



# Is Technology Replacing Jobs?

## Applied Regression Final Project

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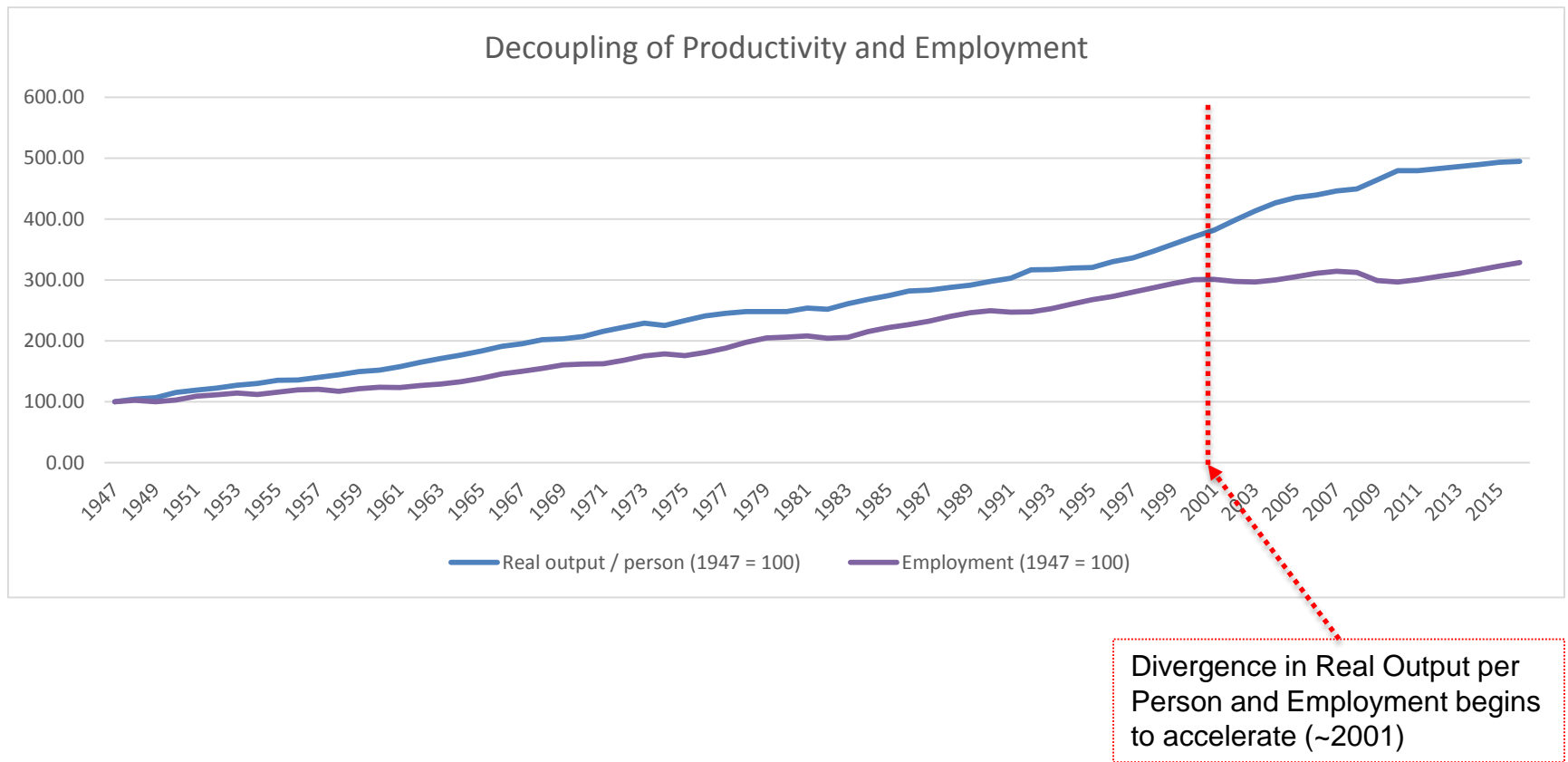
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# Setting the context

- The idea that manual work can be automated and carried out by machines is familiar
- Predictions that technology will make humans redundant go back to the Industrial Revolution
- Historically, though, technology has always ended up creating more jobs than it destroys as humans find new ways to work
- But is this time different?

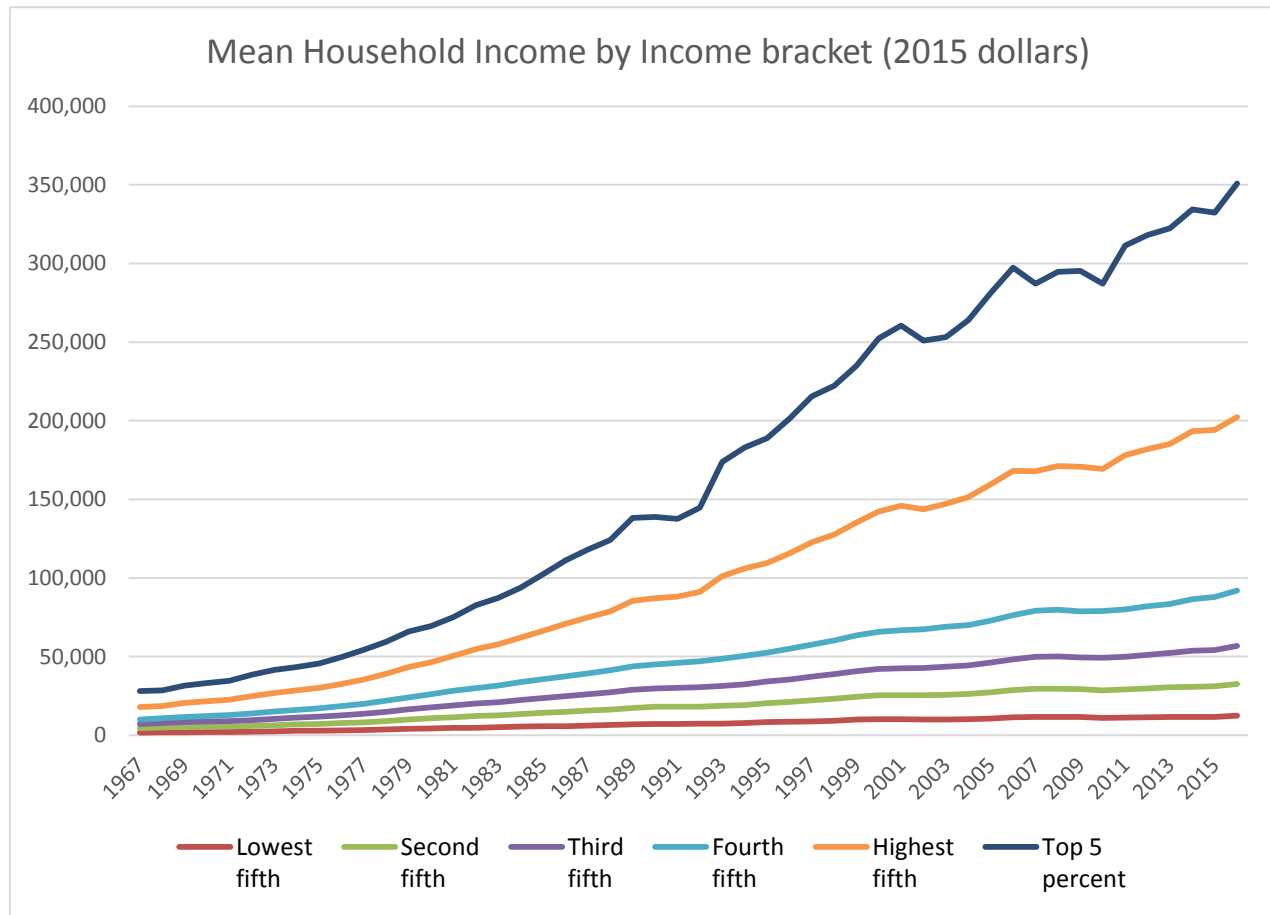
Source: <http://www.economist.com/news/special-report/21700758-will-smarter-machines-cause-mass-unemployment-automation-and-anxiety>

# The gap between productivity and employment is widening



Source: <https://fred.stlouisfed.org>; MIT Technology Review

# The gap between the wealthy and the rest of the workforce is accelerating



Source: <http://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-households.html>

# Technology has shifted where jobs are needed—and not needed

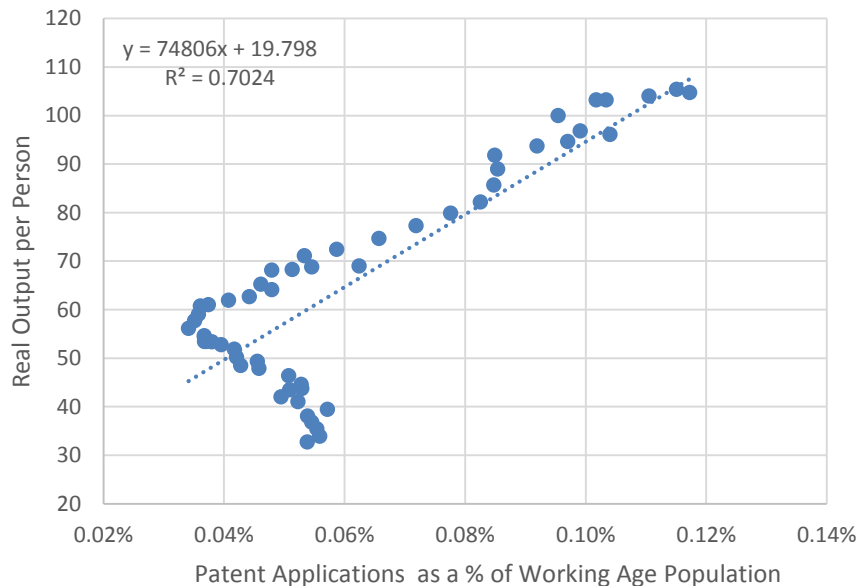
Occupations	Employment in		Change since 1992
	1992	2014	
Total employment	24,746,881	30,537,415	23%
Nursing auxiliaries and assistants	29,743	300,201	909%
Teaching and educational support assistants	72,320	491,669	580%
Management consultants and business analysts	40,458	188,081	365%
Information technology managers and above	110,946	327,272	195%
Welfare, housing, youth and community workers	82,921	234,462	183%
Care workers and home carers	296,029	792,003	168%
Actors, dancers, entertainment presenters, producers and directors	47,764	122,229	156%
Financial managers and directors	88,877	205,857	132%
Footwear and leather working trades	40,715	7,528	-82%
Weavers and knitters	24,009	4,961	-79%
Metal making and treating process operatives	39,950	12,098	-70%
Typists and related keyboard occupations	123,048	52,580	-57%
Company secretaries	90,476	43,181	-52%
Energy plant operatives	19,823	9,652	-51%
Farm workers	135,817	68,164	-50%
Metal machining setters and setter-operators	89,713	49,861	-44%

Jobs enabled by technological innovation

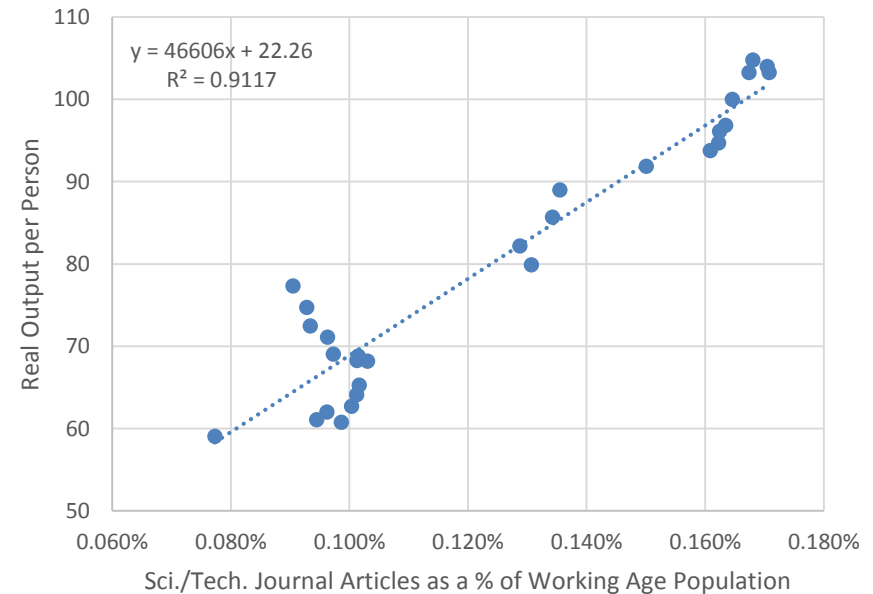
Jobs destroyed by technology

# Unsurprisingly, advancements in technology are correlated with productivity increases

Real Output per Person vs Patent Applications as a % of Working Age Population (1960-2014)



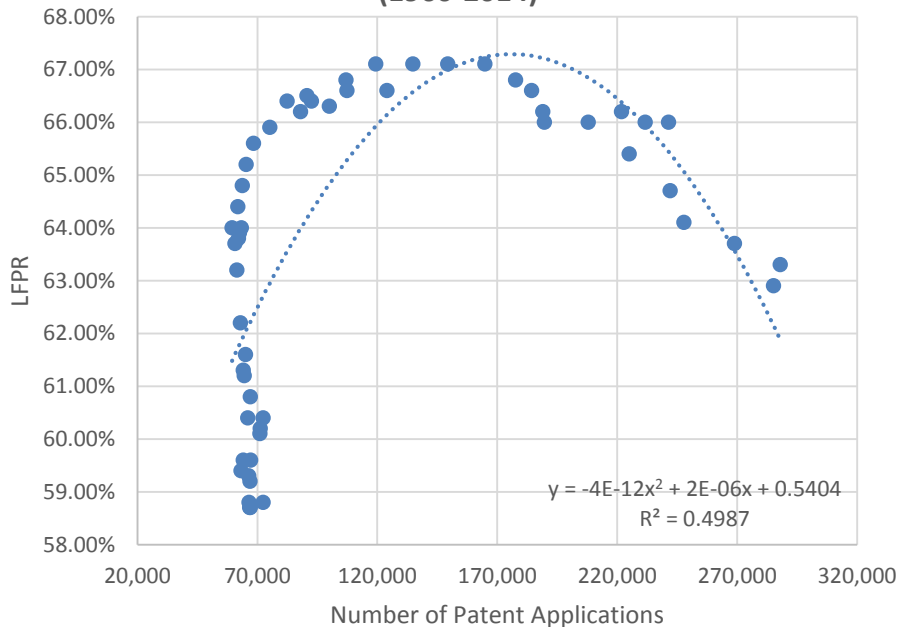
Real Output per Person vs Tech. Journals as a % of Working Age Population (1985-2014)



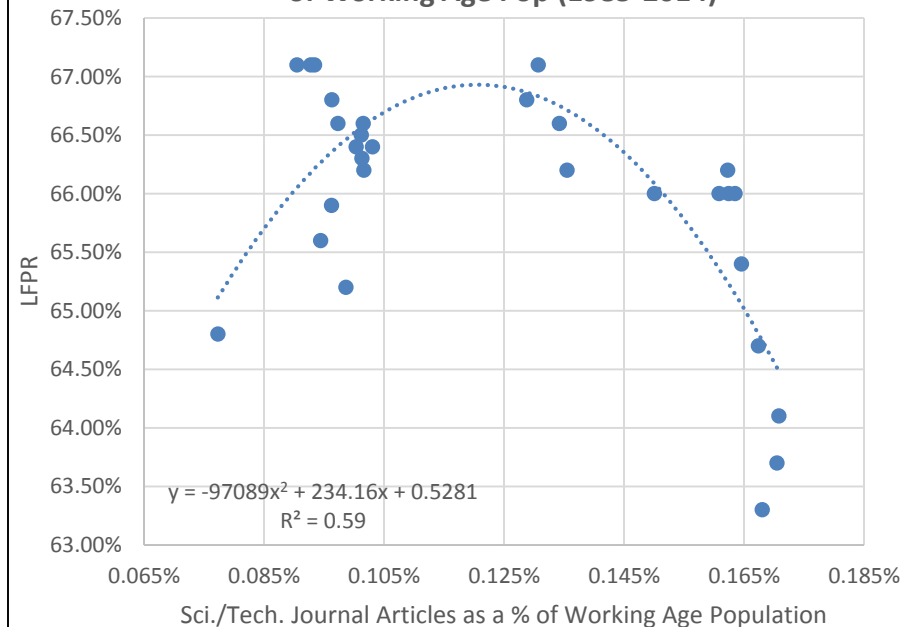
Source: The World Bank

# But could there be a tipping point, where productivity makes humans redundant?

Labor Force Participation vs Patent Applications  
(1960-2014)



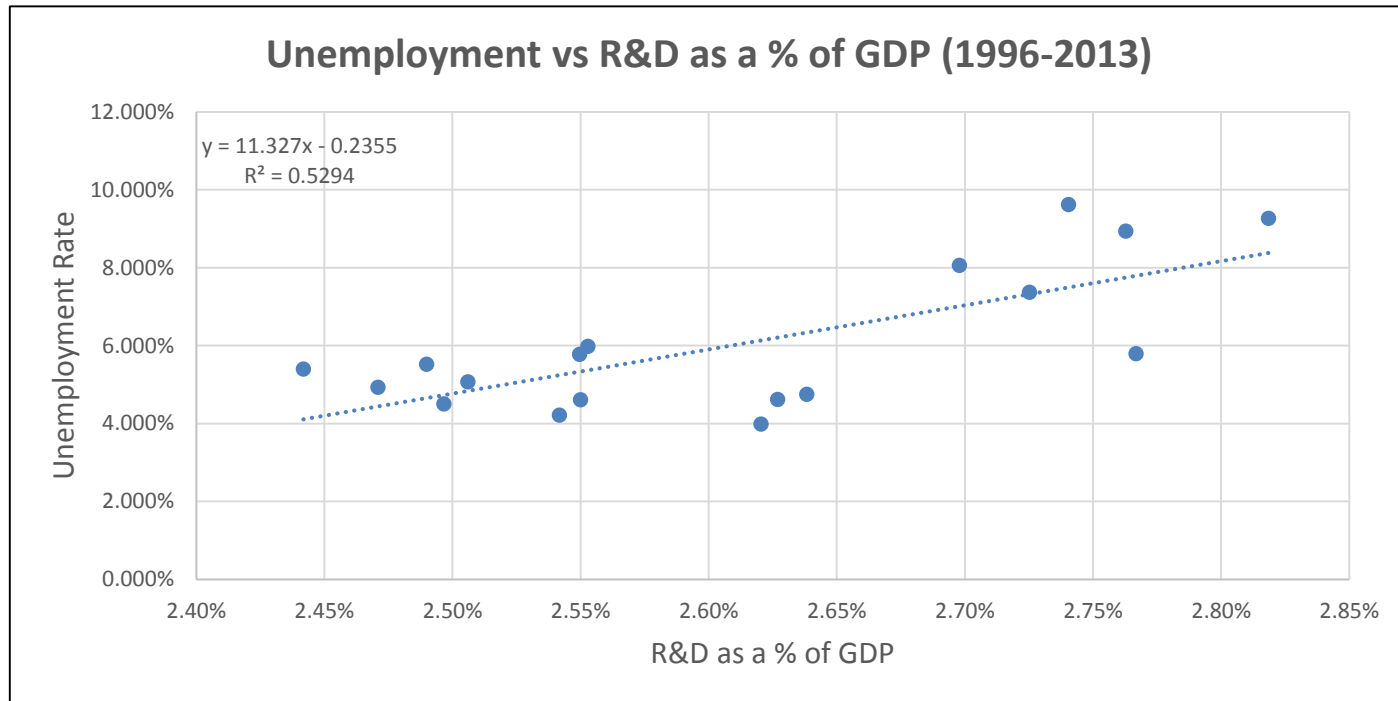
Labor Force Participation vs Scientific Articles as a % of Working Age Pop (1985-2014)



Source: The World Bank



# Significant data suggests that there is a tipping point



# Answering these questions was the motivation for this project

## Key questions

- Are increases in productivity bad for workers?
- Namely, as productivity increases, do wages and job growth slow, controlling for other factors?

## Things we considered

- Productivity vs. Employment
- Wealth and Inequality
- Correlation vs. Causation with TFP
- What data to analyze?

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# After screening a long list of inputs...

## Economic Markers

- GDP per capita (constant 2010 USD)
- Presence of an economic recession
- Hourly earnings
- Average hours worked weekly
- Productivity (nonfarm business)
- Multifactor productivity index
- Real output
- Real output per hour per person

## Job Markers

- Labor force participation rate
- Unemployment rate
- Unemployment to population rate
- New jobs created per year per person

## Technological Advancement Markers

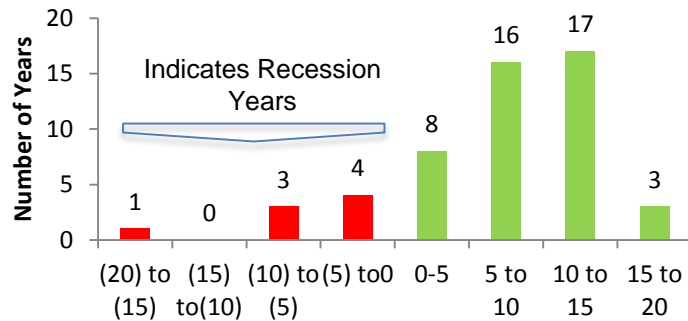
- Capital expenditures
- Researchers in R&D, as a % of labor force
- R&D expenditure, as a % of GDP
- Patent applications, residents: (1) absolute value, (2) as a % of labor force
- Trademark applications, as a % of labor force
- Scientific/technical journal articles published, as a % of labor force

## ...We focused on the following data

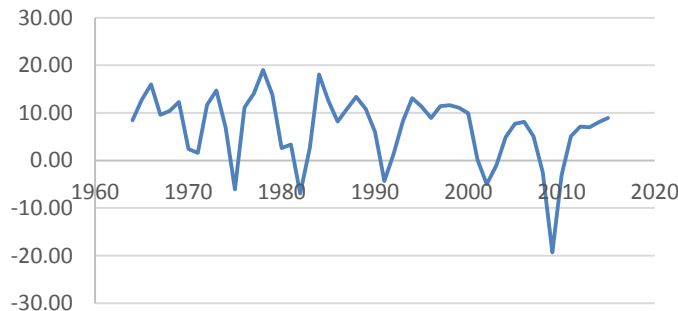
- **Dependent variable**
  - New jobs created per year per person
- **Independent variables**
  - Real Output per hour per person (our proxy for change in productivity)
  - Average weekly hours of production employees (also as a dependent variable in a separate regression)

# As Juran advises, we took a close look at the descriptive statistics of our data

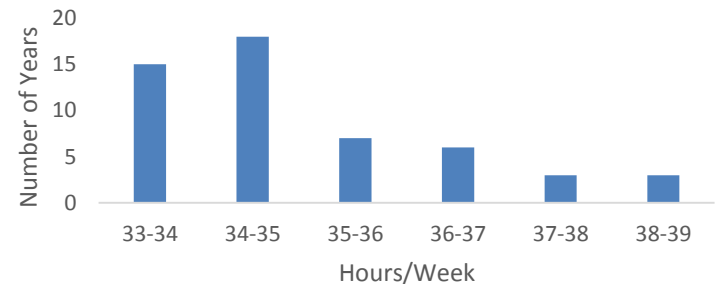
## Frequency of New Jobs Per 1000 People



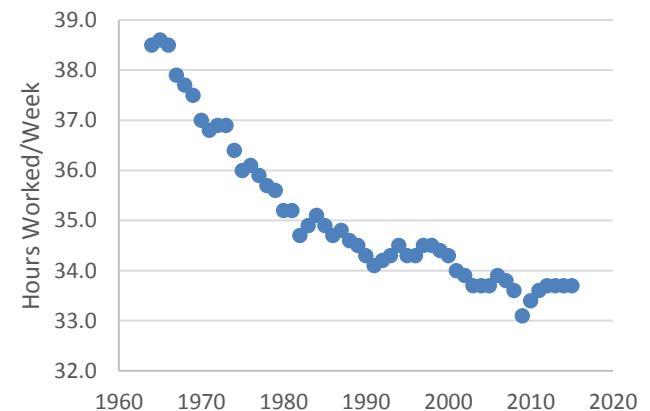
**Average: 6.81**  
**Standard Deviation: 7.19**



## Hours Worked Per Week



**Average: 36.07**  
**Standard Deviation: 1.48**



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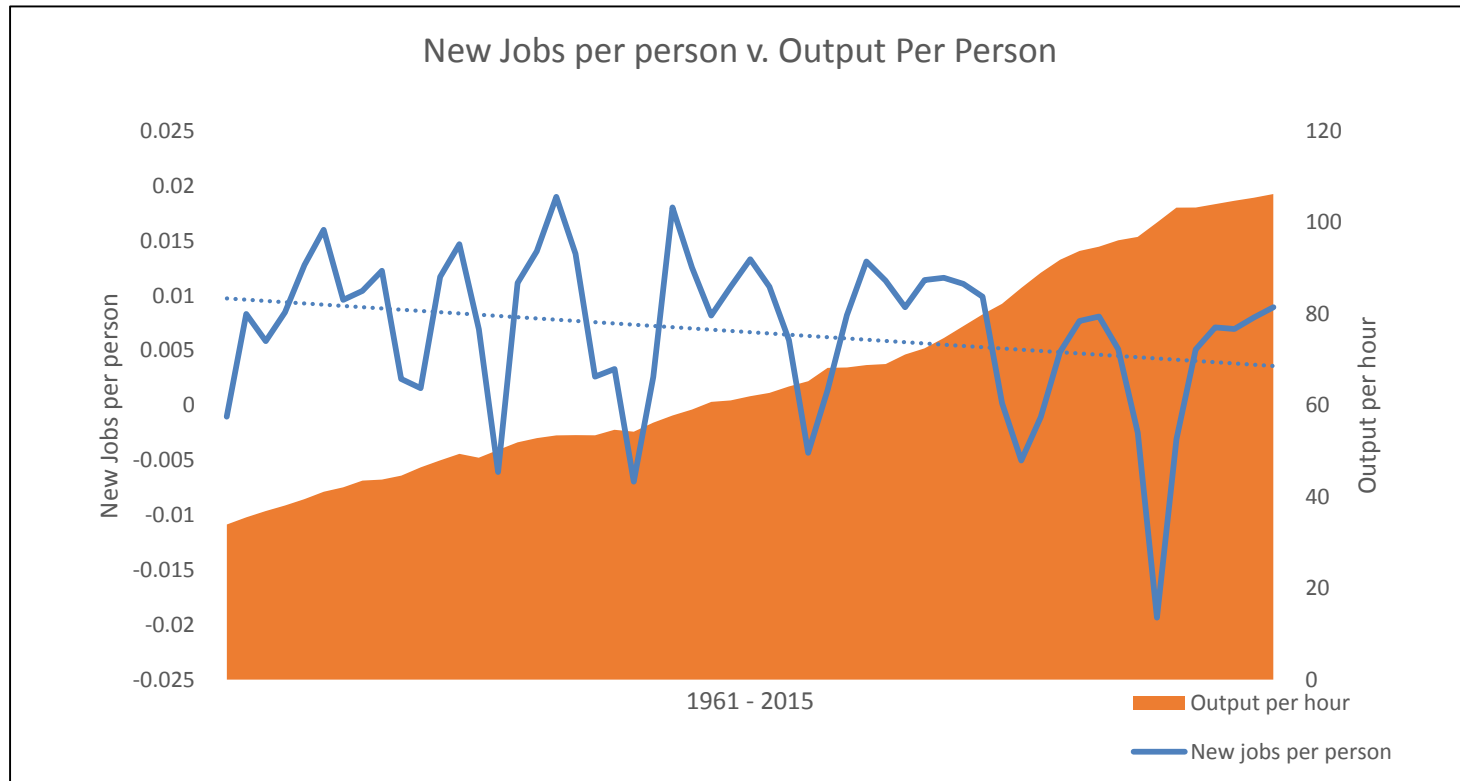
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# As productivity has increased, new job creation has slowed



Source: <https://fred.stlouisfed.org>; US Census Bureau Data



# Indeed, productivity is significant in explaining the decline in new jobs

## Results for: Summary

### Regression Analysis: New Jobs Per Person versus Real output per person

Method

Rows unused 15

#### Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	0.000224	0.000224	4.79	0.033
Real output per person	1	0.000224	0.000224	4.79	0.033
Error	53	0.002480	0.000047		
Total	54	0.002704			

#### Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0068401	8.28%	6.55%	0.68%

#### Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.01291	0.00299	4.31	0.000	
Real output per person	-0.000093	0.000043	-2.19	0.033	1.00

#### Regression Equation

New Jobs Per Person = 0.01291 - 0.000093 Real output per person

Source: <https://fred.stlouisfed.org>: US Census Bureau Data

# But what does our model mean in real terms?

## Sensitivity Analysis

New Job Estimates Based on Change in 2016 productivity

		Estimated Number of New Jobs	Delta (New minus Base Case)
Base Case >>>	No Change in Productivity	954,855	-
	Productivity Up 1%	922,909	(31,947)
Scenarios >>>	Productivity Up 5%	795,122	(159,733)
	Productivity Up 10%	635,389	(319,466)

**For example, the opportunity cost of a 10% increase in 2016 productivity would be ~320,000 jobs; nevertheless, 635,000 new jobs would be added**

Source: <https://fred.stlouisfed.org>: US Census Bureau Data  
Business Sector: Real Output Per Hour of All Persons, Index 2009=100, Annual, Seasonally Adjusted (1961 – 2015)

# One contributing factor is that productivity reduces hours worked...

## Regression Analysis: Average weekly hours versus Real output per person

### Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	83.17	83.1715	137.12	0.000
Real output per person	1	83.17	83.1715	137.12	0.000
Error	51	30.94	0.6066		
Total	52	114.11			

### Model Summary

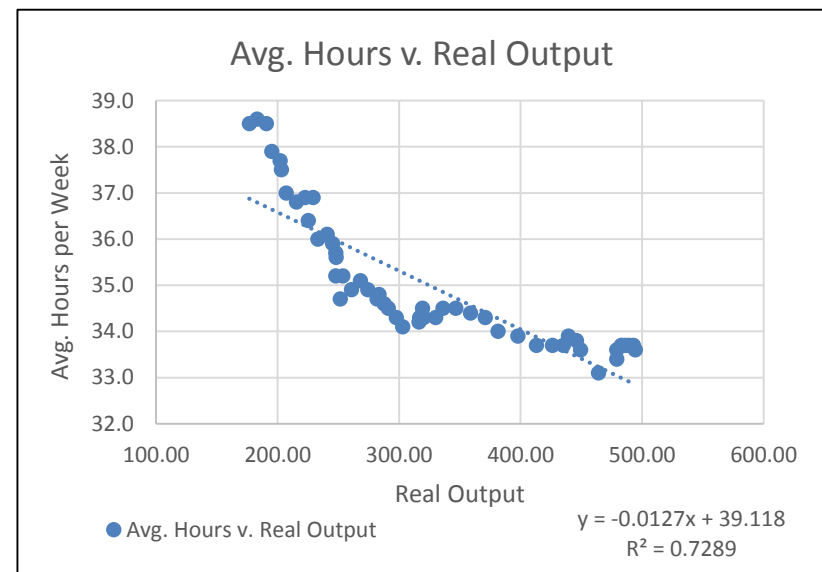
S	R-sq	R-sq(adj)	R-sq(pred)
0.778829	72.89%	72.36%	70.44%

### Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	39.118	0.364	107.35	0.000	
Real output per person	-0.01268	0.00108	-11.71	0.000	1.00

### Regression Equation

Average weekly hours = 39.118 - 0.01268 Real output per person



Source: <https://fred.stlouisfed.org>; US Census Bureau Data

# ...And a decrease in hours worked is significant explaining a decline in jobs created

## Model Summary

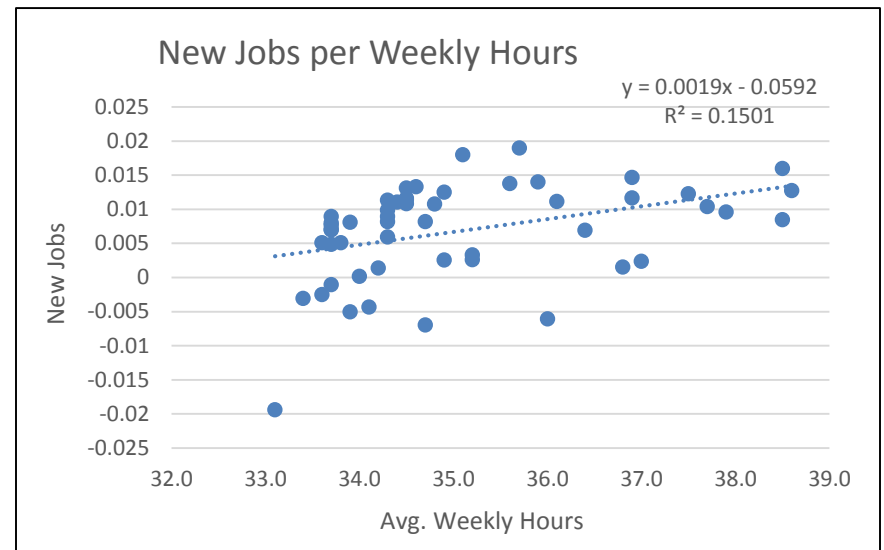
S	R-sq	R-sq(adj)	R-sq(pred)
0.0066985	15.01%	13.31%	8.61%

## Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-0.0592	0.0222	-2.66	0.010	
Average weekly hours	0.001881	0.000633	2.97	0.005	1.00

## Regression Equation

New Jobs per person =  $-0.0592 + 0.001881 \text{ Average weekly hours}$



**One hypothesis is that people have extra capacity or higher efficiency to cover additional work when required**

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# Conclusion: Productivity & New Jobs

## Project Motivation

- Noticeable trend: As technology advances, a decrease of jobs in labor-intensive sectors coincides with an increase of tech & information sector jobs
- Are increases in productivity bad for workers?
- Namely, as productivity increases, do wages and job growth slow, controlling for other factors?



## Results of Analysis

- Productivity is significant in explaining a decline in new jobs
- But the situation is not dire; in the short term, at least, productivity will not cause mass unemployment
- Productivity will, however, slow the creation of new jobs

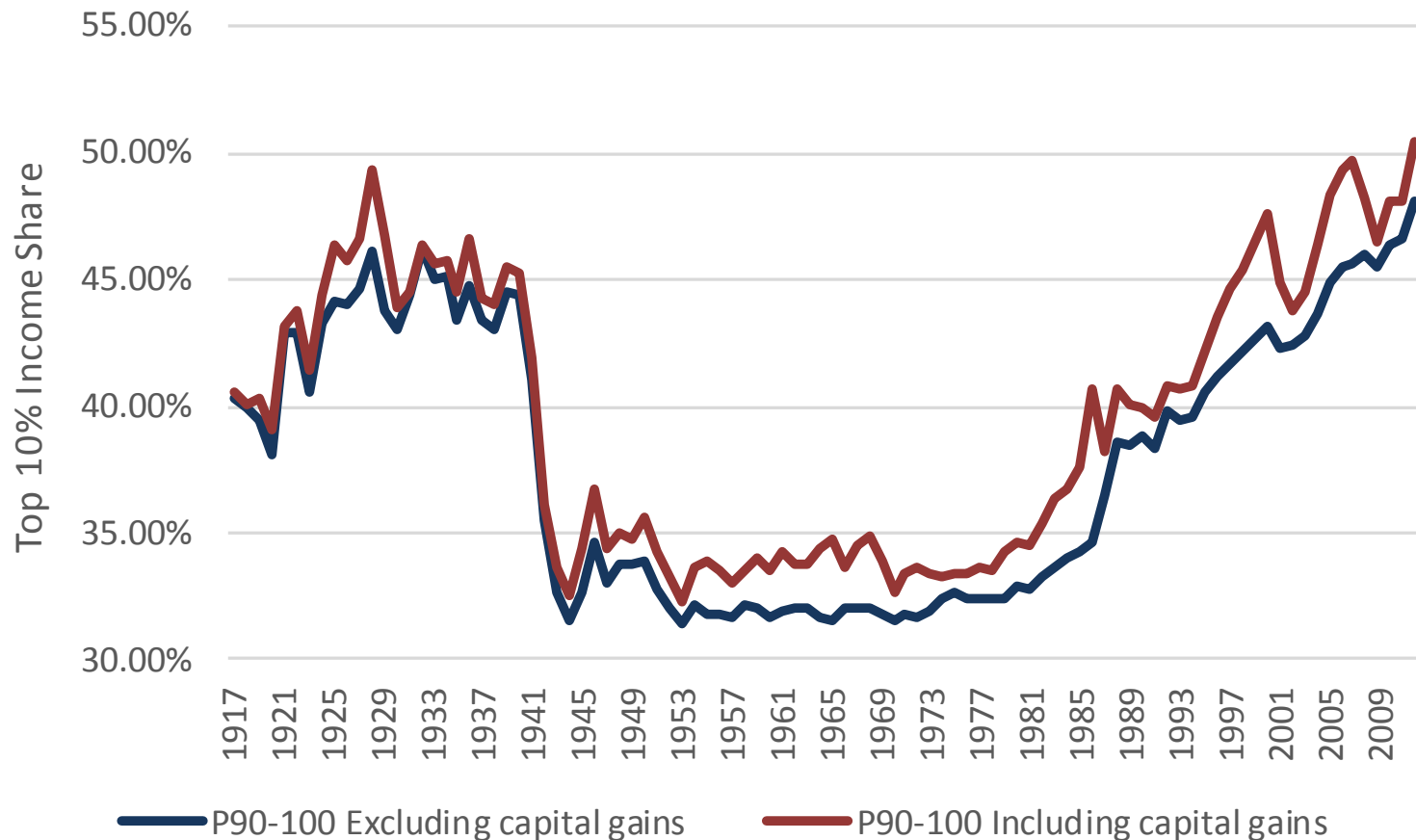


## Further Thoughts

- What is impact of shifting demographics on workforce: Outflux of retiring Baby Boomers & influx of Generation Z?
- Will increased productivity offset smaller Gen Z workforce? And if so, is job growth slowdown OK?
- Gen Z is the first natively digital generation → Will faster adoption of new tech result in accelerated productivity gains?

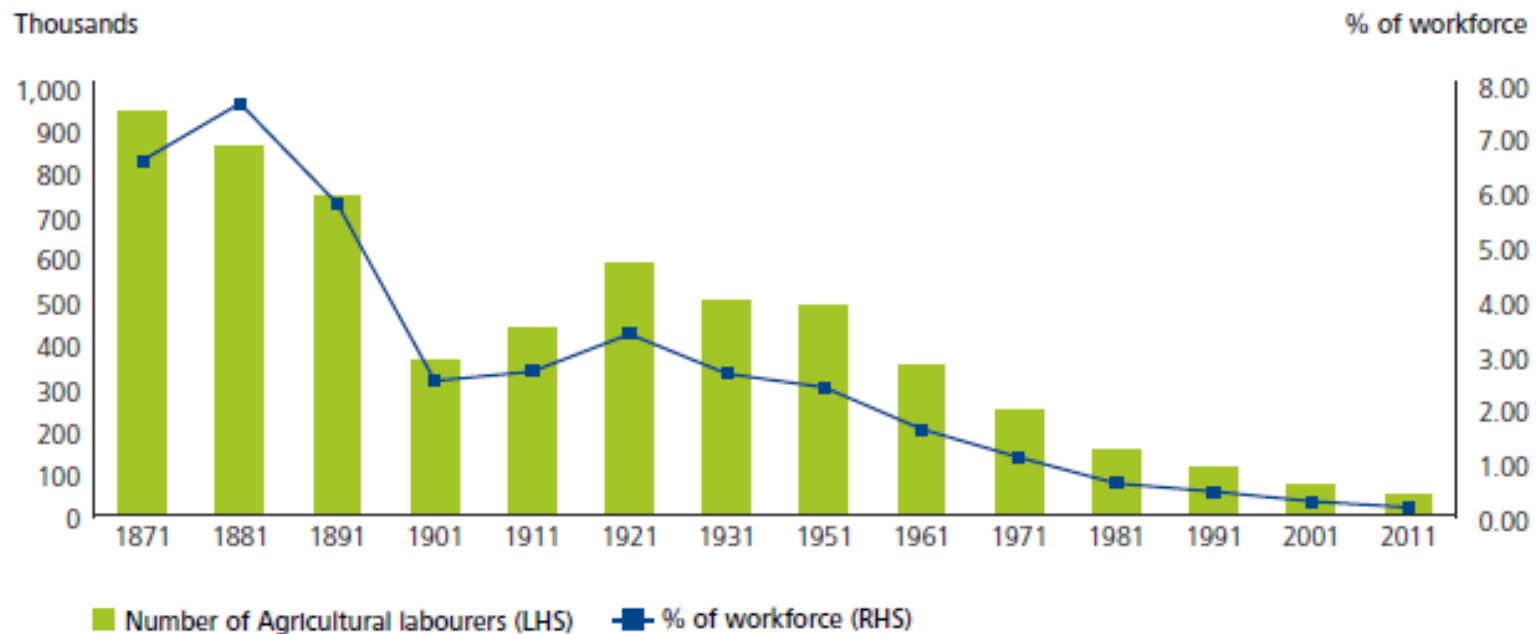
# Appendix

**After WWII, the top 10% share of income with the bottom 90% was stable until the early 1980s following the invention of the microchip**





# The need for physical laborers in certain industries has drastically decreased over time...



# Defining our terms:

- **Real output per person**: The measure describes the relationship between real output and the labor time involved in its production. Measures of labor productivity growth show the changes from period to period in the amount of goods and services produced per hour worked. They reflect the joint effects of many influences, including changes in technology; capital investment; level of output; utilization of capacity, energy, and materials; the organization of production; managerial skill; and the characteristics and effort of the work force<sup>1</sup>

1) <https://www.bls.gov/news.release/pdf/prod2.pdf>