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The role of technological
progress, globalisation and
“winner-takes-most”
dynamics

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ROLE OF TECHNOLOGICAL PROGRESS, GLOBALISATION AND
“WINNER-TAKES-MOST” DYNAMICS**

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By Cyrille Schwellnus, Mathilde Pak, Pierre-Alain Pionnier and Elena Crivellaro

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ABSTRACT/RÉSUMÉ

Labour share developments over the past two decades: The role of technological progress, globalisation and “winner-takes-most” dynamics

Over the past two decades, real median wage growth in many OECD countries has decoupled from labour productivity growth, partly reflecting declines in labour income shares. This paper analyses the drivers of labour share developments using a combination of industry- and firm-level data. Technological change in the investment goods-producing sector and greater global value chain participation have compressed labour shares, but the effect of technological change has been significantly less pronounced for high-skilled workers. Countries with falling labour shares have witnessed both a decline at the technological frontier and a reallocation of market shares toward “superstar” firms with low labour shares (“winner-takes-most” dynamics). The decline at the technological frontier mainly reflects the entry of firms with low labour shares into the frontier rather than a decline of labour shares in incumbent frontier firms, suggesting that thus far this process is mainly explained by technological dynamism rather than anti-competitive forces.

JEL Classification codes: D33, F66, J24, L11, O33.

Keywords: Labour share, superstar firms, global value chains, skills.

Évolution de la part du travail dans le revenu des facteurs au cours des vingt dernières années : influence des progrès technologiques, de la mondialisation et de la dynamique du « presque tout au gagnant »

Au cours des vingt dernières années, dans de nombreux pays de l'OCDE, la croissance des salaires médians réels s'est dissociée de celle de la productivité du travail, en partie sous l'effet de la contraction de la part du travail dans le revenu des facteurs. Ce papier analyse les déterminants de l'évolution de la part du travail dans le revenu des facteurs à partir de données recueillies à la fois au niveau des secteurs et au niveau des entreprises. Les progrès technologiques enregistrés dans le secteur des biens d'équipement et la participation accrue aux chaînes de valeur mondiales ont contribué au déclin de la part du travail dans le revenu des facteurs. Toutefois, les effets des innovations technologiques sont nettement moins marqués pour les travailleurs hautement qualifiés. Dans les pays où la part du travail recule, on observe à la fois un déclin à la frontière technologique et une redistribution des parts de marché au profit des entreprises « superstars » à faible intensité de travail (conformément à une dynamique de « winner-takes-most »). Le déclin constaté à la frontière technologique tient davantage à l'arrivée à cette frontière d'entreprises à moindre intensité de travail qu'à une contraction de la part du travail dans les entreprises déjà situées à la frontière technologique, ce qui donne à penser que jusqu'à présent, ce processus est principalement déterminé par le dynamisme technologique plutôt que par le jeu des forces anticoncurrentielles.

Classification JEL: D33, F66, J24, L11, O33.

Mots-clés: Part du travail, entreprises superstars, chaînes de valeur mondiales, qualifications.

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Labour share developments over the past two decades: The role of technological progress, globalisation and “winner-takes-most” dynamics

By Cyrille Schwellnus, Mathilde Pak, Pierre-Alain Pionnier and Elena Crivellaro¹

1. Introduction

1. Real wage gains are the most direct mechanism through which productivity gains are transmitted to workers, but over the past two decades real median wage growth in most OECD countries has decoupled from labour productivity growth. This reflects declines in labour shares - the decoupling of average wages from productivity - and increases in wage inequality - the decoupling of median wages from average wages. In contrast to previous decades, productivity gains no longer appear to translate into broadly shared wage gains for all workers.² Since wages are typically the main source of market income for low- and middle-income households, this decoupling also tends to increase inequality in market incomes (total pre-tax incomes excluding income from government sources). Since redistribution through taxes and benefits is constrained by efficiency considerations and has declined in many countries (Causa and Hermansen, 2017^[1]), the decoupling of real median wages from labour productivity is a key public policy issue.

2. This paper uses disaggregated data at the industry- and firm levels to analyse the role of technology and global value chain expansion in aggregate labour share developments, i.e. the decoupling of average real wages from productivity. The main contributions to the existing body of research are threefold. Firstly, the use of disaggregated data allows a more credible identification of the structural drivers of labour share developments than studies based on aggregate data. In particular, the industry-level approach used in this paper allows controlling for unobserved country- and industry-specific trends that may bias estimates from country-level studies. Secondly, the paper analyses the role of skills and routine-task intensity in shaping the response of labour shares to technological change and global value chain expansion. Thirdly, the paper sheds

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² Previous analyses of decoupling include Pessoa and van Reenen (2013^[45]) for the United Kingdom, Bivens and Mishel (2015^[43]) for the United States, as well as Schwellnus, Kappeler and Pionnier (2017^[46]) and Sharpe and Ugucioni (2017^[44]) for selected OECD countries.

light on a number of micro mechanisms underlying aggregate labour share developments. In particular, it analyses the extent to which aggregate labour share developments are related to “winner-takes-most” dynamics and provides suggestive evidence on whether such dynamics reflect secular trends or policy distortions.

3. The paper is related to several strands of research analysing the structural and policy drivers of labour share developments. A first strand typically finds that at the aggregate level labour shares are negatively associated with technological change and trade integration, but there is no consensus on the relative importance of these factors (De Serres and Schwellnus, 2018^[2]; Elsby, Hobijn and Sahin, 2013^[3]; IMF, 2017^[4]; Karabarbounis and Neiman, 2014^[5]; OECD, 2012^[6]). A second strand of related research suggests that at the aggregate level the association of labour shares with technological change is more negative in countries with high shares of workers carrying out routine tasks, but has neither provided clear-cut results at the industry-level nor analysed the role of skills (IMF, 2017^[4]). Finally, an emerging strand of research highlights the role of changes in product market structure in labour share developments: technology-, globalisation- or policy-induced “winner-takes-most” dynamics may lead to rising concentration and higher profit shares, thereby reducing labour shares (Autor et al., 2017^[7]; De Loecker and Eeckhout, 2017^[8]; Barkai, 2016^[9]).

4. The main findings are as follows:

- Technological change and globalisation can explain most of the contraction of the labour share. Technology-driven declines in relative investment prices and, to a lesser extent, the expansion of global value chains (in which different stages of production are spread across countries or regions) account for about two-thirds of the aggregate labour share decline in the OECD.
- The substitution of capital for labour in response to declines in relative investment prices is particularly pronounced in industries with a predominance of high routine tasks.
- High shares of high-skilled workers reduce the substitution of capital for labour even in industries with a higher level of routine tasks. High-skilled workers, especially those with high numeracy and problem-solving skills, may be more difficult to replace by machines or may be more easily re-deployed to non-routine tasks than low-skilled workers.
- Declines in relative investment prices affect aggregate labour shares partly by reducing labour shares within firms (labour costs as a proportion of a firm's total value added).
- Global value chain expansion does not affect labour shares within firms, suggesting that such expansion therefore reduces the labour share by reducing the proportion of firms with high labour shares.
- Countries with falling labour shares have witnessed both a decline at the technological frontier and a rise in market shares of capital-intensive “superstar” firms with low labour shares (“winner-takes-most” dynamics).
- The labour share decline at the technological frontier mainly reflects the entry of capital-intensive firms with low labour shares into the frontier rather than a decline in incumbent frontier firms, suggesting that thus far “winner-takes-most” dynamics are mainly explained by technological dynamism.

5. The remainder of the paper is structured as follows. Section 2 provides a brief review of the literature on the drivers of labour shares. Section 3 describes the empirical setup and Section 4 describes the industry- and firm-level data used in the empirical analysis. Section 5 illustrates the empirical results and discusses the policy implications. A particular focus is on the use of firm-level data to analyse and discuss the role of “winner-takes-most” dynamics in explaining aggregate labour share developments. Section 6 concludes.

2. Technology and globalisation as drivers of labour shares: Literature review

6. Capital-augmenting technological change or technology-driven declines in equipment prices may reduce the labour share by raising capital intensity. If factor prices are determined competitively, the labour share declines with capital intensity so long as the elasticity of substitution between capital and labour is above unity. Most estimates of the elasticity of substitution are based on within-country time series variation of factor shares and factor prices. These estimates generally imply an elasticity of substitution below one (Chirinko, 2008^[10]). By contrast, Karabarbounis and Neiman (2014^[5]) use cross-country and cross-industry variation in labour shares and relative investment prices to obtain an elasticity of substitution in the range of 1.2-1.5. According to their estimations, large declines in equipment prices across a broad range of high-income and emerging economies explain around 50% of the global decline of the labour share.

7. Over time, capital may have become more easily substitutable for labour. On the one hand, new technology extends the range of existing tasks that can be carried out by machines, thereby displacing workers and reducing the labour share (Acemoglu and Restrepo, 2018^[11]). On the other hand, new technology also creates new tasks that cannot be carried out by machines. As the nature of technological progress changes, the balance between labour displacement and task creation from new technologies may shift. Evidence for the United Kingdom and the United States, for instance, suggests that the elasticity of substitution between ICT capital and labour is significantly higher than for other capital goods and is well above one (Tevlin and Whelan, 2003^[12]; Bakhshi, Oulton and Thompson, 2003^[13]). In line with this finding, recent evidence on labour share developments for the United States suggests that technological progress has become more labour displacing over time, with particularly large labour-displacing effects in the 2000s (Autor and Salomons, 2018^[14]).

8. Previous research suggests that capital-labour substitution in response to declines in investment prices is particularly pronounced for low-skilled workers. Krusell et al. (2000^[15]) find that in the United States the elasticity of substitution between capital and low-skilled labour is around 1.7, well above the estimated elasticity between capital and high-skilled labour of 0.7. This is consistent with cross-country evidence in IMF (2017^[4]) of particularly negative effects of declines in relative investment prices on labour shares in countries with high initial shares of routine jobs. Moreover, using cross-country cross-industry data, IMF (2017^[4]) find that the elasticity of substitution between capital and labour increases with industries' routine task exposure and is above unity in about half of the industries covered by their analysis.³

³ In a cross-country-industry panel covering high-income countries, Bassanini and Manfredi (2012^[37]) find that capital-augmenting technical change reduces the labour share. By contrast,

9. Globalisation in the form of increased trade integration may have similar effects on the labour share as increases in capital intensity (Acemoglu and Autor, 2010^[16]). For instance, offshoring of the most labour-intensive stages of production or increased import competition may lead to worker displacement and an increase in capital intensity. If the aggregate elasticity of substitution between capital and labour is above unity, this would reduce the labour share. The cross-country evidence in Harrison (2005^[17]) and the cross-industry evidence for the United States in Elsby, Hobijn and Sahin (2013^[3]) are consistent with this hypothesis. In a cross-country, cross-industry study IMF (2017^[4]) find that increased participation in global value chains has reduced the labour share in low-income countries but that there is no effect in high-income countries.⁴

10. Technology and globalisation strengthen supply- and demand-side economies of scale, which may in turn give rise to “winner-takes-most” dynamics (Rosen, 1981^[18]; Frank and Cook, 1995^[19]; Autor et al., 2017^[7]). While the relevant market for the best manufacturing firms used to be primarily national or regional, the fall in transport costs and tariffs implies that these firms can now serve significant shares of the global market, strengthening supply side economies of scale. The trend toward larger market size has been reinforced by rapid progress in information and communication technologies (ICT) that allow matching sellers and buyers across geographically distant locations.⁵ Rapid progress in ICT has also facilitated the emergence of markets with a global scale in a number of traditional services industries, such as retail and transport, as well as new ICT services with near zero marginal cost of scaling up operations.⁶ In some of these industries, including ICT services, retail and transport, network externalities (demand side economies of scale) that favour the emergence of a dominant player have become more important.⁷

11. The presence of “winner-takes-most” dynamics implies falling labour shares in the technologically most advanced firms as well as reallocation of market shares toward these firms. In a standard model with heterogeneous firms, the best firms have low labour shares because the fixed overhead labour cost needed for production is distributed over a larger output and/or because large market shares allow these firms to charge higher

Grossman et al. (2017^[38]) develop a theoretical model in which a *decline* in the rate of technical change reduces the labour share irrespective of whether it is labour- or capital-augmenting.

⁴ Participation in global value chains is measured by the sum of the share of foreign value added in gross exports (backward participation) and the share of exports consisting of intermediate inputs used by trading partners for the production of their exports to third countries (forward participation). Annex Table 3.5.1 (Column 6 in IMF, 2017^[4]) shows that participation in global value chains has a negative and significant effect on labour shares in emerging market economies but that the effect is close to nil for advanced economies.

⁵ For instance, the internet has created international marketplaces on which sellers offer a large variety of products and buyers can compare prices globally.

⁶ For instance, the marginal cost of replicating and supplying the informational goods provided by digital platforms is near zero.

⁷ Network externalities are relevant for digital platforms (e.g. through better matching of suppliers and buyers) but also for retail (e.g. through better access to network of suppliers) and transport (e.g. through more efficient logistics). In some industries, network externalities operate through more subtle channels; for instance, the use of private airlines' computerised reservation systems among travel agents can lead to the emergence of dominant players (Frank and Cook, 1995^[19]).

markups (Autor et al., 2017^[7]). “Winner-takes-most” dynamics imply that as technology and globalisation raise the relevant market size the best firms become larger which implies that: (i) the labour share in these firms declines as the value added share of fixed overhead labour cost declines and/or the markup increases; and (ii) production is reallocated toward low labour share firms as the market share of the best firms increases.

3. Modelling industry-level labour shares

12. Adopting an industry-level approach to the modelling of labour shares is both conceptually and econometrically appealing. From a conceptual standpoint, the fact that changes in aggregate labour shares overwhelmingly reflect developments within industries rather than cross-industry reallocation justifies modelling industry-level labour shares to explain aggregate developments (Figure A B.1).⁸ From an econometric standpoint, the industry-level approach has the advantage that country- and industry-specific trends can be controlled for through an appropriate fixed effects structure.

3.1. Theory

13. The baseline empirical specification is motivated by a theoretical model linking the cost of capital, offshoring and the labour share. The model introduces capital into the two-factor model of offshoring in Grossman and Rossi-Hansberg (2008^[20]) and explicitly models factor shares under the assumption of an elasticity of substitution between capital and routine labour above unity. The detailed analysis is in Annex D, but the main predictions are sketched here.

14. The first key prediction of the model is that a decline in the relative investment price reduces the labour share, with the reduction being larger in industries using a larger share of routine labour. Declines in relative prices of capital goods lead to the substitution of capital for routine labour, which reduces the overall labour share. The larger the share of routine labour in an industry, the larger is the negative effect of a given relative investment price decline on the labour share, which reflects the assumption that the elasticity of substitution with capital is higher for routine than for non-routine labour.

15. The second key prediction of the model is that a decline in the cost of offshoring has an ambiguous effect on the labour share. On the one hand, the decline in the cost of offshoring leads to the substitution of imported intermediate goods for domestic routine labour and thereby to a reduction in the domestic wage bill as a share of gross output. On the other hand, offshoring of previously domestically produced output leads to a reduction in domestic value added as a share of gross output. Without further restrictions on parameters, the effect on the ratio of the domestic wage bill to domestic value added is ambiguous. This theoretical ambiguity is consistent with conflicting results on the impact of offshoring on the labour share in the empirical literature: while a number of studies find a negative impact (Elsby, Hobijn and Sahin, 2013^[3]; IMF, 2017^[4]), other studies find

⁸ At the level of industry disaggregation used in this paper, labour share developments within industries explain around 80% of aggregate labour share developments, which is broadly in line with previous studies (Bassanini and Manfredi, 2012^[37]; Karabarbounis and Neiman, 2014^[5]; IMF, 2017^[4]). Given that reallocation across industries explains only a small fraction of aggregate labour share developments, weighting industries with shares in aggregate value added in the regression analysis allows making direct statements on aggregate effects.

that the negative impact on the wage bill is smaller in magnitude than the impact on value added so that the labour share increases in response to offshoring (Autor et al., 2017^[7]).

3.2. Empirical model

16. The estimated baseline empirical specification is as follows:

$$\Delta LS_{ijt} = \beta_1 \Delta P_{ijt}^{Inv} + \beta_2 \Delta T_{ijt} + \beta_3 (RTI_{ijt}^0 \times \Delta P_{ijt}^{Inv}) + \beta_4 (RTI_{ijt}^0 \times \Delta T_{ijt}) + \beta_5 X_{ijt} + \alpha_{it} + \alpha_{jt} + \varepsilon_{ijt} \quad (1)$$

where subscripts i, j and t denote, respectively, countries, industries and periods; ΔLS_{ijt} denotes the medium-term (5- or 6-year) change in the labour share; RTI_{ijt}^0 denotes initial routine task intensity; ΔP_{ijt}^{Inv} denotes the medium-term change in the relative investment price; ΔT_{ijt} denotes the medium-term change in participation in global value chains; X_{ijt} denotes control variables that vary at the country-industry-period level, including the initial routine task intensity RTI_{ijt}^0 ; α_{it} and α_{jt} denote country-by-period and industry-by-period fixed effects. Given that the model is estimated in differences, the fixed effects pick up country-period and industry-period specific trends.⁹ A drawback of the fixed effects structure in equation (1) is that it does not permit the explicit identification of business cycle effects since changes in the output gap are perfectly collinear with the country-period fixed effects. Some of the results reported below therefore replace the country-period fixed effects by country fixed effects while including medium-term differences in the output gap.

17. A large body of macro-level evidence suggests that the elasticity of substitution is higher for unskilled labour than for skilled labour (Duffy, Papageorgiou and Perez-Sebastian, 2004^[21]; Krusell et al., 2000^[15]). This implies that capital-labour substitution should be lower in industries with a high-share of high-skilled labour. A simple test of this hypothesis that is conducted below is to replace the routine task indicators that are interacted with changes in relative investment prices in the baseline specification by skill intensity indicators. However, routine and skill intensity indicators are likely to be positively correlated across industries, implying that any impact of skills on capital-labour substitution in this simple test may reflect the omission of routine intensity indicators. A more rigorous test conducted below is to augment the baseline specification with skill intensity indicators. A negative coefficient would suggest that even at a given level of routine task intensity capital-labour substitution is lower in high-skill industries than in low-skill industries. This could, for instance, be the case if higher-skilled workers are more difficult to replace by machines than lower-skilled workers or are reassigned to non-routine tasks within an industry more easily.

18. The econometric model is estimated over the period 1995-2011 focusing on medium-term changes in labour shares. For this purpose, the data is split into three periods of approximately 5 years (1995-2000, 2000-05 and 2005-11). The analysis of medium-term changes rather than long-term changes over the entire period permits a more precise estimation of the effects of structural and policy drivers of labour shares while allowing labour shares sufficient time to adjust given that the elasticity of substitution between labour and capital is likely to be higher in the medium term than in

⁹ Identification in this specification is obtained through the acceleration or deceleration of labour shares and the explanatory variables over and above country- and industry-specific trends.

the short term. Depending on the specification, business-cycle effects are controlled for by including country-period fixed effects or changes in output gap as explanatory variables.

4. Data and descriptive statistics

19. The empirical analysis is conducted on 20 OECD countries over the period 1995-2011 for which the dependent and all explanatory variables can be constructed.¹⁰ The industry-level labour shares are constructed from the OECD Annual National Accounts Database complemented with additional data from the archives of the OECD STAN database and the EU-KLEMS database. Labour compensation is the sum of compensation of salaried workers and the imputed compensation of self-employed workers. The imputation is based on the average compensation of salaried workers in the corresponding industry.¹¹ Labour compensation of salaried and self-employed workers is then divided by value added at factor costs to obtain industry-level labour shares. Value added at factor costs is defined as value added at basic prices less taxes net of subsidies on production. Using value added at factor costs in the denominator ensures that labour and capital shares of value added sum to one.¹²

20. Industry-level relative investment price indices are constructed from the OECD Annual National Accounts database with additional data from the EU-KLEMS database and the archives of the OECD STAN database. Price deflators for gross fixed capital formation are divided by value added price deflators in the corresponding industry. The same reference year (2000) is used for all indices.¹³

¹⁰ The countries included in the econometric analysis are: Australia, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Slovak Republic, Spain, Sweden, the United Kingdom and the United States. Observed data on global value chain participation (rather than forecasts) is not available after 2011.

¹¹ Depending on data availability, the imputation is based on hourly labour compensation or on per-capita labour compensation of salaried workers. This measure is based on the assumption that within industries average wages of salaried workers and self-employed workers are the same. If within industries average wages of self-employed workers are below those of salaried workers, this measure overestimates the labour share (Elsby, Hobijn and Sahin (2013_[3]); DNB (2016_[41]; 2017_[42])). However, basing labour compensation of self-employed workers on their total income (“mixed income” in the national accounts) as suggested by DNB (2016_[41]) risks overestimating the labour share in countries in which a large share of total income of self-employed workers consists of capital income.

¹² The primary, coke and refined petroleum manufacturing, housing and non-market industries are excluded from the analysis since labour shares in these industries are driven by changes in commodity and asset prices or by imputation choices (Schwellnus, Kappeler and Pionnier, 2017_[46]).

¹³ Extreme outliers in ICT manufacturing for some countries likely reflect measurement error and are dealt with by using the relative investment price in ICT manufacturing for the United States as an instrumental variable for the relative investment price in ICT manufacturing for all countries. Dropping ICT manufacturing from the regressions neither qualitatively nor quantitatively affects the results reported below. Observations below the first percentile or above the 99th percentile of the distribution of changes in nominal investment prices are dropped.

21. In line with previous studies, industry-level participation in global value chains is constructed as the sum of backward and forward linkages in vertical specialisation of production. Backward linkages measure the offshoring of intermediate inputs used in exports and are defined as foreign value added embodied in exports. Forward linkages measure trading partners' offshoring of intermediate inputs and are defined as domestic value added used as intermediate inputs in trading partners' exports.¹⁴ For the sample of high-income countries included in this paper, increases in backward and forward linkages are likely to have similar effects on labour shares: offshoring raises specialisation on the most capital-intensive stages of production while trading partners' offshoring raises demand for capital-intensive intermediate goods. The data are sourced from the OECD TiVA database, the OECD Annual Accounts database and EU-KLEMS database.

22. The industry-level routine intensity index is based on the occupation-level routine intensity index of Marcolin, Miroudot and Squicciarini (2016_[22]) and the industry-level skill indicators are constructed from the OECD Survey of Adult skills (PIAAC). The occupation-level routine intensity index provides a measure of the routine content of occupations, based on data from PIAAC. The routine intensity index measures the degree of independence and freedom in planning and organising the tasks to be performed on the job. The occupation-level index is translated into an industry-level index by constructing the weighted average of the occupation-based index by industry, with the occupational weights by industry are obtained from the European Labour Force Survey (1995-2015).¹⁵ PIAAC also allows constructing industry-level skill indicators in three areas: literacy, numeracy and problem-solving in technology-rich environments.¹⁶

23. The share of high-routine jobs is particularly high in industries such as transportation and non-metal manufacturing, and particularly low in ICT services and finance. While routine intensity and skill intensity are correlated across industries, a high employment share of low-skilled workers does not necessarily imply a high share of high-routine jobs, which allows to empirically distinguish between the effects of routine tasks and skills. The accommodation and construction industries, for instance, employ high shares of low-skilled workers but low shares of high-routine jobs (Figure 1).

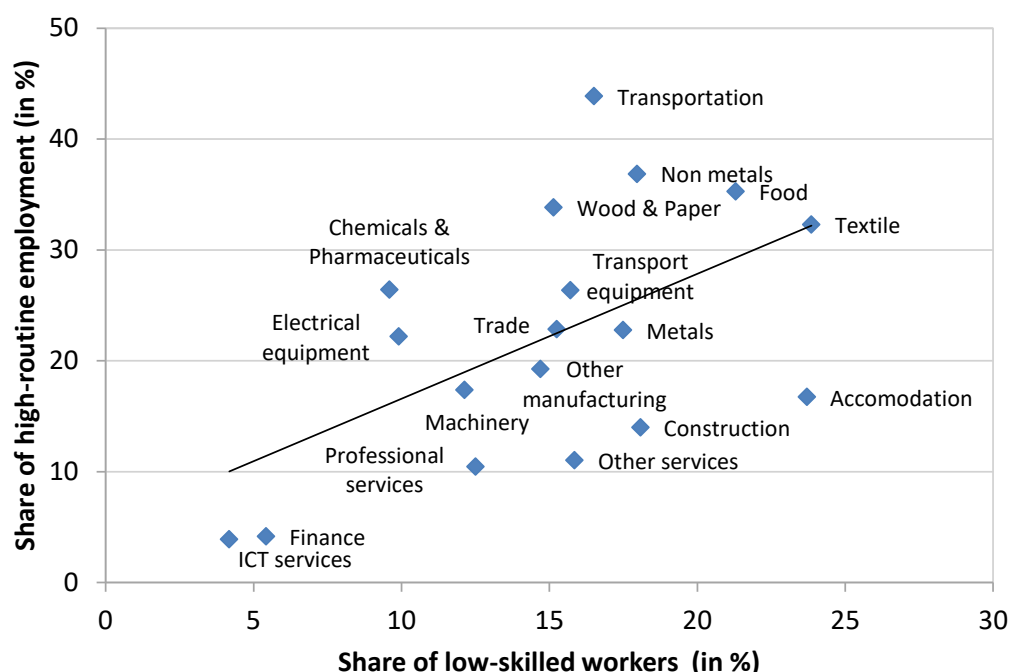
¹⁴ Backward and forward linkages are normalised by industry-level value added to account for the overall trade openness of the the industry. To avoid spurious correlations with the denominator of the labour share 5-year changes in global value chain participation are defined as follows: $\Delta GVC P_{ijt} = \Delta \ln \left(\frac{FWP_{ijt} + BWP_{ijt}}{EXGR_{ijt}} \right) \times \frac{EXGR_{ijt_0}}{VA_{ijt_0}}$, where FWP_{ijt} and BWP_{ijt} are forward and backward linkages in in country i , industry j and year t , $EXGR_{ijt_0}$ and VA_{ijt_0} are respectively gross exports and value added; and t_0 is the initial year of each five-period in the empirical analysis.

¹⁵ For Australia, Japan, Korea and the United States, the simple average of the occupational weights across all European countries is used.

¹⁶ The share of high-skilled at the industry level is defined as the share of adults in each skill area achieving the two highest PIAAC competency levels for numeracy and literacy, and the highest competency level for problem solving. Data for problem solving exclude France, Italy and Spain since they did not participate in the assessment of problem solving in technology-rich environments. For these countries, the simple average across all countries is used.

Figure 1. High routine intensity does not imply low skill intensity

OECD, 2012



Note: The share of low-skilled workers is defined as the share of workers with numeracy skills below level 2 in PIAAC. The share of high-routine employment is defined as the share of workers in an occupation above the 75th percentile of the routine-task distribution.

Source: Marcolin et al. (2016^[22]), European Labour Force Survey, OECD PIAAC.

24. The firm-level analysis is based on the 2013 OECD-ORBIS database containing information from firms' income statements and balance sheets, including on revenues, value added, employment and compensation. In order to limit the influence of erratic or implausible firm-behaviour, the dataset is cleaned by removing extreme outliers using the procedure described in Andrews, Criscuolo and Gal (2016^[23]). For the purpose of the labour share analysis in this paper, the dataset is additionally cleaned by removing observations with extreme values for labour shares.¹⁷ The resulting database covers firms in the non-primary and non-financial business sector of 17 OECD countries.¹⁸

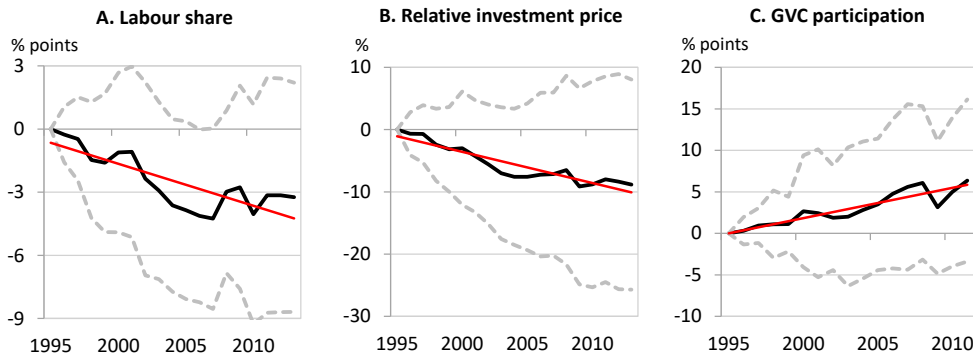
25. The labour share in the countries covered by the analysis declined by around 3½ percentage points over the sample period, which coincided with falls in relative investment prices and the expansion of global value chains (Figure 2). While the coincidence of these trends does not imply causation, it is consistent with the mechanisms highlighted in the above theoretical model as declining relative investment prices may have triggered capital-labour substitution and increased global value chain participation may have led to the offshoring of the most labour-intensive tasks.

¹⁷ Observations below the first percentile or above the 99th percentile of the labour share distribution are dropped and observations remaining outside the 0-100% range are winsorised.

¹⁸ The included countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Spain, Sweden, United Kingdom and United States.

Figure 2. Falls in labour shares coincided with falls in relative investment prices and the expansion of GVCs

Excluding the primary, coke and refined petroleum, housing and non-market industries, 1995=0



Note: GDP weighted average of 20 OECD countries included in the industry-level regressions. The black lines indicate cumulated changes; the red lines indicate the corresponding trends; and the dotted lines indicate ± 1 standard deviation around the weighted average.

Source: OECD National Accounts Database and OECD TiVA Database.

26. While the aggregate OECD labour share has declined over the past two decades, there have been conflicting cross-country developments. Cross-country heterogeneity in labour share developments is reflected in the large confidence band around the aggregate labour share decline in the covered OECD countries. OECD countries with significant declines in labour shares include large countries such as Japan and the United States. For instance, in the United States labour shares declined by around 7 percentage points over the sample period (Table A A.1). In a number of other OECD countries, labour shares have remained broadly constant or have increased. These include a number of large countries, such as France, Italy and the United Kingdom (Schwellnus, Kappeler and Pionnier, 2017^[24]).

27. Cross-country differences in labour share developments may partly reflect cross-country differences in workers' skills and differences in firm-level dynamics. Workers' skills differ widely across the countries covered by the analysis in this paper. For instance, around 19% of adults achieve the highest level of numeracy skills in Finland, Japan and Sweden, whereas this share is under 5% in Turkey, Chile, Spain and Italy. Given that capital-labour substitution is typically found to be significantly higher for low-skilled workers than for high-skilled workers (Krusell et al., 2000^[15]), such skill differences likely contribute to cross-country differences in the response of labour shares to technology-driven declines in investment prices. Cross-country differences in the nature and the pace of technological progress and the integration into global value chains may also contribute to different labour share developments by giving rise to different firm-level dynamics. For instance, more rapid adoption of information and communication technologies may give rise to “winner-takes-most” dynamics by which a small number of highly innovative firms with low labour shares rapidly gains market shares (Autor et al., 2017^[7]).

5. Empirical results

5.1. Technological change, globalisation and the role of skills

28. According to the baseline specification in Equation (1), declines in relative investment prices and increases in GVC participation reduce the labour share.¹⁹ Both in a

¹⁹ All results reported below are robust to including industries' initial labour shares to control for unobserved industry characteristics (Table A B.1).

modified baseline specification that allows estimating the effect of the business cycle on labour shares (Table 1, Columns 1) and in the baseline specification (Column 2), the estimated semi-elasticity of the labour share to the relative investment price is 0.19, which suggests that on average across industries a decline in relative investment prices of 10 percent reduces the labour share by approximately 1.9 percentage point. The estimated semi-elasticity of the labour share to GVC participation is around -0.1, which suggests that an increase of backward and forward linkages of 10 percentage points of value added reduces the labour share by 1 percentage point.²⁰

Table 1. Baseline specification
Selected OECD countries, 1995-2011

Dependent variable	(1)	(2)	(3)	(4)
	Change in business labour share excluding primary, coke and housing industries			
Change in relative investment price	0.19*** (0.03)	0.18*** (0.03)	0.11*** (0.04)	0.18*** (0.03)
Change in GVC participation	-0.10** (0.04)	-0.11** (0.04)	-0.11** (0.04)	-0.09* (0.04)
High routine intensity x Change in relative investment price			0.11** (0.05)	
High routine intensity x Change in GVC participation				-0.04 (0.05)
Change in output gap	-0.47*** (0.11)			
High routine intensity	YES	YES	YES	YES
Industry x period fixed effects	YES	YES	YES	YES
Country x period fixed effects	NO	YES	YES	YES
Country fixed effects	YES	NO	NO	NO
Observations	959	968	968	968
Number of countries	20	20	20	20
Number of industries	19	19	19	19
Adjusted R ²	0.26	0.28	0.30	0.28

Note: The dummy for high-routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD National Accounts Database, OECD TiVA Database, Marcolin et al. (2016^[22]), European Labour Force Survey, OECD Economic Outlook Database No. 99.

29. The baseline results are consistent with macro-level evidence that the labour share is counter-cyclical. The coefficient on changes in the output gap – i.e. the difference in business cycle conditions in the initial year and the final year of each 5-year period – is negative and statistically significant at the 1% level, with the estimated semi-elasticity suggesting that a 1

²⁰ The value added deflator implicitly enters both the denominator of the labour share and the denominator of the relative investment price, which raises endogeneity concerns. However, a Hausman (1978^[39]) test suggests that the difference between the estimated coefficient on the change in the relative investment price obtained by OLS is not significantly different from the one obtained by instrumenting the change in the relative investment price by the change in the non-deflated investment price (p-value of 0.38). Given that theory implies a link between relative rather than non-deflated investment prices and labour shares, the remainder of the paper is based on the statistically more efficient OLS estimator that uses the entire variation in the relative investment price rather than only the part related to the numerator. Changes in GVC participation may partly be driven by labour share developments, e.g. if labour share increases induce offshoring of intermediate goods production. If anything, this could bias the coefficient on GVC participation upwards, but does not call into question the significant negative coefficient on GVC participation.

percentage point increase in the output gap (observed GDP growth exceeding potential GDP growth by 1 percentage point) reduces the labour share by 0.5 percentage point. Replacing country-period fixed effects by changes in the output gap neither qualitatively nor quantitatively changes the results on relative investment prices, global value chain participation and the interactions with routine-task intensity (Table A B.2).

30. The baseline specification further suggests that a decline in relative investment prices reduces the labour share by more in industries with high initial routine intensity (Table 1, Column 3). To test for heterogeneous effects of changes in the relative investment price across high-routine and low-routine industries, the change in the relative investment price is interacted with an indicator variable that takes a value of 1 if initial routine intensity is higher than in the median industry. The estimated semi-elasticity is 0.11 for low-routine industries whereas it is around 0.22 for high-routine industries, with the difference being statistically significant.²¹ By contrast, there is no such heterogeneity across low- and high-routine intensive industries for the estimated semi-elasticity of the labour share to increased GVC participation (Table 1, Column 4).²²

31. Even at a given level of routine task intensity, labour share declines in response to relative investment price declines are lower in countries and industries with a high share of high-skilled workers (Table 2)²³. One explanation could be that high-skilled labour is more complementary to capital than low-skilled labour, implying lower capital-labour substitution in response to declines in relative investment prices (Krusell et al., 2000^[15]). While high literacy skills do not appear to significantly reduce capital-labour substitution in response to relative investment price declines, numeracy and problem solving skills are statistically significant when added to the baseline specification separately. The estimated coefficients suggest that even in a high-routine industry a decline in the relative investment price results in a only modest decline in the labour share if the industry employs a high share of workers with high numeracy- or problem-solving skills (Columns 2 and 3; Figure 3). When all skill indicators are added to the baseline specification simultaneously, the individual indicators become statistically insignificant because of high collinearity but remain jointly significant.

²¹ The coefficient on the change in the relative investment price in Column 3 (0.11) denotes the semi-elasticity for low-routine industries. The sum of this coefficient and the estimated coefficient on the relative investment price interacted with the indicator of high routine intensity (0.22) denotes the semi-elasticity for high-routine industries.

²² This result is robust to restricting the sample to high-income countries.

²³ Similar results are obtained when the routine task indicators are replaced by skill indicators (Table A B.3).

Table 2. High skills reduce capital-labour substitution

Selected OECD countries, 1995-2011

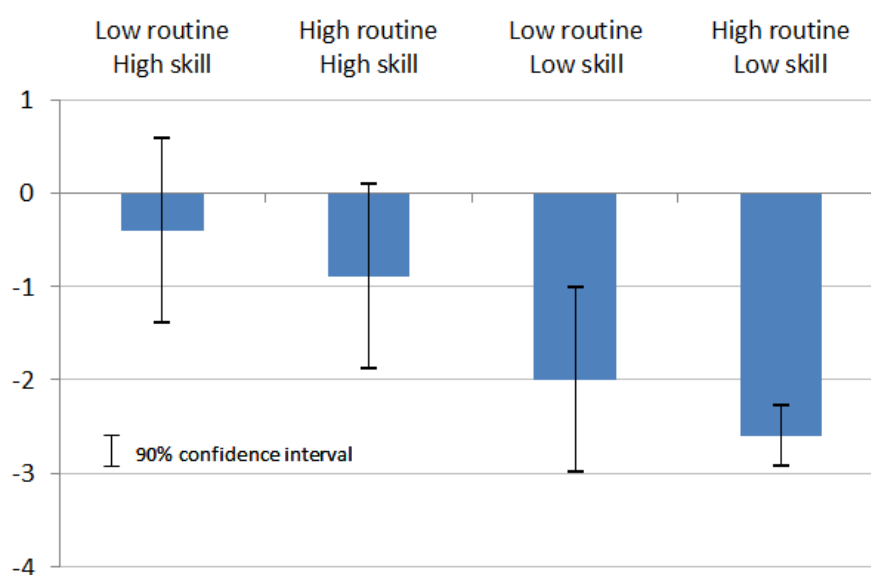
	(1)	(2)	(3)	(4)
Dependent variable	Change in business labour share excluding primary, coke and housing industries			
Change in relative investment price	0.16** (0.06)	0.21*** (0.04)	0.17*** (0.05)	0.22*** (0.05)
Change in GVC participation	-0.12*** (0.04)	-0.12*** (0.04)	-0.12*** (0.04)	-0.12*** (0.04)
High routine intensity x Change in relative investment price	0.08** (0.04)	0.05 (0.04)	0.07 (0.04)	0.05 (0.04)
High share of high skilled (literacy) x Change in relative investment price	-0.09 (0.07)			-0.02 (0.09)
High share of high skilled (numeracy) x Change in relative investment price		-0.17** (0.06)		-0.14 (0.08)
High share of high skilled (pb solving) x Change in relative investment price			-0.13* (0.06)	-0.03 (0.07)
High routine intensity	YES	YES	YES	YES
High skills	YES	YES	YES	YES
Country x period fixed effects	YES	YES	YES	YES
Industry x period fixed effects	YES	YES	YES	YES
Observations	916	916	916	916
Number of countries	20	20	20	20
Number of industries	18	18	18	18
Adjusted R ²	0.30	0.31	0.30	0.31

Note: The dummy for high routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries. The dummy for high share of high-skilled is set to 1 when the share of high-skilled is above the median across countries and industries. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD National Accounts Database, OECD TiVA Database, Marcolin et al. (2016^[22]), European Labour Force Survey, OECD PIAAC.

32. These results suggest that high skilled workers, especially those with high numeracy skills, may be more difficult to replace by machines or may be more easily re-deployed to non-routine tasks (OECD, 2018^[25]). Basic literacy, numeracy and problem-solving skills remain in high demand in OECD countries and are key to allow workers to make the most of the opportunities and challenges afforded by technological change and globalisation (Vignoles, 2016^[26]; OECD, 2017^[27]). The challenge for skill policies is to develop strong skill foundations in youth while also supporting life-long learning, including through strong systems of skills validation and certification (OECD, 2018^[28]).

Figure 3. Change in the labour share in response to a 10% decrease in the relative investment price, percentage points



Note: Based on the industry-level results for numeracy skills reported in Table A B.4.

Source: See Table A B.4.

33. Firm-level analysis can shed light on the micro-level mechanisms underlying the estimated industry-level effects. In particular, firm-level analysis can help understand the extent to which relative investment prices and global value chain participation affect industry-level labour shares primarily through changes in labour shares within firms or through changing firm composition. Since firms in the same industry face similar changes in relative investment prices, the industry-level response of labour shares should at least partly be driven by within-firm developments rather than reallocation effects. The results suggest that the effect of changes in relative investment prices partly operates through within-firm changes, with larger effects in highly productive firms and smaller effects in firms that are more dependent on external finance (Box 1). Highly productive firms may be better able to adopt new technologies embodied in capital goods if adoption requires complementary know how and firms with better access to external finance may be better able to raise investment in response to a decline in relative investment prices. By contrast, the firm-level analysis finds no evidence that global value chain expansion affects labour shares within firms, suggesting that the industry-level effect mainly reflects a shift in firm composition to firms with lower labour shares.

Box 1. The response of firm-level labour shares to relative investment price declines

This box analyses the extent to which firm-level labour shares respond to changes in industry-level relative investment prices and whether the response differs across firms. Two potential sources of firm heterogeneity are investigated: initial productivity to proxy for know-how required for technology adoption and initial financial leverage to proxy for external finance dependence.

In order to assess whether within-firm labour shares respond to changes in industry-level relative investment prices, the following baseline equation is estimated:

$$\Delta LS_{cjit} = \beta_1 \Delta P_{cjt}^{Inv} + \beta_2 \Delta T_{cjt} + \gamma' X_{cji0} + \alpha_{cj} + \alpha_t + \varepsilon_{cji}$$

where subscripts c, j, i, t denote, respectively, countries, industries, firms and time; ΔLS_{cji} denotes the annualised long difference in the firm-level labour share, with long differences computed over the longest period a firm is observed and the sample is constrained to firms that are observed for at least 8 years over the period 2001-13; ΔP_{cjt}^{Inv} denotes the annualised long difference of the log relative investment price; ΔT_{cjt} is the annualised change in global value chain participation; X_{cji} is a set of firm-level controls that include: initial values of the firm's age, size (as measured by employment) and the initial labour share;¹ α_{cj} denotes country-industry fixed effects and α_t are period-fixed effects that cover all permutations of possible start and end years over the period 2001-13.

In order to address the question of whether the response of firm-level labour shares to changes in industry-level relative investment prices depends on firms' initial productivity and initial financial leverage, the baseline equation is augmented as follows:

$$\Delta LS_{cjit} = \beta_1 \Delta P_{cjt}^{Inv} + \beta_2 \Delta T_{cjt} + \beta_3 (C_{cji0} \times \Delta P_{cjt}^{Inv}) + \gamma' X_{cji0} + \alpha_{cj} + \alpha_t + \varepsilon_{cji}$$

where all definitions are as in the baseline and C_{cji0} denotes initial productivity and/or initial financial leverage, and X_{cji0} includes C_{cji0} . Including separate country-industry and year-fixed effects instead of including combined country-industry-year fixed effects has the advantage that both the effect of industry-level relative investment prices for a low-productivity/low-leverage firm and the interaction with these firm characteristics can be identified. To check the robustness of the estimated coefficient on the interaction terms, the separate industry and year-fixed effects can be replaced by combined country-industry-year fixed effects.

The model is estimated using firm-level data from OECD-ORBIS and industry-level relative investment price indices for 9 countries for which long differences in labour shares can be computed for a sufficient number of firms.² High-productivity firms are defined as the top 5% of leading firms within an industry with the highest labour productivity across the countries covered by the analysis. Access to external finance is proxied by a measure of leverage, the rationale being that highly leveraged firms may both be more dependent on external finance and find it more difficult and costly to raise external funds.³ The results reported below are based on the ratio of current liabilities and long term debt to total assets.⁴

A decline in the relative investment price is estimated to reduce firm-level labour shares (Table 3, Column 1). The average estimated firm-level semi-elasticity is around 0.15, remarkably similar to the estimated industry-level semi-elasticity of around 0.2. However, the firm- and industry-level results are not directly comparable as high-productivity firms

– for which the estimated semi-elasticity of labour shares to relative investment prices is higher (Column 2) – are over-represented in OECD-ORBIS. Moreover, the firm-level analysis is based on 8-year or longer differences as compared to 5- or 6-year differences in the industry-level analysis and is based on a more limited country and year sample. Consequently, the positive and statistically significant semi-elasticity in the firm-level analysis implies that declines in the relative investment price affect aggregate labour shares at least partly through within-firm effects, but the similarity in estimated semi-elasticities across the firm- and industry-level analyses cannot be interpreted as ruling out composition effects. By contrast, the insignificance of the estimated coefficient on global value chain participation suggests that the effects of increased global value chain participation mainly operate through the reallocation of production from high-labour share to low-labour share firms, which is consistent with the theoretical model described in Annex D.

High leverage (i.e. high external finance dependence) dampens the transmission of declines in the relative investment price on the labour share (Table 3, Columns 3-5). In firms that are more financially leveraged a decline in the relative investment price reduces the labour share significantly less than in less leveraged firms. The semi-elasticity of labour shares to the relative investment price for a firm with a leverage ratio of 100% is about one third lower than for a firm with zero leverage. This result is robust to including the dummy for high-productivity firm and leverage simultaneously, suggesting that it does not simply capture the fact that high-productivity firms may be less financially leveraged.

Table 3. Financial constraints reduce the elasticity of the labour share to the relative investment price

Selected OECD countries, 2001-13.

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Change in firm-level labour share				
Change in relative investment price	0.14*** (0.05)	0.13** (0.06)	0.18*** (0.05)	0.17*** (0.06)	
Change in GVC participation	-0.02 (0.05)	-0.01 (0.05)	-0.02 (0.05)	-0.01 (0.05)	
Leader x Change in relative investment price		0.19*** (0.07)		0.19*** (0.07)	0.18** (0.07)
Leverage x Change in relative investment price			-0.06** (0.02)	-0.05** (0.03)	-0.06** (0.02)
Initial leverage and/or initial leader	NO	YES	YES	YES	YES
Firm-level controls	YES	YES	YES	YES	YES
Country x industry fixed effects	YES	YES	YES	YES	NO
Year fixed effects	YES	YES	YES	YES	NO
Country x industry x year fixed effects	NO	NO	NO	NO	YES
Observations	416,888	416,888	416,888	416,888	416,888
Adjusted R ²	0.21	0.22	0.21	0.22	0.22

Note: Firm-level controls include the initial firm-level labour share, age and employment. The included countries are Belgium, Germany, Spain, Finland, France, Italy, Korea, Sweden and United Kingdom. A leader is defined as belonging to the top 5% firms within an industry with the highest labour productivity across the countries covered by the analysis. Firm-level financial leverage is proxied by the ratio of current liabilities and long term debt to total assets. Standard errors are clustered at the country-industry level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD calculations based on OECD-ORBIS.

Overall, the firm-level results suggest that industry-level investment prices affect the labour share partly through changes within firms rather than composition effects, with high-productivity firms and firms with low financial leverage typically responding more strongly. By contrast, there is no evidence that changes in global value chain participation affect firm-level labour shares, suggesting that they operate mainly through composition effects.

Notes:

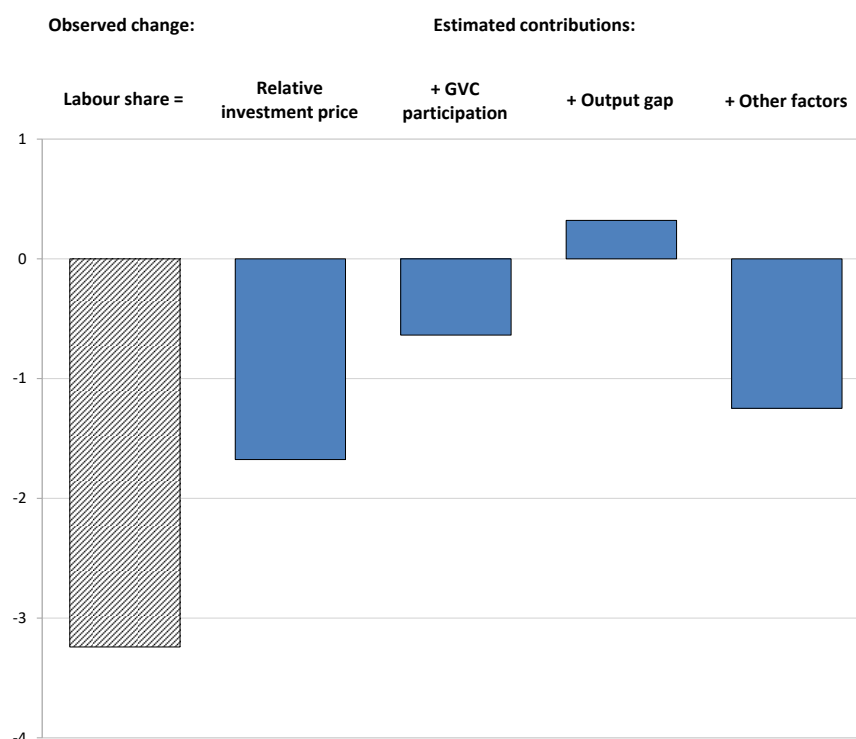
1. Given that the above specification of the firm-level regressions considers only one long difference per firm, firm fixed effects cannot be included. Including the initial values of the dependent variable allows controlling for unobserved firm characteristics in the absence of firm fixed effects (Angrist and Pischke, 2009^[29]).
2. The analysis is constrained to the same industries as the industry-level analysis. The included countries are Belgium, Finland, France, Germany, Italy, Korea, Spain, Sweden and United Kingdom. In order to ensure that results are not driven by firms with extreme values in long differences in labour shares, firms with long differences outside the [-40,+40] percentage point interval are removed from the analysis. The analysis is further constrained to country-industry cells with more than 30 firms in order to ensure that the industry-level variables are identified by a sufficient number of firms. The results are robust to alternative sample restrictions.
3. Ferrando and Mulier (2015^[30]) find that firms with lower leverage ratios are less likely to be financially constrained. Giroud and Mueller (2017^[31]) provide evidence for U.S. firms on a positive relationship between pre-crisis leverage ratio and financial constraints during the Great Recession. Love, Preve and Sarria-Allende (2007^[32]) show that during the Asian Financial Crisis, a firm's vulnerability to financial market imperfections increased the higher its short-term debt to asset ratio. Current liabilities include loans, liabilities to credit institutions, trade payables and any other liabilities due within one year, as well as accruals and deferred income.
4. The results are robust to using a dummy for low vs high financial leverage.

34. Taking the estimated elasticities of the baseline model at face value, the observable variables included in the model can account for a significant part of the aggregate labour share decline in the covered OECD countries over the sample period (Figure 4). The observed average decline in the relative investment price across countries and industries over the sample period was around 9% and the average increase in GVC participation around 8 percentage points (see Figure 2). Assuming that the elasticities estimated at the industry level are similar to those at the aggregate level, over the period 1995-2013 the baseline results suggest that investment price declines reduced the labour share by around 1.7 percentage points and increased GVC participation by around 0.7 percentage point.²⁴ Over the same period, business cycle effects raised the labour share by around ½ percentage point as the average output gap fell by around 1 percentage point. The net contribution of changes in the relative investment price, global value chain participation and business cycle conditions to the observed change in the labour share was around -2 percentage points, suggesting that other factors such as policy and institutional factors may also have played a role.

²⁴ Industry-level elasticities can plausibly be assumed to be similar to aggregate elasticities because within-industry labour share developments explain aggregate developments (Figure A B.1) and the regression analysis weighs industries by shares in value added.

Figure 4. Estimated contributions to aggregate OECD labour share decline

1995-2013, percentage points



Note: GDP weighted average of 20 OECD countries.

Source: See Table 1.

5.2. Firm-level dynamics: Does the winner take it all?

35. Using firm-level data from the OECD-ORBIS dataset allows analysing whether labour share developments over the period 2001-13 are consistent with “winner-takes-most” dynamics.²⁵ Such dynamics imply that (i) the labour share of firms at the technological frontier declines and (ii) production is reallocated toward such firms. To minimise issues related to the under-representation of small firms in OECD-ORBIS, the analysis in this section is constrained to firms with more than 20 employees.

5.2.1. Decoupling of wages from productivity: Superstar firms or the rest?

36. In countries that experienced declines in labour shares over the period 2001-13, wages in technologically leading firms decoupled from productivity but closely tracked productivity in the remaining firms (Figure 5). This implies that in these countries labour shares within the group of leading firms declined while they remained constant in the remaining firms, which is consistent with “winner-takes-most” dynamics.²⁶ The best

²⁵ The main characteristics of leading and other firms are described in Table A C.2.

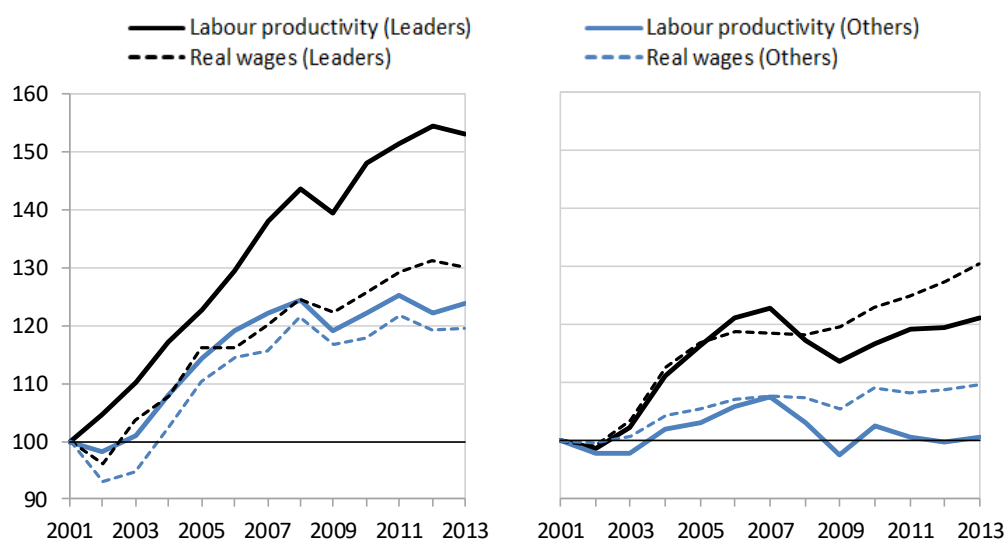
²⁶ Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year, implying that the composition of firms at the technological frontier is allowed to vary over time.

firms in these countries diverged from the remaining firms in terms of both productivity and wages, but wage divergence was much less pronounced than productivity divergence.²⁷

37. In countries that did not experience declines in labour shares, real wage growth outpaced labour productivity growth in both leading firms and the remaining firms. Productivity and wages in leading firms diverged from those of the remaining firms, but labour shares were broadly constant before the crisis of 2008-09 and increased in both groups thereafter. This suggests that in countries with increases in labour shares over the period 2001-13 “winner-takes-most” dynamics were less pronounced. One possible explanation could be that there was less technological dynamism in countries with increases in labour shares, which is consistent with the fact that productivity growth of the leading firms in these countries was similar to that of the non-leading firms in countries that experienced labour share declines.

Figure 5. Average wages and productivity in the best firms and the rest, 2001=100

Panel A: Countries with declines in labour shares **Panel B: Countries with increases in labour shares**



Note: Labour productivity and real wages are computed as the unweighted mean across firms of real value added per worker and real labour compensation per worker. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year. The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2013 are: Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States (Table A C.1). The countries with an increase are: Austria, Czech Republic, Estonia, Finland, France, Italy, Netherlands and Spain.

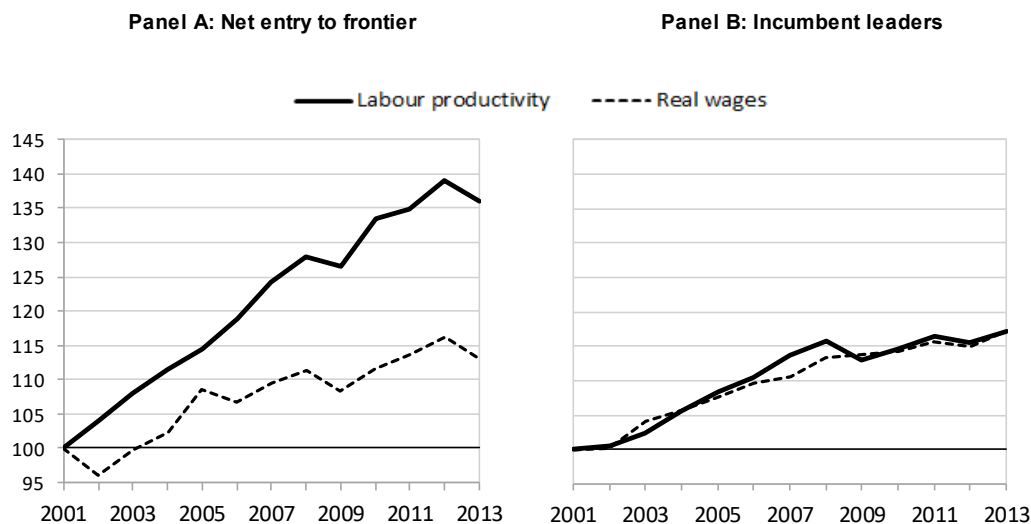
Source: OECD calculations based on OECD-ORBIS.

²⁷ The decoupling of wages from productivity in leading firms does not appear to reflect an increase in stock option compensation. Stock option compensation is typically found to be particularly prevalent in finance and ICT services (Elsby, Hobijn and Sahin, 2013_[3]). The finance industry is not covered by ORBIS so that the role of increasing stock option compensation can be assessed by removing the ICT industry from the analysis in Figure 5. Since the figure remains qualitatively and quantitatively unchanged, increasing non-cash compensation is unlikely to be the main driver of decoupling of wages from productivity in leading firms in countries with declining labour shares (Figure A C.1).

38. The decoupling of wages from productivity in technologically leading firms is overwhelmingly explained by the entry of new firms with lower labour shares into the technological frontier (Figure 6). The decoupling of wages from productivity in leading firms can be decomposed into contributions from firms staying at the technological frontier (“incumbents”) and firms entering and exiting it (“net entry”). While productivity and wages remained closely linked in incumbent technological leaders, net entry into the frontier drove a large wedge between wage and productivity growth. This implies that labour shares of firms entering the technological frontier were significantly lower than those exiting it. This result suggests that the decline of labour shares at the technological frontier was not driven by increasing markups or capital intensity in firms remaining at the technological frontier but rather by the entry of new firms with higher markups or higher capital intensity into the technological frontier.²⁸

Figure 6. Net entry fully explains the decoupling of wages from productivity in leading firms

Contributions to labour productivity and real wage growth at the frontier, countries with declines in labour shares



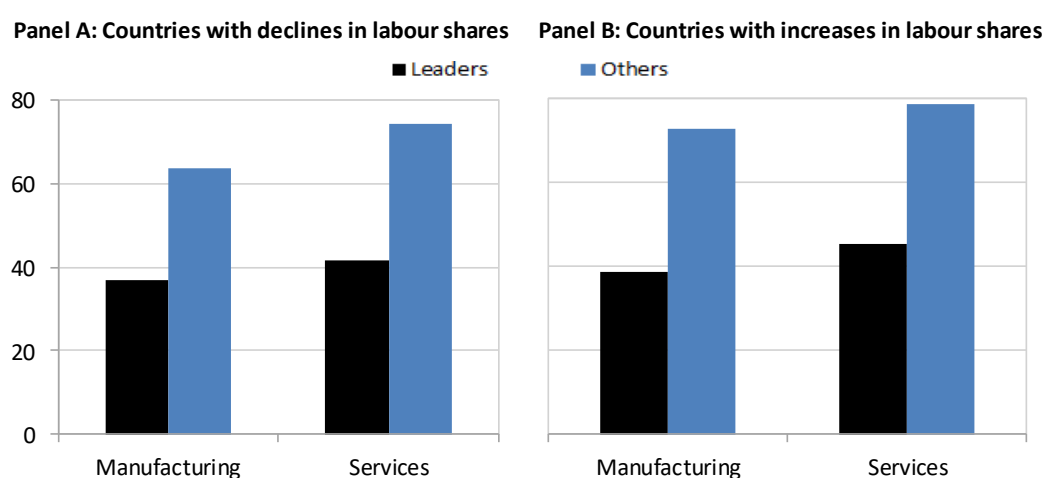
Note: Contributions to real wage growth and labour productivity growth are based on the decomposition $\Delta X = [s_2^{stay} X_2^{stay} - s_1^{stay} X_1^{stay}] + [s_2^{entry} X_2^{entry} - s_1^{exit} X_1^{exit}] = [s_1^{stay} \Delta X^{stay}] + [s_1^{exit} (X_2^{entry} - X_1^{exit})] + \varepsilon$, where X denotes the logarithm of labour productivity or real wages; s denotes the share of each group of firms in the total number of leading firms; superscripts denote groups of firms; and subscripts denote the period (Bailey et al., 1992_[33]). The way in which the frontier is constructed implies $\varepsilon = 0$ (Annex C) so that the first term in squared brackets in the second equality can be interpreted as the contribution of incumbents to growth of labour productivity and wages at the frontier (Panel B) and the second term the contribution of net entry (Panel A). The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2013 are: Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States (Table A C.1).

²⁸ Firms entering the technological frontier were about 60% more capital intensive than those exiting it (Table A C.3).

5.2.2. Labour shares and reallocation: Are superstar firms gaining market shares?

39. Across countries and industries, labour shares in leading firms are lower than in the remaining firms (Figure 7). While labour share developments in leading firms have differed across countries with declining labour shares and those where they increased, labour shares in leading firms are consistently lower relative to remaining firms across both country groups. This stylised fact also holds across manufacturing and services, with limited differences across industries at a higher level of disaggregation (Figure A C.2). This suggests that reallocation of production to firms at the technological frontier would tend to reduce the labour share.

Figure 7. Labour shares in leading and other firms, 2001-13



Note: The labour share is computed as the unweighted mean across firms of the ratio of total labour compensation to value added over the period 2001-13. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year. The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2013 are: Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States (Table A C.1). The countries with an increase are: Austria, Czech Republic, Estonia, Finland, France, Italy, Netherlands and Spain.

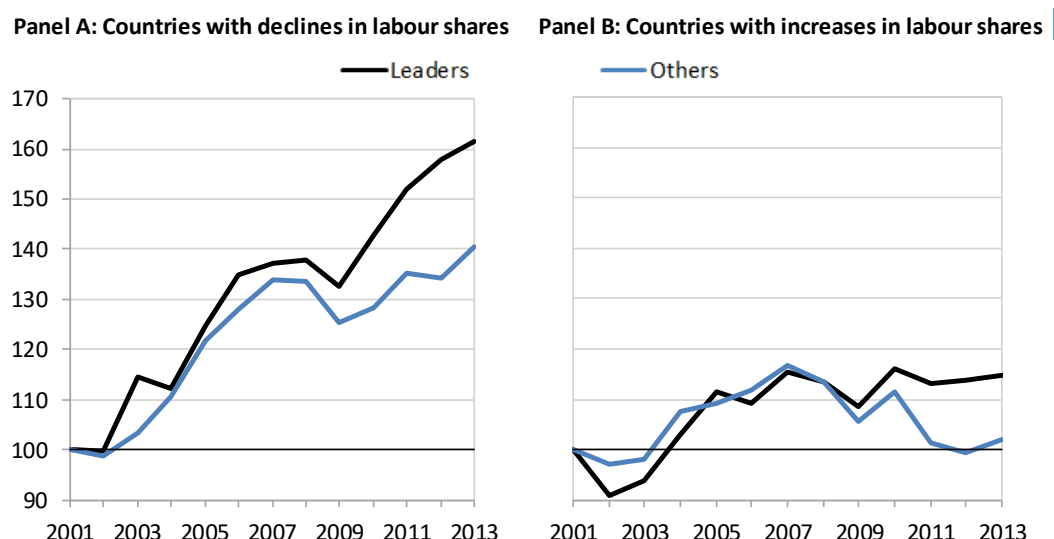
Source: OECD calculations based on OECD-ORBIS.

40. In countries with declines in labour shares, value added in leading firms strongly diverged from remaining firms, implying increasing market shares of firms at the technological frontier (Figure 8).²⁹ Given that labour shares in leading firms are well below those in other firms, in these countries reallocation of value added put further downward pressure on labour shares. This is consistent with “winner-takes-most” dynamics but it does not necessarily indicate an increase in anti-competitive forces, such as higher entry barriers. The emergence of new technologies may allow innovating firms to temporarily pull ahead. Autor et al. (2017^[7]) find evidence that growing market concentration in the United States occurs predominantly in industries with rapid

²⁹ In countries with increases in labour shares, the pattern of increasing market shares of firms at the technological frontier was more muted. This is consistent with the above conjecture that in these countries “winner-takes-most” dynamics were less prevalent.

technological change, consistent with the conjecture that “winner-takes-most” dynamics reflect technological dynamism rather than anti-competitive forces. The risk is that over time incumbent technological leaders attempt to reduce the threat of market entry through anti-competitive practices, e.g. through predatory pricing or mergers and acquisitions of competing firms.

Figure 8. Real value added in leading and other firms, 2001=100



Note: Real value added is computed as the unweighted mean across firms of nominal value added deflated by the industry value added deflator over the period 2001-13. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year. The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2013 are: Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States (Table A C.1). The countries with an increase are: Austria, Czech Republic, Estonia, Finland, France, Italy, Netherlands and Spain.

Source: OECD calculations based on OECD-ORBIS.

41. Summing up, the micro-level analysis suggests that superstar firm dynamics have contributed to labour share declines, both through a decline in labour shares within the group of technologically leading firms and the reallocation of market shares toward these firms. The results further suggest that thus far the decoupling of wages from productivity at the technological frontier is not primarily driven by the entrenchment of a small number of superstar firms that raise their markups, but instead by new firms with lower labour shares leapfrogging incumbent frontier firms. While low labour shares in firms entering the technological frontier may to some extent reflect high markups, the fact that these firms leapfrog incumbents suggests that high markups likely reflect innovation rents rather than a lack of entry barriers. This interpretation is also consistent with the fact that the share of young and small firms is significantly higher for entrants into the technological frontier than for firms staying at the frontier or exiting it.³⁰ A key challenge for product market regulation and competition policy going forward will be to prevent

³⁰ The share of firms that employ less than 100 workers and have been in existence no more than 5 years is 14% for entrants into the technological frontier, whereas it is 8% for firms staying at the frontier or exiting it (Table A C.4).

that the emergence of dominant players leads to anti-competitive practices, including by limiting barriers to entry so that markets remain contestable.

6. Conclusion

42. This paper suggests that technological change and greater global value chain participation have reduced labour shares, including by strengthening “winner-takes-most” dynamics. But technology-induced capital-labour substitution has been significantly less pronounced for high-skilled workers, suggesting that raising skills will be key to reconnect real median wages to productivity. Continued technological change is likely to put further downward pressure on labour shares and create new challenges for the broad sharing of productivity gains. Advances in ICT will continue to raise production efficiency for investment goods, further reducing their relative prices and raising capital-labour substitution. But technological progress may also fundamentally change the substitutability of capital and labour. For instance, technological advances in artificial intelligence and robotics could make more human tasks – including cognitive tasks – replaceable by capital in the future. Even though the evidence suggests that the expansion of global value chains stalled in the wake of the global crisis of 2008-09 (Haugh et al., 2016^[34]), technological advances may lead to further offshoring of labour-intensive services.

43. These technological advances may further strengthen “winner-takes-most” dynamics, with wages decoupling further from productivity at the technological frontier and market shares being reallocated to a small number of “superstar” firms with low labour shares. This paper finds no evidence that the emergence of “superstar” firms indicates the rise of anti-competitive forces rather than technological dynamism. Nonetheless, competition policy will need to find the right balance between preventing anti-competitive practices by incumbent technological leaders and encouraging innovation by allowing entrants into the technological frontier to reap the rewards for their innovations. Irrespective of the source of emerging “winner-takes-most” dynamics, policies that raise human capital through education and training will play a crucial role to broaden the sharing of productivity gains by ensuring that workers can make the most of ongoing technological advances.

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Annex A. Country-level analysis: Supporting technical material

1. This annex provides technical material supporting the descriptive analysis in Section 4.
2. Table A A.1 reports aggregate labour share developments over the period 1995-2013. Half of the analysed countries experienced labour share declines (). The countries with most significant declines include Korea (-11 percentage points), Ireland (-9), as well as large countries like Japan (-6) and the United States (-7). The other half experienced broadly constant or increasing labour shares. They include large countries like Italy (+8 percentage points), France (+5) and the United Kingdom (+4).

Table A A.1. Labour shares between 1995 and 2011

Excluding the primary, coke and refined petroleum, housing and non-market industries

	Level, %			
	1995	2000	2005	2011
Australia	69.9	71.0	67.0	65.5
Austria	67.1	65.5	62.2	63.8
Belgium	69.5	68.4	64.6	64.9
Czech Republic	51.7	52.8	55.3	56.5
Denmark	65.8	67.2	69.2	70.2
Estonia	65.8	57.2	54.1	57.6
Finland	65.1	63.1	63.9	69.7
France	72.1	70.4	71.9	75.1
Germany	71.4	72.1	68.4	68.5
Ireland	54.9	49.0	48.5	46.2
Italy	64.2	63.5	66.7	71.1
Japan ¹	74.5	72.2	67.6	68.9
Korea	74.4	67.2	67.7	62.3
Netherlands	73.9	71.6	67.9	68.8
Norway	65.7	69.9	64.5	67.6
Slovak Republic	48.4	55.5	51.4	52.1
Spain	64.5	65.7	64.6	66.9
Sweden	59.7	62.2	59.8	61.5
United Kingdom	70.1	73.6	72.2	75.1
United States ²	72.0	70.3	66.8	65.8

Note: ¹ Includes coke and refined petroleum; ² Starts in 1997.

Source: OECD National Accounts Database.

Annex B. Industry-level analysis: Supporting technical material

1. This annex provides technical material supporting the industry-level analysis.

Shift-share analysis

2. Changes in aggregate labour shares can be decomposed into within-industry changes (within component) and composition effects (between component) as follows:

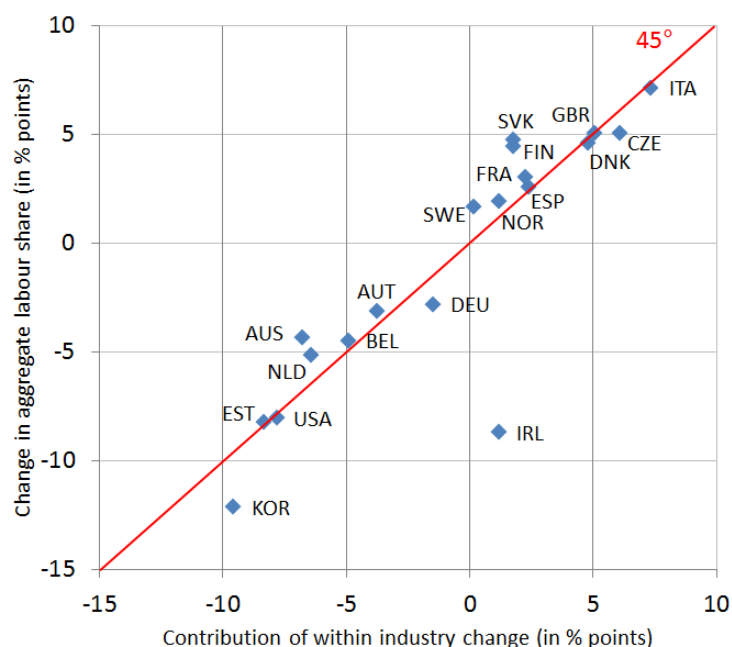
$$\Delta LS_{i,t} = \underbrace{\sum_j \Delta LS_{i,j,t} \overline{\omega_{i,j}}}_{\text{Within component}} + \underbrace{\sum_j \Delta \omega_{i,j,t} \overline{LS_{i,j}}}_{\text{Between component}}$$

where $\Delta LS_{i,j,t}$ denotes the change in the labour share in country i , industry j over period t ; $\Delta \omega_{i,j,t}$ denotes the change in the share of industry j in aggregate value added of country i ; $\overline{LS_{i,j}}$ denotes the average labour share of industry j in country j over the period; and $\overline{\omega_{i,j}}$ denotes the average share of industry j in aggregate value added of country i over the period.

3. Changes in aggregate labour shares overwhelmingly reflect developments within industries. (Figure A B.1). In most countries, the within-industry component of aggregate labour share changes is very close to the aggregate change. Only in Ireland has the decline in the labour share mainly been driven by the reallocation of value added to industries with lower labour shares.

Figure A B.1. Shift-share decomposition of aggregate labour share developments

(1995-2011)



Note: The contribution of the within-industry change is defined as the weighted average of within-industry changes, using industry value added in aggregate value added as weights. It cannot be computed for Japan because of missing data for some industries.

Source: OECD National Accounts Database.

Baseline results including initial labour share

4. Given that the baseline equation analysed in Section 5.1 includes country-period and industry-period fixed effects, the remaining unobserved country-industry heterogeneity is likely to be small. Since the inclusion of industries' initial labour share in a model with the baseline's fixed effect structure is likely to induce dynamic panel bias (Nickell, 1981_[35]) and the gain in terms of reducing unobserved country-industry heterogeneity is likely to be small, the preferred industry-level specification does not include industries' initial labour share. In any case, including industries' initial labour shares does not qualitatively change the results reported in Section 5.1 (Table A B.1).

Table A B.1. Baseline specification with initial labour share

Selected OECD countries, 1995-2011

	(1)	(2)	(3)
Dependent variable	Change in business labour share excluding primary, coke and housing industries		
Initial labour share	-0.17* (0.10)	-0.18* (0.10)	-0.17* (0.10)
Change in relative investment price	0.17*** (0.04)	0.09** (0.04)	0.17*** (0.04)
Change in GVC participation	-0.10** (0.04)	-0.10** (0.04)	-0.08* (0.04)
High routine intensity x Change in relative investment price		0.12** (0.04)	
High routine intensity x Change in GVC participation			-0.04 (0.05)
High routine intensity	YES	YES	YES
Country x period fixed effects	YES	YES	YES
Industry x period fixed effects	YES	YES	YES
Observations	968	968	968
Number of countries	20	20	20
Number of industries	19	19	19
Adjusted R ²	0.32	0.33	0.32

Note: The dummy for high routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD National Accounts Database, OECD TiVA Database, Marcolin et al. (2016^[22]), European Labour Force Survey.

Baseline results including the output gap

5. Replacing the country-period fixed effects in the baseline specification with country fixed effects and changes in the output gap yields similar semi-elasticities of the labour share to the relative investment price, GVC participation and the interactions with routine intensity as in the baseline specification (Table A B.2). Consistent with macro-level evidence the labour share is found to be counter-cyclical.

Table A B.2. Baseline specification including the output gap

Selected OECD countries, 1995-2011

	(1)	(2)	(3)	(4)
Dependent variable	Change in business labour share excluding primary, coke and housing industries			
Change in relative investment price	0.18*** (0.03)	0.19*** (0.03)	0.12*** (0.03)	0.19*** (0.03)
Change in GVC participation	-0.11** (0.04)	-0.10** (0.04)	-0.11** (0.04)	-0.09** (0.03)
High routine intensity x Change in relative investment price			0.10** (0.04)	
High routine intensity x Change in GVC participation				-0.02 (0.05)
Change in output gap		-0.47*** (0.11)	-0.46*** (0.09)	-0.47*** (0.11)
High routine intensity	YES	YES	YES	YES
Industry x period fixed effects	YES	YES	YES	YES
Country x period fixed effects	YES	NO	NO	NO
Country fixed effects	NO	YES	YES	YES
Observations	968	959	959	959
Number of countries	20	20	20	20
Number of industries	19	19	19	19
Adjusted R ²	0.28	0.26	0.27	0.26

Note: The dummy for high routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD National Accounts Database, OECD TiVA Database, Marcolin et al. (2016_[22]), European Labour Force Survey, OECD Economic Outlook Database No. 99.

Baseline results replacing routine indicators with skill indicators

6. The estimated coefficients of changes in relative investment prices with skills indicators are robust to substituting skills interactions for the routine-intensity interactions instead of adding them to the baseline specification (Table A B.3). When all skill indicators are added simultaneously, only numeracy skills remain significant (Column 4).

Table A B.3. Baseline specification with skill indicators

Selected OECD countries, 1995-2011

	(1)	(2)	(3)	(4)
Dependent variable	Change in business labour share excluding primary, coke and housing industries			
Change in relative investment price	0.23*** (0.06)	0.25*** (0.02)	0.23*** (0.04)	0.26*** (0.04)
Change in GVC participation	-0.12*** (0.04)	-0.12*** (0.03)	-0.12*** (0.04)	-0.12*** (0.03)
High share of high skilled (literacy) x Change in relative investment price	-0.13 (0.08)			-0.03 (0.09)
High share of high skilled (numeracy) x Change in relative investment price		-0.20*** (0.07)		-0.15* (0.08)
High share of high skilled (pb solving) x Change in relative investment price			-0.16** (0.07)	-0.04 (0.07)
High skills	YES	YES	YES	YES
Country x period fixed effects	YES	YES	YES	YES
Industry x period fixed effects	YES	YES	YES	YES
Observations	916	916	916	916
Number of countries	20	20	20	20
Number of industries	18	18	18	18
Adjusted R ²	0.29	0.31	0.30	0.31

Note: The dummy for high routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries. The dummy for high share of high-skilled is set to 1 when the share of high-skilled is above the median across countries and industries. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD National Accounts Database, OECD TiVA Database, Marcolin et al. (2016^[22]), European Labour Force Survey, OECD PIAAC.

Differentiated effects of high skills in low- and high-routine industries

7. The analysis in Section 5.1 implicitly assumes that high skills reduce the effect of declines in relative investment prices to a similar extent in low-routine and high-routine industries. The validity of this assumption can be tested by including all possible routine-skill permutations in the baseline regression. The results show that high skills reduce the effect of declines in relative investment prices in both low-routine and high-routine industries (Table A B.4).

Table A B.4. High skills have similar effects in low- and high-routine industries

Selected OECD countries, 1995-2011

	(1)	(2)	(3)
	Change in business labour share excluding primary, coke and housing industries		
Dependent variable			
Change in GVC participation	-0.12*** (0.04)	-0.12*** (0.04)	-0.12*** (0.04)
Literacy skills			
Low share of high routine x Low share of high skilled x Change in relative investment price	0.16** (0.06)		
Low share of high routine x High share of high skilled x Change in relative investment price	0.07 (0.05)		
High share of high routine x Low share of high skilled x Change in relative investment price	0.25*** (0.05)		
High share of high routine x High share of high skilled x Change in relative investment price	0.16*** (0.04)		
Numeracy skills			
Low share of high routine x Low share of high skilled x Change in relative investment price		0.20*** (0.06)	
Low share of high routine x High share of high skilled x Change in relative investment price		0.04 (0.06)	
High share of high routine x Low share of high skilled x Change in relative investment price		0.26*** (0.02)	
High share of high routine x High share of high skilled x Change in relative investment price		0.09 (0.06)	
Problem solving skills			
Low share of high routine x Low share of high skilled x Change in relative investment price			0.19** (0.07)
Low share of high routine x High share of high skilled x Change in relative investment price			0.05 (0.05)
High share of high routine x Low share of high skilled x Change in relative investment price			0.24*** (0.04)
High share of high routine x High share of high skilled x Change in relative investment price			0.13** (0.05)
High routine intensity	YES	YES	YES
High skills	YES	YES	YES
Country x period fixed effects	YES	YES	YES
Industry x period fixed effects	YES	YES	YES
Observations	916	916	916
Number of countries	20	20	20
Number of industries	18	18	18
Adjusted R ²	0.30	0.31	0.30

Note: The dummy for high routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries and set to 0 otherwise. The dummy for high share of high-skilled is set to 1 when the share of high-skilled is above the median across countries and industries and set to 0 otherwise. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country-level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Source: OECD National Accounts Database, OECD TiVA Database, Marcolin et al. (2016^[22]), European Labour Force Survey, OECD PIAAC.

Annex C. Firm-level analysis: Supporting technical material

1. This annex provides technical material supporting the firm-level analysis in Section 5.2.

Country groups

2. In Section 5.2, the sample is split into a group of countries with declining labour shares over 2001-2013 and a group with increasing labour shares (Table A C.1). Countries with decreasing labour shares include Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States. Countries with increasing labour shares include Austria, Czech Republic, Estonia, Finland, France, Italy, Netherlands and Spain.

Table A C.1. Labour share differences between 2001 and 2013

Percentage points, excluding the primary, coke and refined petroleum, housing and non-market industries

Countries with declines in labour shares		Countries with increases in labour shares	
Belgium	-2.9	Austria	1.2
Denmark	-1.8	Czech Republic	3.7
Germany	-1.3	Estonia	4.0
Ireland	-2.2	Finland	10.1
Japan ¹	-4.0	France	6.4
Korea	-4.9	Italy	9.0
Sweden	-0.2	Netherlands	0.5
United Kingdom	-1.4	Spain ²	1.9
United States	-5.1		

Notes:

¹ Includes coke and refined petroleum

² Difference between 2001 and 2011.

Source: OECD National Accounts Database.

Characteristics of leading firms

3. In countries that experienced declines in labour shares, technologically leading firms were on average 5 times more productive than the other firms (Table A C.2, Panel A). While they were also paying higher real wages, the difference with other firms was less pronounced, implying lower labour shares in leading firms. Value added, sales and capital intensity were higher in leading firms, but the average number of employees was similar to that of other firms. Similar conclusions hold for countries that experienced

increases in labour shares (Table A C.2, Panel B), although the differences between leaders and other firms were less pronounced.

4. Firms entering the technological frontier were on average 60% more capital intensive than those that exited it, while capital intensity was similar to that of incumbent leaders (Table A C.3). The share of young and small firms was higher among firms entering the technological frontier (14%, Table A C.4) than for exiters and incumbents (8%), suggesting that higher capital intensity in entering firms partly reflected innovation rents.

Table A C.2. Mean firm characteristics in 2013

Panel A: Countries with declines in labour shares

Variables	Leaders			Others		
	Mean	St.dev.	N	Mean	St.dev.	N
Labour productivity ¹	250.2	170.1	1,951	49.0	32.4	52,135
Real wages ²	73.9	49.5	1,951	32.9	23.3	52,135
Labour share ³	37.0	21.8	1,951	71.2	20.5	52,135
Real value added ⁴	20.8	34.5	1,951	5.1	7.5	52,135
Real revenue ⁴	71.1	118.8	1,951	19.8	30.7	52,135
Capital-labour ratio ¹	200.8	387.5	1,951	30.9	48.6	52,135
Number of employees	83.9	127.6	1,951	104.6	138.1	52,135

Panel B: Countries with increases in labour shares

Variables	Leaders			Others		
	Mean	St.dev.	N	Mean	St.dev.	N
Labour productivity ¹	147.3	97.2	3,997	40.1	24.1	78,001
Real wages ²	61.1	35.4	3,997	31.9	16.3	78,001
Labour share ³	47.2	21.4	3,997	79.6	16.0	78,001
Real value added ⁴	8.7	12.7	3,997	2.1	2.7	78,001
Real revenue ⁴	26.2	44.7	3,997	6.4	9.6	78,001
Capital-labour ratio ¹	129.3	218.5	3,997	24.6	40.1	78,001
Number of employees	59.1	75.1	3,997	51.9	55.1	78,001

Notes: The set of firms is restricted to a sample where all variables reported in the table are jointly available. Productivity is defined the ratio of real value added to the number of employees. Capital-labour ratio is defined as the ratio of capital stock to the number of employees.

¹: in thousands of 2005 USD (using PPP conversions) per employee

²: in thousands of 2005 USD (using PPP conversions)

³: in %

⁴: in millions of 2005 USD (using PPP conversions).

Source: OECD calculations based on OECD-ORBIS.

Table A C.3. Comparing capital intensity between groups of firms

2002-2013						
	Countries with decreases			Countries with increases		
Ratio of capital intensity between:	Mean	Median	St. dev.	Mean	Median	St. dev.
Entrants to frontier and exiters	1.6	1.3	2.4	1.5	1.3	1.0
Entrants to frontier and incumbent leaders	0.8	0.7	0.4	0.8	0.7	0.4

Note: Within each country group in each industry and year, cells with less than 10 firms are dropped. Capital intensity is measured by the capital-labour ratio.

Source: OECD calculations based on OECD-ORBIS.

Table A C.4. Share of young and small firms at the frontier

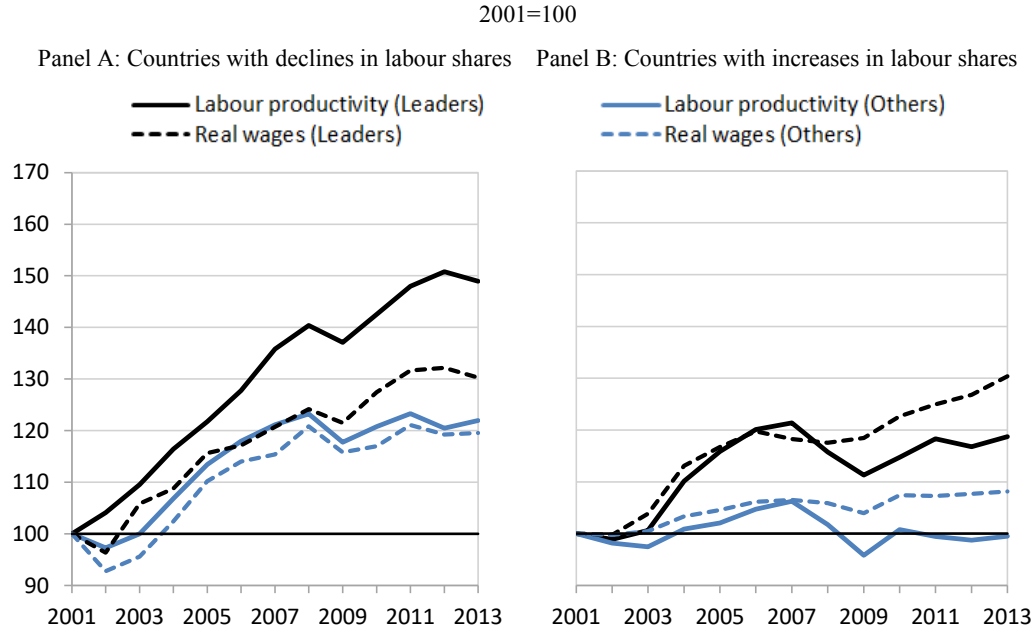
2001-2013						
	Countries with decreases in labour share			Countries with increases in labour share		
	Entrants	Exiters	Incumbents	Entrants	Exiters	Incumbents
Number of young and small firms	2,367	637	1,404	3,767	1,396	2,373
Total number of firms	17,276	8,385	18,695	31,746	17,443	37,154
Share of young and small firms (in %)	13.7	7.6	7.5	11.9	8.0	6.4

Note: Small and young firms are defined as firms with less than 100 employees and in existence no more than 5 years.

Source: OECD calculations based on OECD-ORBIS.

The role of increasing stock option compensation

5. The decoupling of wages from productivity in leading firms does not appear to reflect an increase in stock option compensation. Labour compensation in ORBIS includes cash compensation and non-cash compensation such as firm-level health insurance and pension plans, but it does not include stock option compensation. A shift toward stock option compensation would thus imply a mechanic decline in the labour share in ORBIS (the ratio of labour compensation to value added) without necessarily implying a decline in the share of value added appropriated by workers. A straightforward test of the validity of this hypothesis is to remove industries from the analysis for which there have been large increases in stock option compensation over the period 2001-2013. While industry-level data on stock option compensation are not readily available, the evidence in Elsby et al. (2013) suggests that this type of compensation is particularly prevalent in finance and ICT services. The finance industry is not covered by ORBIS so that the role of increasing stock option compensation can be assessed by removing the ICT industry from the analysis in Figure 5. Since the figure remains qualitatively and quantitatively unchanged, increasing non-cash compensation is unlikely to be the main driver of decoupling of wages from productivity in leading firms in countries with declining labour shares (Figure A C.1).

Figure A C.1. Average wages and productivity of firms excluding ICT services

Note: Labour productivity and real wages are computed as the unweighted mean across firms of real value added per worker and real labour compensation per worker. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year. The countries with a decline in the labour share excluding the primary, housing, financial ICT services and non-market industries over the period 2001-2013 are: Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States. The countries with an increase are: Austria, Czech Republic, Estonia, Finland, France, Italy, Netherlands and Spain.

Source: OECD calculations based on OECD-ORBIS.

Decomposition of labour productivity and real wage growth in leading firms

6. Contributions to labour productivity and real wages growth at the frontier can be decomposed as follow (Baily et al. (1992_[33])):

$$\Delta X = \underbrace{[s_2^{stay} X_2^{stay} - s_1^{stay} X_1^{stay}]}_{\text{Contribution of incumbents}} + \underbrace{[s_2^{entry} X_2^{entry} - s_1^{exit} X_1^{exit}]}_{\text{Contribution of net entry}} \quad (2)$$

where X denotes the logarithm of labour productivity or real wages; s denotes the share of each group of firms in the total number of leading firms; superscripts denote groups of firms; and subscripts denote the period.

7. Equation (2) can also be written as follows:

$$\Delta X = \left[\overline{s^{stay}} \Delta X^{stay} \right] + \left[\overline{s^{net\ entry}} (X_2^{entry} - X_1^{exit}) \right] + \varepsilon \quad (3)$$

where $\overline{s^{stay}} = \frac{s_1^{stay} + s_2^{stay}}{2}$, $\overline{s^{net\ entry}} = \frac{s_1^{exit} + s_2^{entry}}{2}$ and $\varepsilon = \frac{x_1^{stay} + x_2^{stay}}{2} \Delta s^{stay} + \frac{x_1^{exit} + x_2^{entry}}{2} (s_2^{entry} - s_1^{exit})$

8. The numerator of s_1^{stay} and s_2^{stay} is the number of firms staying at the frontier from year 1 to year 2 and the denominator the total number of leading firms in years 1 and 2. The total number of firms at the frontier is held constant over the period 2001-2013 (Andrews, Criscuolo and Gal, 2016^[23]) so that $s_1^{stay} = s_2^{stay}$.³¹

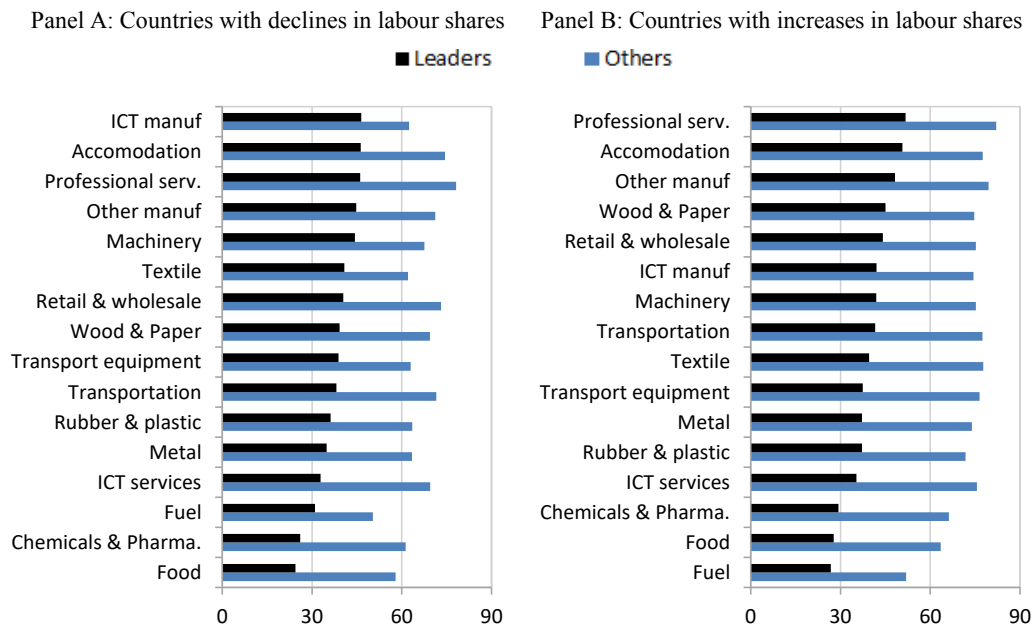
44. Since $s_1^{stay} + s_1^{exit} = 1$ and $s_2^{stay} + s_2^{entry} = 1$, $s_1^{stay} = s_2^{stay}$ implies that $s_1^{exit} = s_2^{entry}$ and $\varepsilon = 0$. As a consequence, equation (3) can be simplified as follows:

$$\Delta X = \underbrace{[s_1^{stay} \Delta X^{stay}]}_{\text{Contribution of incumbents}} + \underbrace{[s_1^{exit} (X_2^{entry} - X_1^{exit})]}_{\text{Contribution of net entry}} \quad (4)$$

Labour shares in leading and other firms: Disaggregated industries

9. Labour shares in leading firms are lower than in other firms in all sub-industries of manufacturing and services across both country groups (Figure A C.2).

Figure A C.2. Labour shares in leading and other firms in manufacturing and services, 2001-2013



Note: The labour share is computed as the unweighted mean across firms of the ratio of total labour compensation to value added over the period 2001-13. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year. The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2013 are: Belgium, Denmark, Germany, Ireland, Japan, Korea, Sweden, United Kingdom and United States. The countries with an increase are: Austria, Czech Republic, Estonia, Finland, France, Italy, Netherlands and Spain.

Source: Source: OECD calculations based on OECD-ORBIS.

³¹ Andrews, Criscuolo and Gal (2016^[23]) define the technological frontier as the top 5% of a fixed number of firms, where the fixed number of firms is the median number of firms in each industry over the period 2001-13.

Annex D. A theoretical model to analyse the effects of decreasing capital and offshoring costs on factor shares in OECD countries

1. This annex presents a theoretical model that allows analysing the effects of decreasing capital and offshoring costs on factor shares in OECD countries. First it provides a brief summary. Then it describes the model and its main predictions. Finally, it contains supporting technical material.

Summary

2. In order to analyse how the capital share of value added in advanced countries responds to declining capital and offshoring costs, the model developed in this annex extends the model in Grossman and Rossi-Hansberg (2008_[20]) (henceforth GRH) to allow for substitution not only between different types labour but also between capital and labour. Moreover, the analysis explicitly models the effect of declining capital and offshoring costs on employment and value added in addition to the effect on wages. In a related paper, IMF (2017_[4]) model the response of capital shares in emerging market economies to declining offshoring and capital costs in high-income countries. In contrast to the model developed in this annex, IMF (2017_[4]) model firms' response to declining capital and offshoring costs as sequential rather than simultaneous decisions and do not analyse the impact on high-income countries.

3. The main predictions of the model developed in this annex are as follows:

- An exogenous decrease in the cost of offshoring influences the aggregate capital share of value added *via* three different channels:
 - a A decline in offshoring costs triggers a decline in the capital share of *output* if the elasticity of substitution between capital and routine labour is higher than 1.³²
 - b The ratio between domestic value added and the value of domestic output declines as some routine labour tasks are offshored, thereby counteracting the effect of (a) and pushing up the capital share of *value added*. Without additional assumptions, the overall effect of (a) and (b) on the capital share is ambiguous.
 - c Offshoring triggers a shift in value added from routine labour intensive activities with lower capital shares to non-routine labour intensive activities with higher capital shares, thus inducing an increase in the aggregate capital share of *value added* through a composition (specialisation) effect.

³² In this annex, output and production are synonymous and defined as the sum of value added and imported intermediate consumption of foreign routine labour tasks.

- Provided that the elasticity of substitution between capital and routine labour is higher than 1, an exogenous decrease in the cost of capital leads to an increase in the capital share of value added. The effect increases with industries' routine labour intensity.

The model

4. This model considers two countries, two industries and three factors of production. Each industry produces a specific product (Y) from three inputs used in different proportions: routine labour (L), non-routine labour (Q) and capital (K). Producers are assumed to minimise costs under perfect competition. The following production function is assumed for industry j :

$$Y_j = \left[(1 - \mu_j) L_j^\sigma + \mu_j (K_j^\lambda Q_j^{1-\lambda})^\sigma \right]^{\frac{1}{\sigma}} \quad (5)$$

5. The model assumes a different elasticity of substitution between capital and routine labour, on the one hand, and capital and non-routine labour, on the other hand. For the tractability of the model, non-routine labour and capital are assumed to form a Cobb-Douglas aggregate, implying that the elasticity of substitution is equal to 1. Routine labour is assumed to be more substitutable with capital than non-routine labour. The corresponding elasticity of substitution $\left(\frac{1}{1-\sigma}\right)$ is assumed to be higher than 1 ($0 < \sigma < 1$) and identical across industries.

6. Industries only differ in the intensity with which they use routine labour in their production process. Two different industries are considered in order to contrast the effects of decreasing capital and offshoring costs across industries, i.e. $j \in \{1, 2\}$. Industry 1 is assumed to be more intensive in routine labour than industry 2, i.e. $\mu_1 < \mu_2$.³³

7. Each unit of routine (non-routine) labour input corresponds to a continuum of routine (non-routine) tasks of measure 1. Some of the routine tasks can be offshored in order to take advantage of lower wages abroad. Offshoring entails a cost which is supposed to be strictly increasing along the continuum of tasks, as in GRH (2008_[20]). Nevertheless, if the wage differential across countries is sufficiently large, firms may find it profitable to offshore some of the routine tasks. Since the aim of the model is to analyse the effect of decreasing offshoring costs to low-income countries which are intensive in routine labour, the cost of offshoring non-routine tasks is assumed to be prohibitive, so that only routine tasks are offshored.³⁴

³³ Note that industries in this model may well correspond to sub-industries or firms in reality. Indeed, the quite aggregated industries in the national accounts may include sub-industries or firms with different routine-labour intensities. In this case, the model can be used to study how decreasing capital and offshoring costs influence capital shares, first at the sub-industry or firm level (equations (8) to (27)) and then at the industry level (equations (28) and (29)).

³⁴ Note that the underlying assumption is that the offshorable tasks are the same tasks that can be more easily substituted by capital. Goos, Manning and Salomons (2014_[40]) make a distinction between the routine intensity and the offshorability of tasks but emphasise that there is a significant positive correlation between the two measures. The model developed in this annex

8. It is assumed that offshoring is a change in the geographical location of (part of) production, but that it does not imply any other change in production technology. This means that at given factor costs a firm deciding to offshore part of its labour input abroad still needs the same total volume of labour input to produce a unit of output. This assumption only differs from the one in GRH (2008_[20]) when it comes to the modelling of offshoring costs. GRH (2008_[20]) model offshoring costs as additional input requirements whereas here they are modelled as mark-up costs which are applied to foreign wages.³⁵ If w_L and w_L^* are domestic and foreign wages, it is assumed that firms pay w for having task i executed domestically and $\beta t(i)w_L^*$ for having it executed abroad, where $\beta t(i)$ is a multiplicative offshoring cost increasing along the continuum of tasks. Therefore, firms offshore routine tasks up to the point I ($I \in [0,1]$) where offshoring stops being profitable. If β and t are the same for both industries, the same is true for I , which is given by the following equation:

$$w_L = \beta t(I)w_L^* \quad (6)$$

9. a_{jL} , a_{jQ} and a_{jK} are defined as the routine labour, non-routine labour and capital inputs for industry j to produce 1 unit of output. Note that the routine labour input is a mix of domestic and offshored routine labour inputs. At given factor costs, input requirements are chosen so as to minimise p_j , industry j 's unit cost of production.³⁶ This unit cost minimisation determines factor shares in both industries.³⁷

10. When routine tasks are offshored up to the point I , the unit cost of production in industry j can be written as follows:

$$p_j = w_L a_{jL}(1 - I) + w_L^* a_{jL} \int_0^I \beta t(i) di + p_Q a_{jQ} + p_K a_{jK}$$

$$\Rightarrow p_j = w_L \underbrace{\left[1 - I + \frac{\int_0^I t(i) di}{t(I)} \right]}_{\equiv w_L \Omega(I) \equiv p_L} a_{jL} + p_Q a_{jQ} + p_K a_{jK} \quad (7)$$

captures the fact that not all routine tasks will be offshored by introducing an increasing offshoring cost along the continuum of routine tasks.

³⁵ In this way, offshoring only impacts factor costs and does not affect input requirements or production functions, which makes it easier to compute factor shares. Note that this assumption leaves all original equations in GRH (2008_[20]) unchanged, except the foreign labour-market clearing condition for routine labour. This equation only plays a role in GRH's proof that decreasing offshoring costs of routine tasks lead to a relative decline in the price of the routine labour-intensive good ($\hat{p}_1 - \hat{p}_2 < 0$) in a large-economy setting (see equations (13) and (14)).

³⁶ Under perfect competition on product markets, which is assumed in this model, product prices are equal to unit production costs, hence the notation p_j for unit production costs.

³⁷ Looking at unit production costs is enough because all production functions in the model are homogeneous of degree 1. In this case, factor shares in each industry or firm are independent of the volume of output produced.

11. Offshoring cost β and the capital cost p_K are set exogenously. Routine labour cost, non-routine labour cost and factor shares are determined endogenously depending on β and p_K .

Relationship between capital shares of output and factor prices

12. Since factor shares sum to 1, focusing on the capital share is the simplest way to analyse the overall labour share without separately considering routine and non-routine labour shares. Industry j 's capital share of output is defined as follows:

$$\theta_{jK} \equiv \frac{p_K a_{jK}}{p_j}$$

$$\Rightarrow \hat{\theta}_{jK} \equiv \frac{d\theta_{jK}}{\theta_{jK}} = \hat{p}_K + \hat{a}_{jK} - \hat{p}_j \quad (8)$$

13. Using Shephard's lemma $\left(a_{jL} = \frac{\partial p_j}{\partial p_L}, a_{jQ} = \frac{\partial p_j}{\partial p_Q}, a_{jK} = \frac{\partial p_j}{\partial p_K}\right)$, $\hat{p}_j$ can be expressed as a linear function of $\hat{p}_L$, $\hat{p}_Q$ and $\hat{p}_K$:

$$\hat{p}_j = \theta_{jL} \hat{p}_L + \theta_{jQ} \hat{p}_Q + \theta_{jK} \hat{p}_K \quad (9)$$

14. Using the same lemma, $\hat{a}_{jK}$ can also be expressed as a linear function of $\hat{p}_L$, $\hat{p}_Q$ and $\hat{p}_K$:

$$a_{jK} = \frac{\partial p_j}{\partial p_K}$$

$$\Rightarrow \hat{a}_{jK} = \frac{p_L}{a_{jK}} \frac{\partial^2 p_j}{\partial p_K \partial p_L} \hat{p}_L + \frac{p_Q}{a_{jK}} \frac{\partial^2 p_j}{\partial p_K \partial p_Q} \hat{p}_Q + \frac{p_K}{a_{jK}} \frac{\partial^2 p_j}{\partial^2 p_K} \hat{p}_K \quad (10)$$

15. The weighting factors in equation (10) are derived in equations (35) to (38). Using those results, (10) can be rewritten as follows:

$$\hat{a}_{jK} = \frac{\theta_{jL}}{1-\sigma} \hat{p}_L + \left(\frac{\theta_{jQ}}{1-\sigma} - \frac{\sigma}{1-\sigma} (1-\lambda) \right) \hat{p}_Q + \left(\frac{\theta_{jK}}{1-\sigma} - \frac{\sigma}{1-\sigma} \lambda \right) \hat{p}_K \quad (11)$$

16. The evolution of industry j 's capital share of output can finally be related to $\hat{p}_L$, $\hat{p}_Q$ and $\hat{p}_K$:

$$\hat{\theta}_{jK} = \frac{\sigma}{1-\sigma} \left[\theta_{jL} \hat{p}_L + \underbrace{\left(\theta_{jQ} - (1-\lambda) \right)}_{<0} \hat{p}_Q + \underbrace{\left(\theta_{jK} - \lambda \right)}_{<0} \hat{p}_K \right] \quad (12)$$

17. Equation (12) makes clear that a decrease in capital costs ($\hat{p}_K < 0$) induces an increase in industry j 's capital share of output ($\hat{\theta}_{jK} > 0$) provided that routine labour and capital are more substitutable than non-routine labour and capital ($\sigma > 0$). The effect of

decreasing capital costs on the capital share of *output* is also higher in the routine labour intensive industry ($\mu_1 < \mu_2 \Rightarrow \theta_{1K} < \theta_{2K}$, see equations (41) to (45)).

18. The model now remains to be solved for the endogenous variables $\hat{p}_L$ and $\hat{p}_Q$ when offshoring costs are decreasing.

Effect of decreasing offshoring costs on capital shares of output

19. In this Section, we analyse the evolutions of capital shares in both industries following an exogenous decrease in offshoring costs ($d\beta < 0$). In this section, the cost of capital is assumed to remain constant ($dp_K = 0$). In this case, the evolutions of labour input prices can be related to the evolutions of product prices:

$$\begin{cases} \hat{p}_1 = \theta_{1L}\hat{p}_L + \theta_{1Q}\hat{p}_Q \\ \hat{p}_2 = \theta_{2L}\hat{p}_L + \theta_{2Q}\hat{p}_Q \end{cases} \quad (13)$$

$$\Rightarrow \begin{cases} \hat{p}_L = \frac{1}{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}} (\theta_{2Q}\hat{p}_1 - \theta_{1Q}\hat{p}_2) & (14a) \\ \hat{p}_Q = \frac{1}{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}} (-\theta_{2L}\hat{p}_1 + \theta_{1L}\hat{p}_2) & (14b) \end{cases} \quad (14)$$

20. Equations (14a) and (14b) imply that, in the absence of variation in product prices ($\hat{p}_1 = \hat{p}_2 = 0$), decreasing offshoring costs do not have any impact on labour input prices: p_L and p_Q remain constant. Given equation (12), this implies that capital shares of *output* are also left unchanged in both industries. Nonetheless, capital shares of *value added* are affected by offshoring even in this small-economy setting (see equations (19) to (22)).

21. Following Krugman (2000_[36]), GRH (2008_[20]) emphasise that the assumption that product prices are exogenously determined, and thus unaffected by declining offshoring costs, is unrealistic. Since the decline in offshoring costs is related to the decline in transportation and communication costs, it should affect all countries at the same time, thus making the small-economy assumption difficult to justify.

22. As mentioned in GRH (2008_[20]), improvements in the offshoring technology generate greater cost savings in the industry which is intensive in the offshorable factor (routine labour). Therefore, it can be expected that decreasing offshoring costs of routine labour lead to a relative decline in the price of the routine labour-intensive good: $\hat{p}_1 - \hat{p}_2 < 0$. This relative price decrease then implies an adjustment of factor prices p_L and p_Q , as shown by (14a) and (14b). Factor share inequalities derived in equations (43) and (44) ($\theta_{1L} > \theta_{2L}$; $\theta_{1Q} < \theta_{2Q}$) and $\hat{p}_1 - \hat{p}_2 < 0$ do not allow to fully determine the signs of factor price evolutions in this case:³⁸

³⁸ Note that the usual Stolper-Samuelson theorem with two goods and two factors of production does not apply here because there are two goods and three factors of production in the model, but the reasoning is similar.

$$\begin{cases} \hat{p}_1 - \hat{p}_2 < 0 \\ \theta_{1L} > \theta_{2L} > 0 \\ 0 < \theta_{1Q} < \theta_{2Q} \end{cases} \Rightarrow \hat{p}_L = \frac{1}{\underbrace{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}}_{>0}} \underbrace{(\theta_{2Q}\hat{p}_1 - \theta_{1Q}\hat{p}_2)}_{\substack{\text{Undetermined sign} \\ \text{in general;} \\ <0 \text{ if } \hat{p}_1 < 0}} \quad (15)$$

$$\begin{cases} \hat{p}_1 - \hat{p}_2 < 0 \\ \theta_{1L} > \theta_{2L} > 0 \\ 0 < \theta_{1Q} < \theta_{2Q} \end{cases} \Rightarrow \hat{p}_Q = \frac{1}{\underbrace{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}}_{>0}} \underbrace{(-\theta_{2L}\hat{p}_1 + \theta_{1L}\hat{p}_2)}_{\substack{\text{Undetermined sign} \\ \text{in general}}} \quad (16)$$

23. Nevertheless, as shown by equation (12), what matters for the evolution of industry j 's capital share of *output* is $\theta_{jL}\hat{p}_L + (\theta_{jQ} - (1 - \lambda))\hat{p}_Q$, whose sign can be unambiguously determined:

$$\begin{aligned} & \theta_{jL}\hat{p}_L + (\theta_{jQ} - (1 - \lambda))\hat{p}_Q \\ &= \frac{1}{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}} [\theta_{jL}(\theta_{2Q}\hat{p}_1 - \theta_{1Q}\hat{p}_2) \\ & \quad + (\theta_{jQ} - (1 - \lambda))(-\theta_{2L}\hat{p}_1 + \theta_{1L}\hat{p}_2)] \\ & \Rightarrow \theta_{jL}\hat{p}_L + (\theta_{jQ} - (1 - \lambda))\hat{p}_Q = \frac{1 - \lambda}{\underbrace{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}}_{>0}} \cdot \underbrace{\theta_{jL}}_{>0} \cdot \underbrace{(\hat{p}_1 - \hat{p}_2)}_{<0} \\ & < 0 \end{aligned} \quad (17)$$

24. Hence, in this realistic large-economy setting, the effect of decreasing offshoring costs on the capital share of *output* is *negative*.³⁹

$$\begin{aligned} \hat{\theta}_{jK} &= \frac{\sigma}{1 - \sigma} [\theta_{jL}\hat{p}_L + (\theta_{jQ} - (1 - \lambda))\hat{p}_Q] \\ \hat{\theta}_{jK} &= \frac{\sigma}{\underbrace{1 - \sigma}_{>0}} \cdot \frac{1 - \lambda}{\underbrace{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}}_{>0}} \cdot \underbrace{\theta_{jL}}_{>0} \cdot \underbrace{(\hat{p}_1 - \hat{p}_2)}_{<0} < 0 \end{aligned} \quad (18)$$

25. This negative effect is magnified for the routine-labour intensive industry (because $\theta_{1L} > \theta_{2L} > 0$).

³⁹ The cost of capital p_K is assumed to remain constant for the derivation of equation (18).

Capital share of output and capital share of value added

26. Offshoring also has an impact on how output is shared between intermediate consumption and (domestic) labour compensation. Indeed, when labour services are offshored and repurchased by domestic firms to produce output, this transaction is recorded as an (imported) intermediate consumption rather than labour compensation in the national accounts. Equation (7) can be rewritten in a way which reflects this distinction between intermediate consumption and value added:

$$p_j = \underbrace{w_L a_{jL}(1-I) + p_Q a_{jQ} + p_K a_{jK}}_{\text{value added}} + \underbrace{w_L a_{jL} \frac{\int_0^I t(i) di}{t(I)}}_{\text{(imported) intermediate consumption}} \quad (19)$$

27. Industry j 's capital share of value added is thus defined as follows:

$$\pi_{jK} \equiv \frac{p_K a_{jK}}{w_L a_{jL}(1-I) + p_Q a_{jQ} + p_K a_{jK}} \quad (20)$$

28. Therefore, the ratio between the capital shares of output and value added depends on θ_{jL} , the routine labour share of output, and I , the proportion of routine tasks that are offshored:

$$\begin{aligned} \frac{\theta_{jK}}{\pi_{jK}} &= \frac{p_j - w_L a_{jL} \frac{\int_0^I t(i) di}{t(I)}}{p_j} = 1 - \underbrace{\frac{p_L a_{jL}}{p_j}}_{\equiv \theta_{jL}} \underbrace{\frac{\int_0^I t(i) di}{t(I) \Omega(I)}}_{>0} \\ &\Rightarrow \frac{\theta_{jK}}{\pi_{jK}} = 1 + \theta_{jL} \underbrace{\frac{1-I-\Omega(I)}{\Omega(I)}}_{<0} < 1 \end{aligned} \quad (21)$$

29. Equation (21) makes clear that offshoring introduces a gap between the capital share of output and the capital share of value added the former being smaller than the latter. This gap depends both on the extent of offshoring (I) and the routine-labour share of output (θ_{jL}) because offshoring costs are modelled as mark-ups over foreign routine-labour cost which, themselves, are related to domestic routine-labour costs via equation (6)⁴⁰.

30. As shown in equation (46), differentiating (21) allows relating $\hat{\theta}_{jK}$ and $\hat{\pi}_{jK}$:⁴¹

⁴⁰ Note that modelling offshoring costs as additional routine-labour requirements, as in GRH (2008_[20]), also leads to equation (21).

⁴¹ The signs of $\frac{1+\Omega'(I)}{1-I-\Omega(I)}$ and $\frac{\Omega'(I)}{\Omega(I)}$ are also derived in equations (47) and (48).

$$\hat{\pi}_{jK} = \hat{\theta}_{jK} + \underbrace{\left(\frac{\pi_{jK}}{\theta_{jK}} - 1\right)}_{>0} \left(\hat{\theta}_{jL} - \underbrace{\frac{1 + \Omega'(I)}{1 - I - \Omega(I)}}_{<0} dI - \underbrace{\frac{\Omega'(I)}{\Omega(I)}}_{<0} dI \right) \quad (22)$$

Effects of decreasing capital and offshoring costs on capital shares of value added in both industries

31. In order to fully exploit equation (22), one first needs to relate dI to the decrease in capital costs ($\hat{p}_K < 0$) and the decrease in offshoring costs ($d\beta < 0$). Actually, GRH (2008_[20]) show that I is the solution of the following system of equations:

$$\begin{cases} w\Omega(I) = w^*A^* \\ w = \beta t(I)w^* \end{cases} \Rightarrow A^* = \beta t(I) \Omega(I) = \beta \left[(1 - I)t(I) + \int_0^I t(i)di \right] \quad (23)$$

where A^* is the relative efficiency gap between the foreign and the domestic economy ($A^* > 1$, meaning that the foreign economy is less productive than the domestic economy). In this case, equation (23) shows that I is uniquely determined by β and thus independent of p_K . Differentiating (23) shows that a decrease in offshoring costs induces an expansion of offshoring, which is conform to intuition.

$$\frac{d\beta}{dI} = -\beta \cdot \frac{d \left[(1 - I)t(I) + \int_0^I t(i)di \right] / dI}{t(I)\Omega(I)} = -\beta \cdot \frac{(1 - I)t'(I)}{t(I)\Omega(I)} < 0 \quad (24)$$

32. It then only remains to relate $\hat{\theta}_{jL}$ to $\hat{p}_L$, $\hat{p}_Q$ and $\hat{p}_K$, which is done in equations (49) to (54):

$$\hat{\theta}_{jL} = \hat{p}_L + \hat{a}_{jL} - \hat{p}_j = \frac{\sigma}{1 - \sigma} [(\theta_{jL} - 1)\hat{p}_L + \theta_{jQ}\hat{p}_Q + \theta_{jK}\hat{p}_K] \quad (25)$$

33. Equations (22), (24) and (25) now allow analysing the effects of decreasing capital and offshoring costs on capital shares of value added.

- Decreasing capital costs ($\hat{p}_K < 0$, $\hat{\beta} = 0 \Rightarrow dI = \hat{p}_L = \hat{p}_Q = 0$):

$$\begin{aligned} \hat{\pi}_{jK} &= \hat{\theta}_{jK} + \left(\frac{\pi_{jK}}{\theta_{jK}} - 1\right) \hat{\theta}_{jL} = \frac{\sigma}{1 - \sigma} (\theta_{jK} - \lambda) \hat{p}_K + \left(\frac{\pi_{jK}}{\theta_{jK}} - 1\right) \frac{\sigma}{1 - \sigma} \theta_{jK} \hat{p}_K \\ &\Rightarrow \hat{\pi}_{jK} = \frac{\sigma}{1 - \sigma} (\pi_{jK} - \lambda) \hat{p}_K \end{aligned} \quad (26)$$

34. Equation (26) shows that when the extent of offshoring is limited (π_{jK} close to θ_{jK} , thus implying $\pi_{jK} - \lambda < 0$) and the elasticity of substitution between capital and routine labour is higher than 1 ($\sigma > 0$), a decrease in the cost of capital leads to an increase in the capital share of value added.

- Decreasing offshoring costs ($\hat{p}_K = 0$, $\hat{\beta} < 0$):

$$\begin{aligned}
\hat{\pi}_{jK} &= \hat{\theta}_{jK} + \left(\frac{\pi_{jK}}{\theta_{jK}} - 1 \right) \left(\hat{\theta}_{jL} - \frac{1 + \Omega'(I)}{1 - I - \Omega(I)} dI - \frac{\Omega'(I)}{\Omega(I)} dI \right) \\
\Rightarrow \hat{\pi}_{jK} &= \frac{\sigma}{1 - \sigma} \left[\theta_{jL} \hat{p}_L + (\theta_{jQ} - (1 - \lambda)) \hat{p}_Q \right] \\
&\quad + \left(\frac{\pi_{jK}}{\theta_{jK}} - 1 \right) \left[\frac{\sigma}{1 - \sigma} ((\theta_{jL} - 1) \hat{p}_L + \theta_{jQ} \hat{p}_Q) - \frac{1 + \Omega'(I)}{1 - I - \Omega(I)} dI - \frac{\Omega'(I)}{\Omega(I)} dI \right] \\
\Rightarrow \hat{\pi}_{jK} &= \underbrace{\frac{\sigma}{1 - \sigma} \cdot \frac{1 - \lambda}{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}} \cdot \frac{\theta_{jL}}{\theta_{jK}} \cdot (\hat{p}_1 - \hat{p}_2)}_{<0} \\
&\quad + \underbrace{\left(\frac{\pi_{jK}}{\theta_{jK}} - 1 \right) \cdot \left[\frac{\sigma}{1 - \sigma} \cdot \frac{1 - \lambda}{\theta_{1L}\theta_{2Q} - \theta_{2L}\theta_{1Q}} \cdot (\theta_{jL} - 1) \cdot (\hat{p}_1 - \hat{p}_2) - \frac{1 + \Omega'(I)}{1 - I - \Omega(I)} dI - \frac{\Omega'(I)}{\Omega(I)} dI \right]}_{>0} \quad (27)
\end{aligned}$$

35. Equation (27) shows that two conflicting effects influence the capital share of value added following a decrease in the cost of offshoring: the capital share of output decreases (first term of the equation), but, for each unit of good produced, the ratio between domestic value added and the value of domestic production shrinks (second term), thus counteracting the first effect and pushing the capital share of value added upwards. Deciding which one of the two effects is stronger is ultimately an empirical question. There is no obvious reason why one should dominate the other.

Effects of decreasing capital and offshoring costs on the aggregate capital share of value added for the whole economy

36. So far, only the evolution of capital shares within each industry has been considered. For this purpose, given that production functions are assumed to be homogeneous of degree 1, it is sufficient to consider what share of unit production costs is allocated to capital. The size of each industry, in terms of production or value added, does not play any role in this case.

37. If the focus is on the evolution of the aggregate capital share, then the evolution of the relative size of both industries matters. Indeed, the previous analysis has shown that a decrease in capital or offshoring costs influences the relative product prices of both industries, which, in turn, can shift their relative size. Because capital shares are different in both industries ($\theta_{1K} < \theta_{2K}$, as shown in equations (41) to (45)), this composition effect can affect the aggregate capital share, even if within-industry capital shares remain unchanged.

38. In general, the influence of relative product prices on relative product demand depends on the elasticity of substitution between products. For simplicity, it is assumed in the following that the demand function for the goods produced in both industries is Cobb-Douglas, an assumption which is also made in Krugman (2000_[36]) for example. In the absence of any strong evidence showing that the elasticity of substitution between products is always lower or higher than 1, this assumption can be regarded as an intermediate scenario. With this Cobb-Douglas assumption, a constant share of world income is spent on each product, whatever their relative price.

39. Although decreasing offshoring costs have an ambiguous effect on the evolution of the capital share of value added in each industry or firm separately (see equation (27)), they can trigger a reallocation of value added across industries or firms, and influence

aggregate capital shares of value added in this way. Indeed, offshoring introduces a gap between production and value-added. For each unit of good produced, the ratio between domestic value added and the value of domestic production, captured by $\frac{\theta_{jK}}{\pi_{jK}}$ in equation (21) is always below 1, the more so for industries or firms which are intensive in routine labour ($\theta_{1L} > \theta_{2L} \Rightarrow \frac{\theta_{1K}}{\pi_{1K}} < \frac{\theta_{2K}}{\pi_{2K}}$). Based on equation (25), it can be shown that a pure decrease in offshoring costs ($\hat{p}_K = 0, \hat{\beta} < 0$) implies that the ratio of value added to production falls more in routine-labour intensive industries ($\hat{\theta}_{1K} - \hat{\pi}_{1K} < \hat{\theta}_{2K} - \hat{\pi}_{2K} < 0$), which is in line with intuition given that only routine labour can be offshored in this model:

(17) and (26) imply:

$$\hat{\pi}_{jK} - \hat{\theta}_{jK} = \underbrace{\left(\frac{\pi_{jK}}{\theta_{jK}} - 1 \right)}_{>0} \underbrace{\left(\frac{\sigma}{1-\sigma} \cdot \frac{1-\lambda}{\theta_{1L}\theta_{2Q}-\theta_{2L}\theta_{1Q}} \cdot \underbrace{(\theta_{jL}-1)}_{<0} \cdot \underbrace{(\hat{p}_1-\hat{p}_2)}_{<0} - \frac{1+\Omega'(I)}{1-I-\Omega(I)} \frac{dI}{d\lambda} - \frac{\Omega'(I)}{\Omega(I)} \frac{dI}{d\lambda} \right)}_{\substack{= \hat{\theta}_{jL} > 0 \\ \equiv g(I) > 0}} \quad (28)$$

$$\text{And } \theta_{1L} > \theta_{2L} \Rightarrow \begin{cases} \frac{\pi_{1K}}{\theta_{1K}} - 1 > \frac{\pi_{2K}}{\theta_{2K}} - 1 \\ \hat{\theta}_{1L} > \hat{\theta}_{2L} \end{cases} \Rightarrow \hat{\pi}_{1K} - \hat{\theta}_{1K} > \hat{\pi}_{2K} - \hat{\theta}_{2K} > 0 \quad (29)$$

40. Therefore, it is expected that offshoring induces a shift in value added from routine-labour intensive activities with lower capital shares to non-routine-labour intensive activities with higher capital shares ($\theta_{1K} < \theta_{2K}$), which induces an increase in the aggregate capital share.

Mathematical derivations of equations used in the previous section

Derivation of unit cost functions in the nested CES case

41. Since similar results apply for both industries, j indices are omitted in this Section.

$$Y = \left[(1-\mu)L^\sigma + \mu(K^\lambda Q^{1-\lambda})^\sigma \right]^{\frac{1}{\sigma}} \equiv [(1-\mu)L^\sigma + \mu F(K, Q)^\sigma]^{\frac{1}{\sigma}} \quad (30)$$

- Optimal choice of the (K, Q) mix

$$\frac{p_K}{p_F} = \frac{\partial F}{\partial K} = \lambda \left(\frac{F}{K} \right) \quad (31)$$

$$\frac{p_Q}{p_F} = (1-\lambda) \left(\frac{F}{Q} \right) \quad (32)$$

42. (31) and (32) allow to determine P_F as a function of P_Q and P_K :

$$p_F = \frac{p_K}{\lambda} \left(\frac{F}{K} \right)^{-1} = \frac{p_K}{\lambda} \left(\frac{K}{Q} \right)^{1-\lambda} = \left(\frac{p_K}{\lambda} \right)^\lambda \left(\frac{p_Q}{1-\lambda} \right)^{1-\lambda} \quad (33)$$

- Optimal choice of the (L, F) mix

43. A similar reasoning is applied in order to determine p as a function of p_L and p_F :

$$p = \left[(1 - \mu)^{\frac{1}{1-\sigma}} \cdot p_L^{\frac{\sigma}{\sigma-1}} + \mu^{\frac{1}{1-\sigma}} \cdot p_F^{\frac{\sigma}{\sigma-1}} \right]^{\frac{\sigma-1}{\sigma}} \quad (34)$$

Derivation of equation (11)

44. Equation (34) and Shephard's lemma allow to derive a relationship between capital input and factor prices (35) which can then be used to derive (36), (37) and (38). Equation (11) follows immediately.

$$a_{jK} = \frac{\partial p_j}{\partial p_K} = \mu^{\frac{1}{1-\sigma}} \cdot \lambda \cdot p_j^{\frac{1}{1-\sigma}} \cdot \left(\frac{1}{p_F} \right)^{\frac{\sigma}{1-\sigma}} \quad (35)$$

$$(35) \Rightarrow \frac{\partial^2 p_j}{\partial p_K \partial p_L} = a_{jK} \frac{\partial \log a_{jK}}{\partial p_L} = a_{jK} \frac{1}{1-\sigma} \frac{1}{p_j} \frac{\partial p_j}{\partial p_L} = a_{jK} \underbrace{\frac{1}{p_j} \frac{\partial p_j}{\partial p_L}}_{=a_{jL}}$$

$$\Rightarrow \frac{p_L}{a_{jK}} \frac{\partial^2 p_j}{\partial p_K \partial p_L} = \frac{1}{1-\sigma} \underbrace{\frac{a_{jL} \cdot p_L}{p_j}}_{\equiv \theta_{jL}} \quad (36)$$

$$\begin{aligned} (35) \Rightarrow \frac{\partial^2 p_j}{\partial p_K \partial p_Q} &= a_{jK} \frac{\partial \log a_{jK}}{\partial p_Q} = a_{jK} \left[\frac{1}{1-\sigma} \frac{1}{p_j} \frac{\partial p_j}{\partial p_Q} - \frac{\sigma}{1-\sigma} \frac{1}{p_F} \frac{\partial p_F}{\partial p_Q} \right] \\ &= a_{jK} \left[\frac{1}{1-\sigma} \frac{a_{jQ}}{p_j} - \frac{\sigma}{1-\sigma} \cdot (1-\lambda) \cdot \left(\frac{1}{p_Q} \right) \right] \\ \Rightarrow \frac{p_Q}{a_{jK}} \frac{\partial^2 p_j}{\partial p_K \partial p_Q} &= \frac{1}{1-\sigma} \underbrace{\frac{a_{jQ} \cdot p_Q}{p_j}}_{\equiv \theta_{jQ}} - \frac{\sigma}{1-\sigma} \cdot (1-\lambda) \end{aligned} \quad (37)$$

$$\begin{aligned} (35) \Rightarrow \frac{\partial^2 p_j}{\partial^2 p_K} &= a_{jK} \frac{\partial \log a_{jK}}{\partial p_K} = a_{jK} \left[\frac{1}{1-\sigma} \frac{1}{p_j} \frac{\partial p_j}{\partial p_K} - \frac{\sigma}{1-\sigma} \frac{1}{p_F} \frac{\partial p_F}{\partial p_K} \right] \\ &= a_{jK} \left[\frac{1}{1-\sigma} \frac{a_{jK}}{p_j} - \frac{1}{p_K} - \frac{\sigma}{1-\sigma} \cdot \lambda \cdot \left(\frac{p_F}{p_K} \right) \right] \\ \Rightarrow \frac{p_K}{a_{jK}} \frac{\partial^2 p_j}{\partial^2 p_K} &= \frac{1}{1-\sigma} \underbrace{\frac{a_{jK} \cdot p_K}{p_j}}_{\equiv \theta_{jK}} - 1 - \frac{\sigma}{1-\sigma} \cdot \lambda \cdot \left(\frac{p_F}{p_K} \right) \end{aligned} \quad (38)$$

Comparison of factor shares in industries 1 and 2, depending on their routine-labour intensity

45. The production functions of industries 1 and 2 are assumed to have identical parameters, except the parameter μ determining the routine labour intensity at given factor prices⁴²:

$$Y_j = \left[(1 - \mu_j) L_j^\sigma + \mu_j (K_j^\lambda Q_j^{1-\lambda})^\sigma \right]^{\frac{1}{\sigma}} \quad (39)$$

46. Using Shephard's lemma and the unit cost equations (33) and (34), the routine labour share of output can be related to factor prices and the parameters of the production functions:

$$\theta_{jL} \equiv \frac{p_L a_{jL}}{p_j} = \frac{p_L}{p_j} \frac{\partial p_j}{\partial p_L} = \frac{1}{1 + \left(\frac{\mu_j}{1 - \mu_j} \right)^{\frac{1}{1-\sigma}} \cdot \left(\frac{p_L}{p_F} \right)^{\frac{\sigma}{1-\sigma}}} \quad (40)$$

47. Similar equations hold for θ_{jQ} and θ_{jK} :

$$\theta_{jQ} \equiv \frac{p_Q a_{jQ}}{p_j} = (1 - \theta_{jL}) \cdot (1 - \lambda) \quad (41)$$

$$\theta_{jK} \equiv \frac{p_K a_{jK}}{p_j} = (1 - \theta_{jL}) \cdot \lambda \quad (42)$$

48. Equation (33) shows that p_F only depends on λ and factor prices p_Q and p_K , which are identical across industries. Therefore, μ_1 and μ_2 completely determine how θ_{1L} and θ_{2L} compare to each other:

$$\mu_1 < \mu_2 \Rightarrow \theta_{1L} > \theta_{2L} \quad (43)$$

49. Since the parameter λ is identical across industries, (41), (42) and (43) imply two other inequalities for θ_{jQ} and θ_{jK} :

$$\theta_{1L} > \theta_{2L} \Rightarrow \theta_{1Q} < \theta_{2Q} \quad (44)$$

$$\theta_{1L} > \theta_{2L} \Rightarrow \theta_{1K} < \theta_{2K} \quad (45)$$

⁴² Note that equation (39) is identical to equation (5). It is also reminded here for convenience.

Derivation of equation (22)

50. Differentiating equation (21) allows to relate $\hat{\theta}_{jK}$ and $\hat{\pi}_{jK}$

$$\begin{aligned}
(21) \Rightarrow \frac{\theta_{jK}}{\pi_{jK}} (\hat{\theta}_{jK} - \hat{\pi}_{jK}) &= \underbrace{\frac{\theta_{jL}(1-I-\Omega(I))}{\Omega(I)}}_{=\frac{\pi_{jK}}{\pi_{jK}}-1} \cdot \text{dlog} \left(\frac{\theta_{jL}(1-I-\Omega(I))}{\Omega(I)} \right) \\
\Rightarrow \hat{\pi}_{jK} &= \hat{\theta}_{jK} + \underbrace{\left(\frac{\pi_{jK}}{\theta_{jK}} - 1 \right)}_{>0} \left(\hat{\theta}_{jL} - \frac{1 + \Omega'(I)}{1 - I - \Omega(I)} dI - \frac{\Omega'(I)}{\Omega(I)} dI \right)
\end{aligned} \tag{46}$$

51. The sign of $\Omega'(I)$ immediately follows from the definition of Ω because t is a positive, strictly increasing function ($t' > 0$):

$$\Omega(I) \equiv 1 - I + \frac{\int_0^I t(i) di}{t(I)} \Rightarrow \Omega'(I) = \frac{-\int_0^I t(i) di \cdot t'(I)}{t^2(I)} < 0 \quad (47)$$

52. To fully characterise the relationship between $\hat{\theta}_{jK}$ and $\hat{\pi}_{jK}$, it is also necessary to investigate the sign of $\frac{1+\Omega'(I)}{1-I-\Omega(I)}$. In order to do this, it is necessary to be more specific about t and, in the following, it is assumed that t is a power function, thus ensuring that the cost of offshoring is strictly increasing with i : $t(i) = 1 + i^\gamma$, $0 < \gamma \leq 2$, $i \in [0; 1]$.⁴³

$$\begin{aligned} \frac{1 + \Omega'(I)}{1 - I - \Omega(I)} &= -\frac{t(I)}{\int_0^I t(i) di} + \frac{t'(I)}{t(I)} = -\frac{1 + I^\gamma}{I + \frac{I^{\gamma+1}}{\gamma+1}} + \frac{\gamma I^{\gamma-1}}{1 + I^\gamma} = \frac{-1 - (2 - \gamma)I^\gamma - \frac{1}{\gamma+1}I^{2\gamma}}{\left(I + \frac{I^{\gamma+1}}{\gamma+1}\right)(1 + I^\gamma)} \\ &\Rightarrow \frac{1 + \Omega'(I)}{1 - I - \Omega(I)} < 0 \text{ for } \gamma \leq 2 \end{aligned} \quad (48)$$

Derivation of equation (25)

$$a_{jL} = \frac{\partial p_j}{\partial p_L} = (1 - \mu)^{\frac{1}{1-\sigma}} \cdot \left(\frac{p_j}{p_L} \right)^{\frac{1}{1-\sigma}} \quad (49)$$

$$\begin{aligned}
 (49) \Rightarrow \frac{\partial^2 p_j}{\partial p_L^2} &= a_{jL} \frac{\partial \log a_{jL}}{\partial p_L} = a_{jL} \frac{1}{1-\sigma} \left(\underbrace{\frac{1}{p_j} \frac{\partial p_j}{\partial p_L}}_{=a_{jL}} - \frac{1}{p_L} \right) \\
 &\Rightarrow \frac{p_L}{a_{jL}} \frac{\partial^2 p_j}{\partial p_L^2} = \frac{1}{1-\sigma} \left(\underbrace{\frac{p_L a_{jL}}{p_j}}_{\equiv \hat{\theta}_{jL}} - 1 \right)
 \end{aligned} \tag{50}$$

⁴³ Note that the case $\gamma = 2$ corresponds to a quadratic offshoring cost function, which can be considered as a meaningful benchmark.

$$\begin{aligned}
(49) \Rightarrow \frac{\partial^2 p_j}{\partial p_L \partial p_Q} &= a_{jL} \frac{\partial \log a_{jL}}{\partial p_Q} = a_{jL} \frac{1}{1-\sigma} \frac{1}{p_j} \underbrace{\frac{\partial p_j}{\partial p_Q}}_{=a_{jQ}} \\
&\Rightarrow \frac{p_Q}{a_{jL}} \frac{\partial^2 p_j}{\partial p_L \partial p_Q} = \frac{1}{1-\sigma} \frac{p_Q a_{jQ}}{p_j} \quad (51) \\
&\quad \equiv \theta_{jQ}
\end{aligned}$$

$$\begin{aligned}
(49) \Rightarrow \frac{\partial^2 p_j}{\partial p_L \partial p_K} &= a_{jL} \frac{\partial \log a_{jL}}{\partial p_K} = a_{jL} \frac{1}{1-\sigma} \frac{1}{p_j} \underbrace{\frac{\partial p_j}{\partial p_K}}_{=a_{jK}} \\
&\Rightarrow \frac{p_K}{a_{jL}} \frac{\partial^2 p_j}{\partial p_L \partial p_K} = \frac{1}{1-\sigma} \frac{p_K a_{jK}}{p_j} \quad (52) \\
&\quad \equiv \theta_{jK}
\end{aligned}$$

$$\begin{aligned}
(49) \Rightarrow \hat{a}_{jL} &= \frac{p_L}{a_{jL}} \frac{\partial^2 p_j}{\partial p_L^2} \hat{p}_L + \frac{p_Q}{a_{jL}} \frac{\partial^2 p_j}{\partial p_L \partial p_Q} \hat{p}_Q + \frac{p_K}{a_{jL}} \frac{\partial^2 p_j}{\partial p_L \partial p_K} \hat{p}_K \\
&\Rightarrow \hat{a}_{jL} = \frac{1}{1-\sigma} [(\theta_{jL} - 1) \hat{p}_L + \theta_{jQ} \hat{p}_Q + \theta_{jK} \hat{p}_K] \quad (53)
\end{aligned}$$

$$\begin{aligned}
\theta_{jL} &\equiv \frac{p_L a_{jL}}{p_j} \Rightarrow \hat{\theta}_{jL} = \hat{p}_L + \hat{a}_{jL} - \hat{p}_j \\
&\Rightarrow \hat{\theta}_{jL} = \hat{p}_L + \frac{1}{1-\sigma} [(\theta_{jL} - 1) \hat{p}_L + \theta_{jQ} \hat{p}_Q + \theta_{jK} \hat{p}_K] - [\theta_{jL} \hat{p}_L + \theta_{jQ} \hat{p}_Q + \theta_{jK} \hat{p}_K] \\
&\Rightarrow \hat{\theta}_{jL} = \frac{\sigma}{1-\sigma} \left[\underbrace{(\theta_{jL} - 1)}_{<0} \hat{p}_L + \theta_{jQ} \hat{p}_Q + \theta_{jK} \hat{p}_K \right] \quad (54)
\end{aligned}$$

53. Provided that the elasticity of substitution between routine labour and capital is higher than 1 ($\sigma > 0$), the routine labour share of output θ_{jL} increases with p_Q and p_K and decreases with p_L .