



MONTHLY REVIEW OF ACADEMIC LITERATURE ON RESEARCH AND INNOVATION AS SOURCES OF GROWTH

Contact: DG RTD, Directorate A, A4, Eva Rueckert, eva.rueckert@ec.europa.eu, and Roberto Martino, roberto.martino@ec.europa.eu

This literature review focuses on the nexus between employment and innovation, as well as on the debate around the evolution of labour and capital shares in total value added.

The *first four papers* investigate the links between innovation and employment, testing different theoretical frameworks with empirical analyses. The *last four papers* analyse the decline of the labour share in value added, by estimating trends with new methods.

On the links between innovation and employment

1. Is modern technology responsible for jobless recoveries?

Graetz G., Michaels G. (2017). *Is modern technology responsible for jobless recoveries?* Discussion Paper Series DP 11789, CEPR, London.

- Outside of the US, routine-intensive industries are not subject to more severe recessions and less pronounced recoveries; this finding also holds for industries which make extensive use of industrial robots and automation.
- The paper finds no link between modern technologies and jobless recoveries in developed countries outside the US since the late 1980s.
- Workers in middle-skill routine jobs are prone to be replaced by technological innovations, but not yet outside the US.

This paper sets out to establish whether the picture of "jobless recoveries" due to technological change observed in the US is replicated in other countries of the developed world. By making use of data on recoveries after 71 recessions in 28 industries and 17 countries within the time period from 1970 until 2011, the authors do not find empirical evidence for slower employment growth during recoveries since the late 1980s. Albeit GDP recovered more slowly, the pattern of recovery does not deviate in routine-intensive industries.

In the US workers holding middle-skill jobs involving routine-tasks are likely to be subject to displacement and subsequent transitioning into other industries and occupations. In the 17 countries observed, however, no difference was found between the post-recession recovery of middle-skill jobs in routine-intensive and non-routine-intensive industries during the period analysed. Hence, the findings of this paper do not support the hypothesis of jobless recoveries caused by technological change.

2. Robots at work

Graetz G., Michaels G. (2015). *Robots at work.* Discussion Paper Series DP 10477, CEPR, London.

- The paper investigates the impact of the use of industrial robots on economic outcomes using industry-level panel data between 1993 and 2007.

- Findings suggests that they have a substantial effect on economic growth, accounting for 0.37 percent, which is about one tenth of aggregate growth after considering possible confounding factors.
- Whilst aggregate employment appears to be unaffected by the increased use of robots, the study finds evidence for labour-saving outcomes for the low-skilled, and to a lesser extent the middle-skilled.

Increased utilisation of robots, or 'robot density', comes at a time when the price of technology is decreasing and the quality is improving rapidly. Using panel data from EU KLEMS and the International Federation of Robotics for 17 countries, this paper finds an increase in robot density of 150 percent over the time span considered. Countries particularly affected included Germany, Denmark and Italy, whereas at the industry level increased robot density is recorded for transport equipment, chemicals and metal industries. The estimation results point towards higher gains in labour productivity within industry and country with accelerated robot density.

However, the research also shows that larger increases in robot density go hand in hand with small gains in productivity. This finding suggests that there exist bottlenecks to the translation of marginal gains from robotisation into productivity growth. Overall the magnitude of the estimated productivity gains is comparable to estimates of the contribution of ICT to EU and US productivity growth, but not as large as estimates for the impact of ICT capital services. The potential for further improvements in the quality and capabilities of robots might change the magnitude of these estimated effects with potentially more substantial effects in the future. The results of the empirical investigation also confirm previous findings of skill-biased technological change. Further important outcomes of robotisation include a positive and significant relationship with total factor productivity as well as average wages.

3. The innovation-employment nexus: a critical survey of theory and empirics

Calvino, F., Virgillito, M. E. (2017). The innovation-employment nexus: a critical survey of theory and empirics. *Journal of Economic Surveys*, 0(0), 1-35.

- The paper provides a critical survey of the relationship between innovation and employment, covering both the theoretical background and the most recent empirical work.
- The nexus is reviewed distinguishing between process and product innovation, as well as different levels of aggregation.
- Product innovation is generally found to be positively related to employment at the firm level, while the role of process innovation is less clear-cut, with a non-negative relationship emerging from the literature.
- The magnitude of the effect is lower when specific sectors are analysed, due to business stealing and competitive dynamics. Product innovation is robustly linked to higher employment and seems to be a relevant driver for the expansion of industries.

The survey reviews the most recent literature on the link between innovation and employment. Theoretically, innovation may affect job creation via different mechanisms. On the one hand, technological progress leads to displacement of workers and, as long as innovation is labour saving and capital and employment are substitutes, the lower labour demand will be. On the other hand, increases in productivity can reduce prices, leading to higher demand and eventually higher labour demand. In addition, the Schumpeterian view emphasizes the positive net-effect of new products as drivers of demand, consumption and consequentially employment creation, counterbalancing the destruction of old vintages.

Conversely, process innovation is usually seen as labour-unfriendly. Empirically, several stylized facts emerge from the recent empirical works. At the firm level, a general positive effect of innovation on employment is found, in particular for high-growth and high-knowledge intensive companies. Product innovation is also confirmed to be positively related to employment suggesting that the net effect on job creation is positive. The evidence is ambiguous for process innovation, however, when the analysis is moved to the sectoral level, a negative correlation prevails, suggesting that competitive dynamics and job displacement effects between industries are in place.

4. Technological change and employment: were Ricardo and Marx right?

Piva M., Vivarelli M. (2017). *Technological Change and Employment: Were Ricardo and Marx Right?* IZA DP No. 10471

- The paper discusses the impact of technological change on employment from an economic history perspective as well as providing empirical evidence.
- By making use of an original taxonomy for R&D intensity, the authors reveal new insights about the R&D-employment nexus across sectors from 1998-2011 for 11 member states.
- They find a significant positive relationship between R&D intensity and job creation which is however confined to the medium- and high-tech sectors. Conversely, capital formation is not found by the authors to be labour-friendly.

This paper starts out with a short review of the main arguments presented throughout the history of economic thought on the interaction between technological change and employment, also known as technological unemployment since David Ricardo and Karl Marx. Together with the historical and economic context the authors present the so called "compensation theory" for process innovations and its critique, as well as the theory concerned with the employment impact of product innovation. The former theory starts with the premise that the direct impact of process innovation is job destruction as by definition the same amount of output is generated with fewer production factors. However one compensation mechanism would be creation of jobs in new sectors which benefit from this technological change and another mechanism would trigger job creation through a decrease in prices as demand, and hence production, picks up.

Enhanced investment opportunities as well as wage decrease and income increases can, under certain assumptions, also lead to higher rates of employment. However, the authors state that classical and current economic theory suffers from an "optimistic bias" and that the argument of compensation mechanisms no longer holds in the current market environment. No compensation can be empirically observed and the evidence suggests a labour-saving effect associated with process innovation and the embodied technological change. On the other hand, R&D expenditure which is related more to product rather than process innovation is found to have a positive elasticity with respect to employment. Its impact is small but significant. A doubling in investment in R&D would imply a rise of the employment rate of about 0.5%.

On the decline of the labour share in value added

5. Concentrating on the fall of the labor share

Autor D., Dorn D., Katz L. F., Patterson C., van Reenen J. (2017). *Concentrating on the Fall of the Labor Share.* IZA DP No. 10539.

- The authors establish a model which highlights the increase in the market share of superstar firms and a declining share of labour of GDP.
- The key finding of the paper is that as the concentration of superstar firms who control a large share of the market increases, the aggregate share of labour in value added decreases.
- Between 2007 and 2012 an increase of a percentage point in concentration leads to a 0.4 percentage point fall in the associated labour share in value added.

The recent interest in the falling labour share of GDP has resulted in many empirical investigations and modelling exercises. The present paper postulates that technological change and competitive conditions as well as their interaction are responsible for an increase in the share of sales amongst a selected group of firms with superior products or higher levels of productivity. Relative to sales or value added the share of labour falls as profits rise, leading to a lower aggregate share of labour as market concentration intensifies. The estimates are presented for 5-year intervals in the observed time period and show an acceleration of concentration and falls in labour shares over time.

The exploited US Census data for the period between 1982 and 2012 and six sectors of the economy account for four-fifths of total private sector employment. Alternative explanations for the "winner takes most" hypothesis and the corresponding increase in industry sales concentration include an incumbent's firm advantageous innovation activity and subsequent increase in the market share and anti-competitive forces such as lobbying for regulatory barriers. In terms of the mechanism of the effect, the paper clearly shows that within industries where concentration rises the most, the decline in the labour share is the sharpest. This fall is mainly accounted for by the reallocation of labour towards firms with lower (and declining) labour shares, as opposed to falling labour shares within companies.

6. Has the labor share declined? It depends

Cho T., Hwang S., Schreyer P. (2017). *Has the Labour Share declined? It depends*. OECD Statistics Working Papers, Paris.

- This paper adds a new angle to measurement issues related to the declining share of labour in the distribution of income and the associated discussion on inequality.
- The two measurement approaches produce diverging estimates with regards to the decline in the labour share.
- While the production-based measure of labour and capital income confirms a statistically significant, yet modest decline in the labour share across countries, the income-based measure provides much weaker and even no empirical support for this hypothesis. Hence the latter measure cannot provide insights on the divergence in inter-household income distributions.
- A measure to decompose the differences between the two measures for the labour share reveals that the most important driver for the divergence in share changes is depreciation.

According to the production perspective, the labour share is equal to the share of factor income or production cost that is attributed to labour. In neoclassical growth accounting, the firm minimises its costs and the labour share approximates the unobserved cost elasticity of labour in the production process. From an income perspective on the other hand, the labour shares refer to the distribution of income between the two production factors capital and labour. As noted by Nobel laureate Atkinson, it is insightful to study the links between the macro- and the household perspective of income to establish issues of inequality and the loss of societal welfare.

A falling labour share can be interpreted as a widening of the aggregate income distribution as the income from work tends to be a more important source of income for lower-income than high-income households. The approach taken excludes housing services for the product, but not the functional income analysis of the labour share. Further, in the framework of the income as opposed to the production perspective, the measure is computed net of depreciation rather than in gross terms. From the production perspective the share of labour is declining, whereas this finding is not confirmed when adopting the income perspective. Hence changes in the functional income distribution where labour is replaced by capital are solely responsible for the rise in observed income inequality in OECD countries. A further key finding of the analysis is a change in the distribution within capital income components. To shed further light on the movement of capital and labour shares in OECD countries alternative measures taking into account assets which do not stem from production, such as land for example, would need to be readily available.

7. Labor share decline and intellectual property products capital

Koh, D., Santaaulàlia-Llopis, R., Zheng, Y. (2016). *Labor share decline and intellectual property products capital*. Barcelona GSE Working Paper Series, 927.

- The paper looks at the drivers of the decline in the US labour share over the past 65 years.
- Results show that the downward trend of the labour share is due to the rise of investment in intellectual property products (IPP) capital.
- Investment in IPP has been growing by a factor of 25 in 1947-2013, 4 times than traditional investment, despite a similar price.

The labour share has been declining over the last decades in developed economies, such as the US, where it fell from 0.68 in 1947 to 0.60 in 2013. The study makes use of national income and product accounts data for the US to investigate the role of rising investment in IPP in the labour share fall. Investment in IPP is characterised by higher growth rates than traditional capital and a higher depreciation rate, despite a similar price.

The hypothesis that the increase in IPP offsets the labour share decline is tested by complementing official national accounts with investment in IPP capital. Results show that IPP, in particular software, can explain the decline of the share of labour on national US income¹. IPP depreciation is the main contributor, accounting for 65% of the total decline, while the remaining can be attributed to net IPP capital income, signalling the structural transition of the US economy towards more IPP intensive activities.

8. Declining labor and capital shares

Barkai S. (2016). *Declining Labor and Capital Shares*. Working Paper, University of Chicago.

- The study investigates the trend of labour and capital shares in the US in the last 3 decades to verify whether the decline in the former is offset by an increase in the latter.
- Contrary to findings presented in the previous literature, the decline in the labour share is not accompanied by an increase in the capital share, but by a rise in profits.
- The results are due to a different accounting method for the returns on capital and are robust to the inclusion of unobserved capital, such as intangibles assets excluded by the standard national accounts.

Recent evidence documents the sharp decline in the share of labour in gross value added in developed economies. The standard explanation highlights the trade-off between labour and capital, pointing at technological change, mechanisation and change in the relative price of capital as the main source of the shift from labour to capital inputs. If this assumption would be robust, then the reduction in the labour share would bring efficiency (in production) and welfare (decline in commodities prices) gains.

By using a new method to compute the rate of return to capital, the paper shows that the reduction in the labour share is not offset by an increase in the capital share, the latter being decreasing as well. As a consequence, the efficiency argument is not supported. Differently, the study shows that the fall in the labour share has been accompanied by a six-folds increase in profits between 1984 and 2014, with an estimated share of 15.7% at the end of this period. The accounting procedure is corroborated by an empirical exercise which shows a negative relation between mark-ups and labour share. The results are robust to the inclusion of intangible assets excluded in standard national accounts and whose value would need to be 560% of observed gross value added in order to nullify the estimated rise in the profit share.

¹ Note that the authors include profits in the capital share. A different approach is in paper 8 below.