGY AND THE THREAT OF A JOBLESS FUTURE

These fears are not new..

- Long history of fears about impact of new technology

- These predictions have always been wrong
  - Over medium to long-run, technology has been the source of the rise in living standards for everyone
  - though there have been big losers at times

- But past is not necessarily a good guide to the future (‘this time its different - really’)

- It is useful to ask where past predictions went wrong

Where past predictions went wrong

- Analysis focused almost exclusively on jobs where humans were going to be displaced by new technology – the losers who are often very concentrated and visible – ‘first-round’ effects
- But analyses often missed the gainers
- Gainers are not just in new jobs created by new technology, they are mostly dispersed across ‘old’ jobs:
  - Firms adopt new technology because it lowers costs
  - if lower costs lead to lower prices then consumers have more disposable income
  - And spend this on all sorts of stuff leading to higher labour demand in many other areas

What about current predictions?

- Almost all analysis focuses again on ‘first-round effects’ ignoring second-round/general equilibrium effects which we know to have been important in the past
- True both of popular discussion and of more sophisticated econometric analyses which compare low- and high-impact jobs/areas without a way to assess aggregate impacts
- There is a real risk that the same mistakes are being made today as were made in the past
- But it is hard to assess aggregate effects – models can be useful here

The Perils of Economic Models

- All economic models are wrong
- But models do have advantage of imposing consistent logical thinking in moving from assumptions to conclusions
- If conclusions are wrong then assumptions must be wrong as well and this provides some insight as well
- But can never rely on models alone so will present some evidence at end of talk as well
- Presentation based on Caselli and Manning “Robot Arithmetic: New Technology and Wages”

Start with a very simple model

- Output is produced by labour, L, capital, K, and technology, θ according to a production function F(L,K, θ)

- Assume:
  - constant returns to scale
  - perfect competition
  - One type of labour, one capital good

- Will come back to these assumptions but useful starting-point

The Impact of New Technology on the Production Function

- Higher θ means more output given (L, K) so we have

$$\frac{\partial F}{\partial \theta} > 0$$

- Few people will disagree with that
- Possible that new technology reduces marginal product of labour:

$$\frac{\partial^2 F}{\partial L \partial \theta} < 0$$

Wages in Equilibrium

- Labour and Capital Earn their 'Marginal Product' i.e.:

$$W = \frac{\partial F\left(L, K, \theta\right)}{\partial L}$$

- With fixed capital we get result that wage will change could fall with new technology:

$$\frac{\partial W}{\partial \theta} = \frac{\partial^2 F\left(L, K, \theta\right)}{\partial L \partial \theta}$$

- But capital cannot be treated as fixed and that makes a big difference

The Cost of Capital

- Cost of capital is $P^K(r+\delta)$, where:
  - r is interest rate
  - δ is depreciation rate
  - P^K is relative price of capital goods
- Assumes perfectly elastic supply of capital
- Employ capital until point where

$$\frac{\partial F\left(L,K,\theta\right)}{\partial K} = P^K\left(r+\delta\right)$$

Wages in the Long-Run

- Total income to labour is (from CRS): $WL = F\left(L,K,\theta\right) - P^K\left(r+\delta\right)K$
- If assume that cost of capital is constant then by envelope theorem:

$$L\frac{\partial W}{\partial \theta} = \frac{\partial F\left(L,K,\theta\right)}{\partial \theta} + \left[\frac{\partial F\left(L,K,\theta\right)}{\partial K} - P^K\left(r+\delta\right)\right]\frac{\partial K}{\partial \theta} - \frac{\partial\left[P^K\left(r+\delta\right)\right]}{\partial \theta}K$$

- First term is positive
- Second term is zero by envelope condition
- Third term is zero if cost of capital goods relative to consumption goods does not change

Implication

- If relative price of capital does not rise then real wages must rise with improvement in technology
- The nature of new technology is irrelevant
  - Does not matter whether it is a substitute or complement to labour
  - Does not matter whether it is labour- or capital-augmenting
- Intuition is the following:
  - Must be some gainers from new technology
  - ‘New’ capital gets paid its marginal product so cannot gain
  - ‘Old’ capital cannot gain unless relative price of capital goods rises
- Simple underlying idea is that labour is the fixed factor and gains go to the fixed factor

How could one get the opposite result?

- Decreasing Returns to scale
- Imperfect Competition
- Rising cost of capital

Decreasing Returns to Scale

- New technology can lead to falling wages with decreasing returns to scale e.g. $Y=(L+\theta K)^{\alpha}$, $\alpha<1$

- But decreasing returns to scale is often thought to be the result of an omitted fixed factor

- So this can be thought of as saying returns could go to a fixed factor other than labour:
  - But what is this omitted fixed factor?

Imperfect Competition

- Cost of capital could include a mark-up
- A constant mark-up, μ, in product or labour market leads to:

$$WL = (1-\mu)F(L,K,\theta) - P^K(r+\delta)K$$

- Wages must rise if mark-up constant
- But wages could fall if new technology leads to a higher mark-up
- Serious current concern about the impact of new technology on:
  - competition in product markets
  - competition in labour markets
  - Increased privatization of knowledge

Rising Cost of Capital

- Wages could fall if new technology leads to a rising cost of capital
- This could happen if:
  - Interest rates rise
  - Relative cost of capital rises
- Rising interest rate should be interpreted as a supply of capital that is not perfectly elastic:
  - In this case capital is quasi-fixed so gets some of the return
  - Could be that imperfect capital market+new technology leads to rising return to capital and lower wages
  - But new technology is then causing problems for workers because of low not high investment
- What about rising relative cost of capital?
  - With one good the cost of capital cannot rise enough to make wages fall
  - But what about many goods and types of labour? Might worry that results are all special

Caselli and Manning ‘Robot Arithmetic: New Technology and Wages’

- Any number of types of labour in fixed supply
- Any number of goods: consumption, intermediate and investment
- Technology can affect production possibilities in any way except must weakly increase output
- Constant returns to scale in all sectors, perfect competition, constant interest rate (but impact of relaxing them the same as in simple model)
- Comparative steady states approach – compares wages in steady-state in two economies with different levels of technology

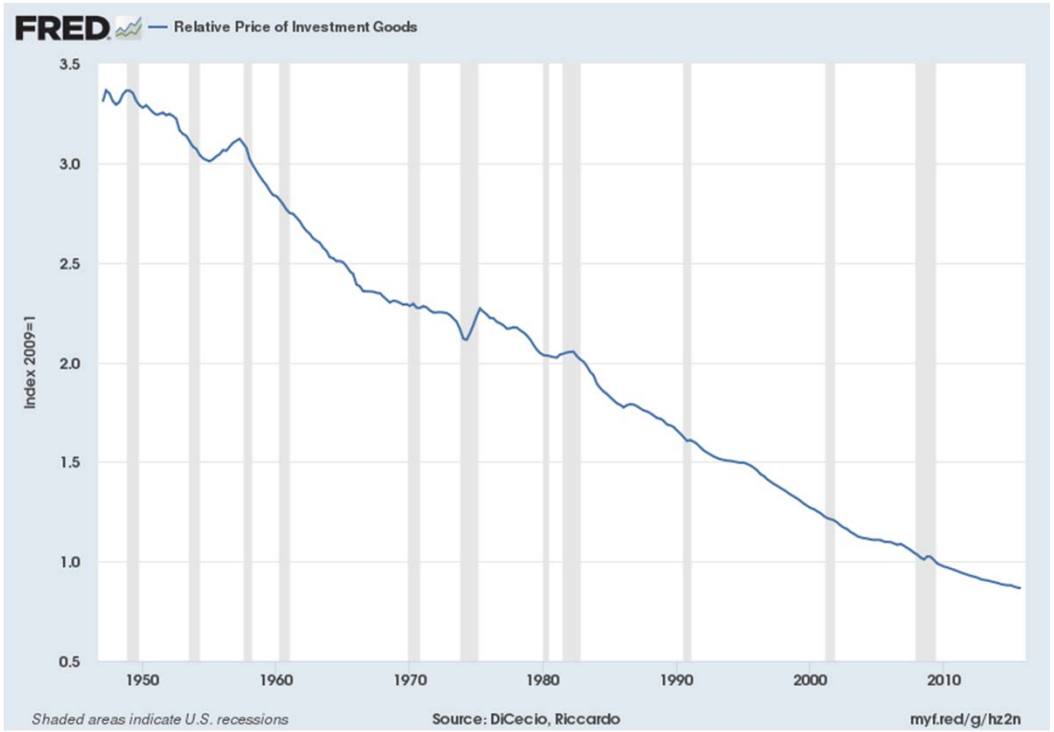
Caselli-Manning: Result 1: New technology cannot make all types of labour worse off

- New technology cannot make all types of labour worse off
- Whatever form new technology takes
- Corollary: if one type of labour then all types must be better off
- But gainers might be a very small group – what about the average worker

Caselli-Manning: Result 2: New technology must raise the average wage if price of investment goods falls relative to consumption goods

- Intuition is the same as in the one good model:
  - New technology allows more output to be produced so someone must gain
  - Any new capital gets its marginal product so gainers must be labour or existing capital
  - If relative price of investment goods falls then it must be labour
- Labour is, in long-run, the only fixed factor so gains must flow to it
- Possible that labour share of total income falls
- And possible that distributional effects are very severe

The relative price of investment goods



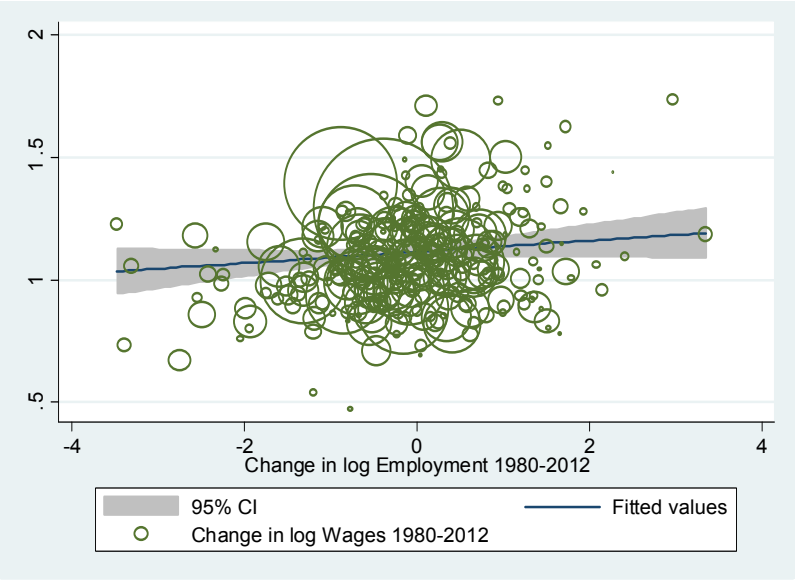
Caselli-Manning, Result 3: If labor of different types is in perfectly elastic supply, then workers of all types must gain from technological progress.

- Intuition is that relative wages of different occupations are fixed
- So effectively one type of labour: Result 1 then implies that new technology will raise wages of all types of labour
- May seem an extreme assumption but changes in relative employment much larger than changes in relative wages
- Occupational mobility is high and entrants stop entering declining occupations

The Supply of Labor to Occupations

- We would expect:
  - Long-run elasticity quite high (infinite?)
  - Short-run elasticity lower (specific human capital)
- Some suggestive (not definitive) evidence about elasticity of supply
  - The long-run relationship between changes in occupational wages and employment
- Slope coefficient:
  - Tiny and not significantly different from zero in weighted regression
  - significantly different from zero in unweighted regression but only 0.052
- Suggests a very elastic supply in long-run
- Perhaps not very surprising
  - Huge changes in employment shares over long periods
  - Modest changes in relative wages

The Long-Run Relationship between Changes in Wages and Employment, US 1980-2012



This has been mostly theory – what about evidence?

- Will focus on Frey-Osborne work as this was first and was creative and innovative
- Tried to answer the question “Can the tasks of this job be sufficiently specified, conditional on the availability of big data, to be performed by state-of-the-art computer-controlled equipment”
- Produced estimates of probability of automation “over some unspecified number of years, perhaps a decade or two”
- Controversy about the estimates of numbers affected but I think these are probably better measures of relative rather than absolute probability of automation
- It is now almost 5 years since the exercize so perhaps we might begin to look for evidence – though might be future acceleration in change

Data

- US Occupational Employment Survey
- Provides data on employment and earnings for 700+ occupations
- Aligned with Frey-Osborne measures of probability of automation

Results: change in employment 2012-17

Dependent Variable	Change Log Employment	Change Log Employment
Sample Period	2012-2017	2012-2017
	Unweighted	Weighted
Probability of Automation	-0.018 (0.004)	-0.015 (0.003)
R2	0.016	0.015

- Is evidence that those with higher probability of automation have slower employment growth
- But explanatory power is very low
- Impact is not large relative to the changes seen e.g. 10th percentile of decadal change is -22%, 90th percentile is +53%

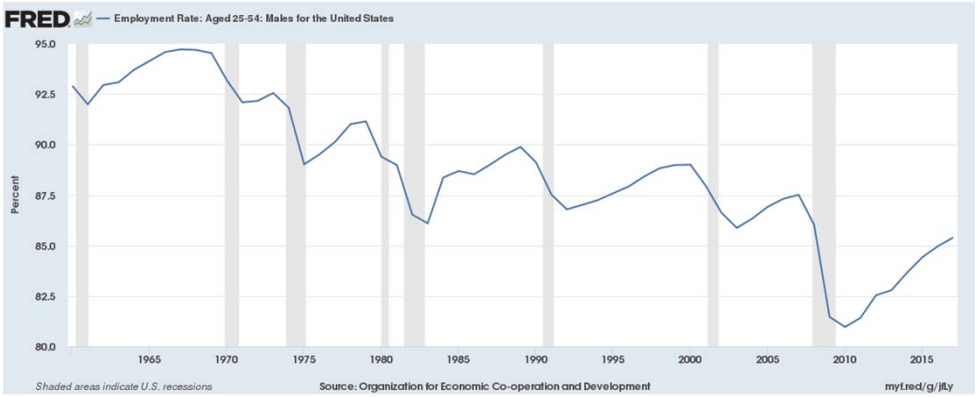
And other pieces of evidence do not line up

Dependent Variable	Change Log Employment	Change Log Employment	Change in Log Wages
Sample Period	2000-2011	2000-2004	2012-2017
Probability of Automation	-0.036 (0.004)	-0.033 (0.006)	0.003 (0.001)
R2	0.069	0.026	0.067

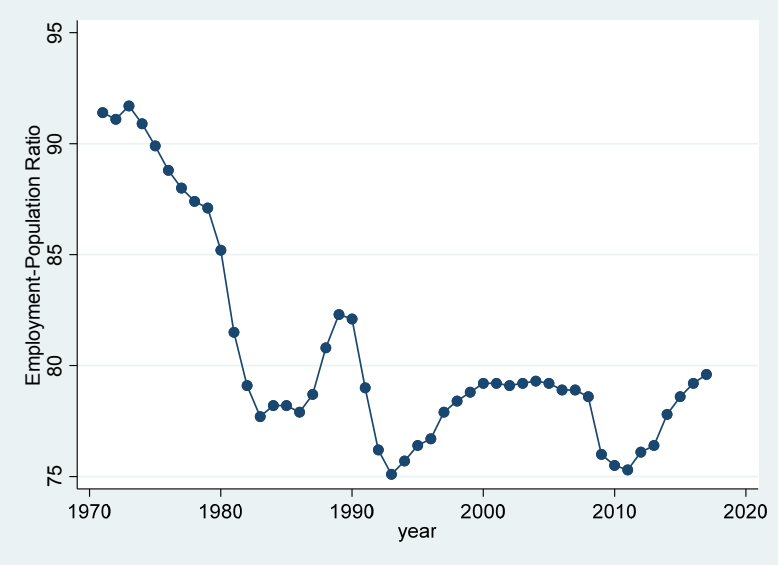
- Better predictor of employment change in earlier than recent years
- Not surprising because underlying task variables from O*NET are similar to those used to explain earlier technical change
- Wages are moving in the opposite direction though small impact

The aggregate impacts? Much of techno-angst dates from circa2012 when overall employment appeared weak

US male 25-54 employment-population ratio



UK male 16-64 employment-population ratio



Is this view of the impact of new technology complacent? We should worry about:

- Impact of technology on competition in labour and product markets
- The increasing privatization of knowledge
- Dysfunctional financial markets that limit productive investment
- The supply of skills not matching the changing demand for skills
- The threat of rising inequality, across people and regions
- But many of these problems are not just caused by technology and the solution to the problems is the same whatever the cause
- Perhaps self-indulgent (though fun) to spend so much time talking about technology when many of these problems are so serious

Delivering Inclusive Growth is Vital: Policies require an active state

- Promote Technological Change for Growth
  - We know that frontier productivity growth is driven by changes in knowledge
  - We know that knowledge is a public good
  - We know that markets fail to provide the efficient level of public goods
- We cannot leave education/skills provision to the market
  - In UK we have long tail of poor basic skills and poor vocational training
  - These are long-standing weaknesses unchanged by recent technical change
- Be prepared to redistribute more actively to ensure inclusive growth
- Pay more attention to persistent regional inequalities
  - The decades-long decline in manufacturing has had bad effects on those areas that once specialized in it
  - See Amior and Manning, “The Persistence of Local Joblessness”, AER forthcoming for my take on this

Conclusion

- Technology always has and always will lead to changes in the structure of employment
- There is little evidence for faster change now than earlier
- This process can lead to increases in inequality though they are generally less marked than changes in structure of employment
- Policy is needed to deliver inclusive growth