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Abstract

The widening gap between labor productivity growth and real wage growth in the United States has attracted much attention in recent years, since they are supposed to grow in tandem according to theory. This paper provides an industrial and cross-country comparative perspective, which has been lacking so far in the literature. The results suggest that the widening of the gap between productivity growth and real wages growth was most pronounced in the U.S manufacturing sector, followed by Japan, whereas European economies in general tend to show smaller gaps. Our analysis of industry origins of the wage-productivity gap in the aggregate market economy suggests that across countries, ICT goods and services and distributive services sectors are the dominant drivers of the aggregate wage-productivity growth gap. Within these industries, as well as in other industries, worsening terms of trade – measured as the difference between consumer and output prices – is the major contributor to the widening gap.

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1. Introduction

Increases in real wages and labor productivity have important welfare implications, as they are indicative of the degree to which workers benefit from economic growth. Real wages are the mechanism through which productivity gains are translated into welfare. Neoclassical theory asserts that in the absence of market frictions, workers' real wages and marginal product should be equal.[1] If this would not be the case, for example if wages are below marginal product, firms would find it profitable to hire more workers, leading to an upward pressure on wages and a downward pressure on productivity because of diminishing returns. On the other hand, if wages are higher than workers' marginal productivity, firms would find it profitable to lay off workers, putting downward pressure on wages and upward pressure on productivity. Therefore, in equilibrium, a workers' wage rate should be equal to what he or she can produce. Following this logic, it is expected that the changes in real labor income will go in tandem with changes in productivity of workers, which is why higher productivity growth is stimulated from a welfare perspective.

In practice, a comparison of marginal product and real wages is challenging, as it is nearly impossible to accurately measure the marginal product of workers. However, in a perfectly competitive world, changes in marginal products can be approximated by changes in average labor productivity.[2] The relationship between average labor productivity and real hourly wages has attracted much attention as evidence points to an increasing divergence in the trends of these two variables – henceforth referred to as 'wage-productivity gap' – in the United States and in many advanced economies. Bivens and Mishel (2015) suggest that real wages have been moving in tandem with productivity in the United States for the first three decades after the Second World War. However, labor productivity growth outpaced growth in real wages since the 1970s, creating a gap between workers' productivity and their real earnings (Bivens and Mishel 2015; Mishel and Shierholz 2013; Sharpe et al, 2008). Limited evidence on income and productivity data for other economies worldwide also suggest the existence of a discrepancy between earnings and productivity (Karanassou and Sala, 2010).[3]

[1] In general, neoclassical theory assumes that factors of production are paid according to their marginal products.
[2] In a Cobb Douglas production function $Y = AK^{\alpha}L^{1-\alpha}$ marginal product of labor can be approximated as the product of labor productivity and the elasticity of capital, i.e. $\partial Y/\partial L = \alpha Y/L$. Workers are assumed to get a wage which is equivalent to their marginal products. Assuming a constant α one can approximate changes in marginal productivity by changes in labor productivity, which can thus be compared with real wages to see if both indicators are moving together.
[3] Fischer and Hostland (2002) suggest and increasing gap between productivity and wages in Canada since 1994. They have argued that this gap will be closed in the long-run, as the two tend to converge, a proposition, which has been

The wage-productivity growth gap has been most extensively researched for the United States. The first objective of this paper therefore is to provide an international perspective, comparing the United States with selected advanced economies. Secondly, most analysis has focused on the wage-productivity gap for the total economy. This paper decomposes the aggregate market economy wage-productivity growth gap into the contributions from different sectors of the economy, worker's terms of trade and the share of labor income in GDP. The famous Baumol's cost disease hypothesis suggests that while aggregate economy wages will go along with productivity changes, the same will not happen at the industry level (Baumol and Bowen, 1965). In sectors where technological progress is very limited (e.g. music or performing arts), wages will follow the trend in other sectors, where technology changes rapidly resulting in faster productivity growth (e.g. manufacturing). Hence the wages in the former type of sectors would grow faster than productivity. In effect, productivity gains in other sectors might lead to escalation of wages in sectors where productivity is not growing. Since the wage-productivity gap is increasing at the macro level, which defies the neoclassical theory, it is interesting to look into which sectors are driving these differences. In particular, whether the sectors that are advancing in productivity – which would imply that wages in sectors that witness faster technological change are not keeping pace with their productivity growth – or whether the sectors that are lagging in productivity – which would imply that wages in these sectors are not moving in tandem with sectors that witness faster productivity growth. It is quite possible that the aggregate picture will mask such dynamics at the sectoral level. For example, the surge in productivity growth in the United States in the late 1990s and early 2000s is often attributed to productivity gains in market services, and the increased use of ICT (van Ark et al, 2008; Jorgenson and Vu, 2005). We make a first attempt to understand whether the observed wedge between income and productivity is manifest in some specific sectors only, or whether it exists across the board. We do this by examining the industry origins of the aggregate market economy wage-productivity gap. We also decompose the observed wage-productivity gap at the sectoral level into contributions from changes in the share of total labor income in GDP and terms of trade using a standard decomposition analysis as used in the literature (e.g. Bivens and Mishel, 2015). Two major databases maintained by The Conference Board – the Total Economy Database for the aggregate economy and the

challenged by by Russel and Dufour (2007), who suggested that even in the long-run the divergence between the two variables continue.

International Labor Comparisons program for the manufacturing sector –, along with EU KLEMS data on different education, skill and age groups of workers at a detailed sectoral level allow for such an analysis.

The paper is organized in seven sections. In the next section, we provide a brief review of the most important literature in the context of productivity-wage gap and its explanatory factors. Section three contains a discussion of the data sources, followed by a description of cross-country evidence on the wage-productivity growth gap of manufacturing industries in section four. Section five discusses the industry origins of the aggregate market economy wage-productivity growth gap. This analysis is taken further in section six, where the industry specific wage-productivity growth gap is decomposed into contributions from labor's share in GDP and workers' terms of trade. Section seven summarizes and discusses the most important conclusions of this paper.

2. Literature Review

The link between productivity growth and wage growth is well established in the literature, with neoclassical theory suggesting that firms will hire workers up until the point where the marginal product of labor is equal to the real wage. Shapiro and Stiglitz (1984) proposed an alternative theory, the efficiency wages hypothesis, which states that the causal relationship is the opposite, with wages affecting productivity. This theory argues that higher wages would induce higher productivity as the cost of job loss for workers is high (Akerlof and Yellen, 1990). Shapiro and Stiglitz (1984) postulate that above a certain wage, workers are discouraged from shirking their work and encouraged to work more efficiently. Therefore, an ideal wage must exist, which is higher than the marginal product of labor, but the lowest wage at which the worker is incentivized to work rather than shirk. The level of the ideal wage is influenced by factors such as the probability of being caught shirking and the level of unemployment compensation.

It is difficult to disentangle which of the two theories predominate in practice, but it is likely that both are in effect, while the influence of one or the other varies across countries. Millea (2002), for example, states that whether productivity follows wages or vice versa is dependent on the structure of a country's labor market institutions, as strong unions make for a system in which greater productivity leads to wage increases, whereas decentralized wage setting systems with weaker unions tend to favor efficiency wages. Fuess and Millea (2006) find that efficiency wages are predominant in countries with the shortest duration of employment benefits. While the question remains which hypothesis describes the actual situation most accurate, the data suggests that growth in productivity and wages have diverged, which is contrary to both these hypothesis that argue for a co-movement in these two indicators.

The literature identifies four key factors that drive this gap, namely, the growing inequality in wages and compensation, the worsening terms of trade as measured by the divergence of consumer and output prices, a decline in the share of labor income in value added, and finally measurement errors (Bivens and Mishel, 2015; Mishel and Bivens, 2011; Sharpe et al, 2008; Feldstein, 2008; Harrison, 2009). We'll discuss each of those factors, in turn, below.

Inequality

There is a vast body of literature that shows a U-shaped pattern of earning inequality in the United States, regardless of the measure of inequality (e.g. gini coefficient, or the log of variance in income) one use (Kopcsuk et al, 2010). While earning inequality declined in the 1930s, it increased in the 1970s and 1980s. In particular, the top of the annual earnings distribution experienced enormous gains over the last 25 years (Piketty and Saez, 2003). Researchers have put forward both supply and demand side explanations for the increasing wage inequality in the U.S. economy. The demand side explanations include increasing trade with developing countries that lead to outsourcing of low skilled jobs (Freeman 1995; Wood 1995). In general, evidence suggests that the increasing fragmentation of global production leads to a shift of opportunities from low- and medium-skilled jobs to high-skilled (Timmer et al, 2014), which contributes to a lower wage for less skilled workers, whose supply outpaces demand. Autor et al (2013) show that rising imports from China has employment and wage reducing effect on the U.S. economy leading to a decline in average household earnings. Technological change also increases demand for higher skills and causes a rise in inequality (Caselli, 1999; Aghion et al., 2004). For instance the increased use of information and communication technologies (ICT) in production has increased demand for skilled workers, leading to a re-structuring of jobs (Autor et al., 1998; Michaels et al, 2014).

Studies on supply side arguments highlight the role of changes in the relative supply of highly-educated workers across different cohorts, changes in labor market institutions such as a decline in unions and their bargaining power and a fall in the real value of the minimum wage (Blau and Kahn, 1996; Faggio et al 2010).

The increases in earning inequality are shown to be an important determinant of the increasing wedge between productivity and real wages in the U.S (Bivens and Mishel, 2015; Harrison, 2009). Bivens and Mishel (2015) show that during the period 1973-2014, two thirds of the wage-productivity gap is caused by increasing earning inequality (see Table 1). Similarly, Harrison (2009) suggests that almost 45 percent of total wage-productivity gap in the United States during 1980-2005 was due to earnings inequality, whereas in Canada it contributed about 28 percent.

Table 1: Explanatory factors for productivity gap in the United States (annual growth rates)

	1973-1979	1979-1995	1995-2000	2000-2007	2007-2014	2000-2014	1973-2014
Total Gap	**0.78**	**1.44**	**1.15**	**1.57**	**1.35**	**1.46**	**1.31**
Contributions from:							
Wage share	0.18	0.18	-0.6	0.66	0.52	0.59	0.23
Terms of trade	0.12	0.57	0.71	0.25	0.34	0.29	0.43
Earning inequality	0.48	0.69	1.04	0.66	0.49	0.58	0.66

Note: Results are based on 'gross' productivity concept, which includes depreciation as part of output.
Source: Bivens and Mishel (2015)

Terms of trade

Another key factor in driving the wage-productivity gap is the so called worsening terms of trade, meaning that the growth in prices of goods and services workers buy (consumer price indices) outstrips price growth of the products which they produce. While measuring productivity, output is deflated using producer prices, whereas real wages are usually obtained using consumer prices, as it captures the welfare aspect better. As a consequence, the difference between these two prices will have an impact on the wage-productivity gap. It is argued that the dramatic decline in the prices of computers has been a reason for the changes in laborer's terms of trade. Since computers and related products, produced in the non-farm sector, constitute only a small part of consumption, the benefit accrued to consumers from the sharp decline in computer prices might be lower relative to producers' benefit (Bosworth and Perry, 1994). Another argument is the increased cost of owner-occupied dwellings, which forms a large share of consumer expenditure but is excluded from non-farm business output. Obviously, as such, its impact on consumers is much higher than on producers.

Hausman (2003) argues that the standard measure of consumer prices (CPI) fails to capture the introduction of new goods, changes in the quality of existing goods and the lower prices for consumers as they shift their shopping patterns to of low priced stores such as Wal-Mart. The implication is an overstated consumer price and a larger wage-productivity gap. A similar case are price declines due to increasing imports from low-cost foreign suppliers, which are often not captured in existing intermediate input price indices, thus leading to an overestimation of real value added growth (Houseman et al, 2011). This will also lead to a larger wage-productivity gap, as productivity growth will be overstated.

While the debate on which price index is appropriate to deflate nominal wages (e.g. consumer price deflators or personal consumption expenditure deflators) continues, the choice of the deflator does not close the income-productivity gap fully, although it is somewhat reduced (Bosworth and Perry, 1994). Bivens and Mishel (2015) suggest that, during 1973-2014, nearly 30 percent of the wage-productivity gap was due to worsening terms of trade. During 1995-2000, the period of the ICT boom, it contributed more than half of the total gap. However, the role of terms of trade in explaining the wage-productivity gap has declined since 2000. In comparing the United States with Canada, Harrison (2009) observes that the role of terms of trade in explaining the wage-productivity gap was relatively higher in Canada, contributing about 33 percent compared to 22 percent in the United States during the years 1980-2005.

Labor share in income

The third key factor that drives the wage-productivity gap is the decline in labor's share in total income. Kaldor (1957) famously observed that the shares of national income received by labor and capital are roughly constant over time, but recent analysis by Karabarbounis and Neiman (2013) and others finds that the labor share has declined since the early 1980s across all countries and industries (also see OECD, 2012 and IMF, 2007). This may contribute to simultaneously observed faster growth in productivity relative to wages. Bivens and Mishel (2015) estimate that during the 1973-2014 period, the declining share of labor in total income contributed only 12 percent to the overall wage-productivity gap. The contribution was even negative in the 1970s, and also during 1995-2000 when terms of trade and earnings inequality were mostly driving the wage-productivity gap. However, the role of declining labor share increased since 2000 when it reached nearly 40 percent (see Table 1).

Though there is no consensus on the causes of the decline in the labor share, the same set of factors that are argued to be driving earning inequality – technology and increasing trade and global fragmentation of production – are considered as the key variables (OECD, 2012; IMF, 2007; Feenstra and Hanson, 2001). Feenstra and Hanson (2001) argue that the increasing trade in intermediate goods and the outsourcing of part of production processes had an even larger impact on wages than trade in final goods, as it impacted demand for labor – the demand and consequently the wages for skilled labor increased while that of unskilled labor decelerated significantly – both in import competing industries as well as in industries that use the imported intermediate inputs.

Rodrik (1997) argues that international trade has a significant impact on labor income volatility. Since production can be moved abroad if wages goes up, open economies are likely to see wage moderation. Krishna et al (2014) support this view and suggest that international trade poses significant labor income risk in the U.S manufacturing industry. IMF (2007) found that technological change is more prominent in explaining the decline in the labor share, though globalization also plays a role. Stockhammer (2013) reinforces the role of technology in reducing the wage share in advanced economies, but also argues that its impact on developing countries is positive.

There have been other factors that are also argued to have contributed to the declining wage share and the consequent increase in wage-productivity gap. An example is the expansion of the labor supply over the past several decades, as women entered the labor force and immigration increased in the United States and across OECD economies, which may have lead to a relative decline in wages even while productivity increases. Similarly, a decline in the wage bargaining power of workers as the power of unions has waned in recent decades (Blanchard and Giavazzi, 2003) may have hampered worker's ability to increase wages in line with their productivity. An associated effect is noted by Lopez-Villavicencio and Silva (2011), who find that among OECD economies, wage increases have exceeded productivity growth for permanent workers, while the opposite is true for temporary workers, in line with their lower bargaining power. Given the inter-country variation in the share of temporary workers, this may be an important reason why the size of the wage-productivity gap varies across countries.

Measurement errors

Finally, measurement errors also seem to contribute to the measured gap between income and productivity. They include a mismatch between price deflators and the measures of wages used (Bosworth and Perry 1994; Anderson, 2007; Feldstein, 2008). When wages alone are used in comparison with productivity, the wage-productivity gap may get exaggerated, as the compensation paid to workers also include other form of benefits such as social security, pensions, variable pay, etc. However, Zavodny (1999) shows that total compensation which includes all other benefits grew only slightly quicker than wages alone, and was still not enough to close the gap. Greenhouse and Leonhardt (2006) come to a similar conclusion. Other measurement errors comprise the use of different unit of inputs, such as earnings based on full-time-full-year workers, while productivity is based on all workers, whether part-time or full-time. Finally, it has been argued that the recent slowdown in measured productivity is partly due to downward biases in official output statistics, which fails to capture several positive benefits of technology. If this is true, if productivity is measured correctly, the gap might be even larger.

3. Analyzing the Wage-Productivity Gap Using The Conference Board Databases

Throughout this paper, we define the aggregate wage-productivity growth gap as follows:

$$G = \Delta lny - \Delta lnw \qquad (1)$$

where G is the total gap between productivity growth and wage growth, y is labor productivity (defined as GDP per hour), and w is the real wage (defined as nominal compensation costs deflated using consumer prices per hour). This approach is different from Bivens and Mishel (2015), who define the gap as the difference between average labor productivity (both gross and net concepts) and median hourly compensation. While their approach allows for accounting for earnings inequality (comparing median wage with average wage), this is feasible only with micro data allowing to calculate median wages. Therefore, using our industry and aggregate data, we compare productivity growth rate of average workers with the growth rate of average real earnings. The implication is that we cannot delineate the contribution of income inequality to the wage-productivity growth gap. All results in this paper are presented as cumulative series which allows for an insightful interpretation of the accumulated growth gap over time.[4]

Following (1), understanding the wedge between labor productivity and workers' real wage growth rate require time-series data on GDP, hours, compensation, output prices and consumer prices. The underlying data used for the analysis in this paper are derived from two datasets maintained by The Conference Board – The Conference Board Total Economy Database and International Labor Comparison database – along with the EU KLEMS database. The unique feature of these databases is that they ensure cross-country comparability, and consistency in definition over time. In what follows we discuss these databases and how they can be used in analyzing wage-productivity gap.

The Total Economy Database (TED) is a comprehensive database containing a number of macroeconomic variables, carefully constructed for international comparisons, covering more than 120 countries and the period 1950-2015. TED provides processed data on basic indicators such as Gross Domestic Product (expressed in real purchasing power parities), population, employment, hours worked and labor composition (high skilled, medium skilled and low skilled), capital services by assets (ICT, other machineries & transport equipment and non-residential buildings). In addition, it also

[4] That is, the difference between the cumulative growth rate of productivity and the cumulative growth rate of real compensation is considered as the cumulative wage-productivity gap.

provide estimates of per capita income, labor productivity (output per hour and output per worker) and a decomposition of output growth into contributions from total factor productivity (TFP), labor quantity, labor composition, ICT capital and non-ICT capital. Therefore, from the perspective of wage-productivity gap, TED is helpful to make aggregate economy comparisons across countries and over time. Moreover, one can also analyze the role of factors identified in the literature such as technological change as measured by total factor productivity and ICT and non-ICT capital deepening in determining the wage-productivity gap at the macro level.

The Conference Board International Labor Comparisons Program (ILC) provides comprehensive and internationally comparable productivity and labor market data. While a major advantage of ILC data is its usefulness in understanding competitiveness of countries, based on unit labor cost, it also provides comparable information on manufacturing output, employment, hours and compensation. We use labor productivity measures, defined as real value added per hour from ILC in comparison with real hourly compensation costs deflated by consumer price deflators, in the U.S manufacturing sector, in comparison with other advanced economies – the United Kingdom, Japan, South Korea, Germany, France and Norway. The compensation data in ILC are based on a broad definition to include wages and salaries and all other employer contributions in the manufacturing sector.

The third database used is EU KLEMS, which provides industry wise data on factor inputs (ICT and non ICT capital services, employment and labor quality, wage share by skill and age groups, intermediate inputs etc.), output (value added and gross output), input and output prices and estimates of total factor productivity for the period since 1970.[5] The first version of EU KLEMS also contained data on the skill composition of workers in about 70 industries for about 30 countries including the United States, Japan, South Korea and most European economies and for the period 1970-2005. The data has been updated subsequently for a smaller number of countries and industries, and with fewer variables, which are generally available for the period up to 2010. Whereas ILC data allows for productivity and labor costs analysis in the manufacturing sector and for aggregate workers only, the EU KLEMS database provides data for a large number of sectors and by skill categories. However, ILC has the advantage of having more recent estimates, which are available for the period up to 2014.

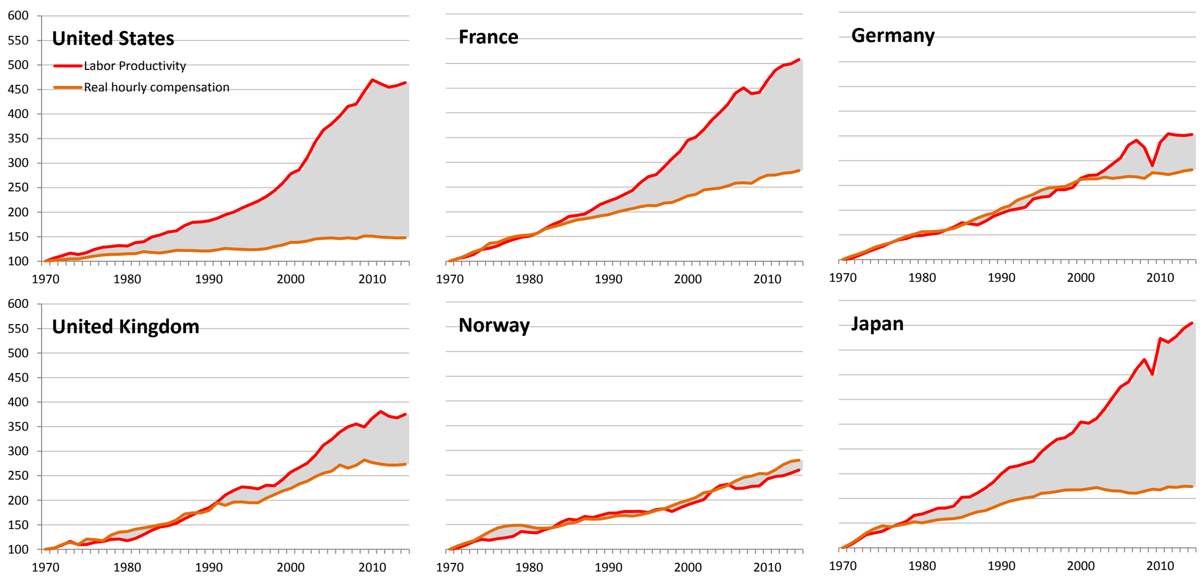
[5] See O’Mahony, Mary and Marcel P. Timmer (2009).

To analyze the wage-productivity gap, we obtain industry wise data on value added, total hours worked, total labor compensation (including estimates for self-employed workers) and value added prices from the latest version of EU KLEMS. However, to examine the differences between various skill categories in terms of productivity and wage, we use the older version of the data, as the newer version does not provide such details as explained above. We obtain the shares of various skill groups (aggregated to low-skilled, medium-skilled and high-skilled, depending upon the educational attainment of workers) in total hours worked and in total wage bill by industries and gender.

4. The Wage-Productivity Gap in the Manufacturing Sector

This section documents some cross-country evidence on the gap between labor productivity (measured as value added per hour) and real hourly compensation in the manufacturing sector for a number of mature economies, using data from The Conference Board International Labor Comparisons (ILC) program. A detailed analysis of the gap for the aggregate market economy and its sub-sectors is carried out in the next sections.

Figure 1: Indices of labor productivity and real hourly compensation in the manufacturing sector (1970=100)



Note: The gray area represents the gap between growth of labor productivity and real hourly compensation. Labor compensation is deflated using Consumer Price Indices (CPI).
Source: The Conference Board International Labor Comparison Program.

Figure 1 depicts the trends in labor productivity in comparison with trends in real hourly wages in the manufacturing sector for the United States, Japan, Germany, France, the United Kingdom and Norway. The difference between the two (as marked by the gray shaded area in the chart) represents the evolution of wage-productivity gap over time. It is immediately noticeable from the charts that the gap is the largest in the United States, as labor income continuously stagnated while productivity accelerated. Apart from a moderate increase in the early 2000s, real wages in the United States have not shown any improvement, whereas productivity has accelerated substantially, barring the recent stagnation. Whereas the index of productivity increased from 100 in 1970 to 464 in 2014 in the U.S manufacturing, compensation increased only to 148. This means that labor productivity increased by more than 4 and half times, while wages rose by only less than one and half times.

Japan witnessed the second largest increase in the gap between productivity growth and real wages growth. In this country the gap started to emerge in the early 1980s, while in the years before wage growth outpaced productivity growth. The wage moderation was more pronounced since the 2000s, and continued to stagnate, while productivity continued to improve, albeit at a lower rate. Japanese productivity improved by almost five and a half times (the productivity index increased from 100 to 555) and its wages increased only by just above two times (from 100 to 224). One explanation for a slow growth of real wages in Japan is the increasing incidence of non-regular employment – sectors that had high and increasing share of non-regular employment seem to have witnessed low real wage growth (Sommer, 2009). During 1990-2007 period there has been a 14 percent increase in the share of non-regular employment, owing to the relatively less and even declining employment protection regulation for the non-regular employment. The increase in non-regular employment and wage stagnation has been more prevalent among large firms. Sommer (2009) also argues that the declining working age and the consequent rise of re-employment of retired workers has put a further downward pressure on real wages. In addition, the Japanese economy has been witnessing a long period of deflation, which might have had a further depressing effect on wages. Productivity on the other hand has been stimulated by increased capital deepening in Japanese economy (see The Conference Board Total Economy Database, 2015).

In general, since the 1970s, productivity grew much faster than hourly compensation in the US manufacturing as compared to European countries. In Europe, both the United Kingdom and France seem to have witnessed faster productivity growth compared to wage growth since the 1990s, whereas Germany seem to have seen a co-movement of both variables until the 2000s. In fact, France joined the list since the mid-1980s. However, since wages kept on growing, though at a lower rate, the magnitude of the gap is relatively smaller when compared to the US and Japan. While the level of productivity in France in 2014 was five times larger than what it was in 1970, wages in 2014 were only three times as large. Norway is an example of a country where both wages and productivity moved quite closely, leaving no gap between the two. In fact in several years, wages grew even slightly faster than productivity. Clearly, Norway is an exception, perhaps because of its lavish social welfare policies, but manufacturing productivity growth in Norway was also much slower than elsewhere, and wages were largely "subsidized" from the rapid revenue growth in natural resources exploitation. Relatively small wage-productivity gaps can also be observed in UK until the 1990s and in Germany until early 2000s. Both countries showed a widening of the gap since then. The 'agenda 2010' reforms in Germany in the early 2000s are often argued to have had a dampening effect on labor income share in GDP. For instance ILO (2012) suggests that by 2008 the wage share in national income in Germany lowered to a 50 year low.

This analysis based on ILC data suggests that the wage-productivity gap is evidently higher in the United States, when compared with other parts of the world. However, as was indicated earlier, the observed gap for all workers may not be reflective of differences between different skill groups, which is the topic of analysis of the next section.

5. The Wage-Productivity Gap across Sectors in the Economy

Earlier literature often argued that the onset of ICT industries might be an important factor that drove the wage-productivity gap as it resulted in a worsening terms of trade. For instance, a 2007 study by the Centre for Spatial Economics found that countries with a larger ICT sector had a more persistent wage-productivity gap. Bosworth and Perry (1994) argued that the drastic decline in the price of ICT products has caused to worsen the laborer's terms of trade. The observed gap at the aggregate level could be a manifestation of rapid increase in productivity in some sectors, while the wage rate might be increasing following the general trend in the economy.

In this section, we look at the contribution of various industries to the aggregate market economy wage-productivity gap. Considering only the aggregate market economy, in equation (1), we have:

$$G = \Delta ln y - \Delta ln w \qquad (7)$$

where G is the total gap between productivity growth and wage growth in the aggregate market economy, y is aggregate market economy labor productivity growth, and w is the aggregate market economy real wage growth. Defining aggregate productivity and real wage growth as the Tornqvist sum of sectoral productivity growth and sectoral wage growth, with the respective weights being the nominal GDP share of each sector in the case of labor productivity and the nominal wage share of each sector in the case of aggregate wage growth, equation (7) can be rewritten as:

$$G = \sum_{i=1}^{n} [\bar{s}_i \Delta ln y_i - \bar{v}_i \Delta ln w_i] \qquad (8)$$

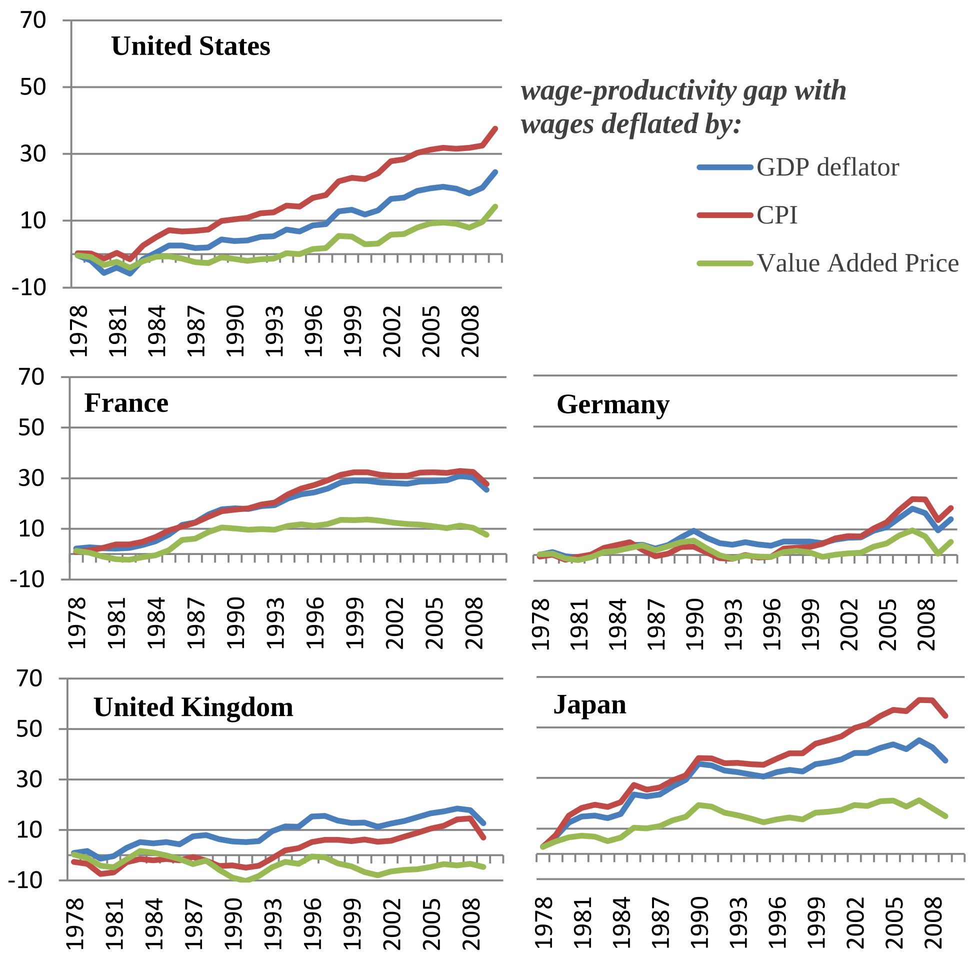
where $\bar{s}_i$ is the share of industry i in total nominal GDP and $\bar{v}_i$ is the share of industry i in total nominal wages, both averaged over current and previous years. y_i and w_i are respectively labor productivity and real wage in industry i. Note that in the above formulation, for simplicity, we exclude any sectoral reallocation effect.[6] This sectoral decomposition allows us to understand which sectors have a larger share in driving the observed total gap between productivity and wages in the market economy.

We analyze the industry origins of aggregate market economy wage-productivity gap using the most recent version of the EU KLEMS data (ISIC revision 4). This version of the database provides all the relevant indicators for 1970-2009 period for 34 detailed industries, classified under market and non-market segments of the economy, of which

[6] If sectoral reallocation effect is taken into account, the equation will be $G = \sum_{i=1}^{n} [\bar{s}_i \Delta ln y_i - \bar{v}_i \Delta ln w_i] + (R_L - R_w)$, where R_L is the labor productivity reallocation effects, and R_w is the real wage reallocation effect across industries.

we consider only the market economy. Within the market sector, the database provides sub-aggregates of industries, which are used in our analysis. We use the industry aggregates for ICT goods and services, which includes electrical and optical equipment, publishing, audiovisual and broadcasting services, telecommunications and IT and other information services; manufacturing excluding electrical and optical equipment; other production; and market services excluding ICT services. Manufacturing is further sub-divided into consumer, intermediate and investment goods manufacturing; other production to agriculture, mining and quarrying, utilities, and construction; and market services to trade and distributive services, financial and business services and personal services.

Figure 2: Wage-Productivity gap using alternate price concepts



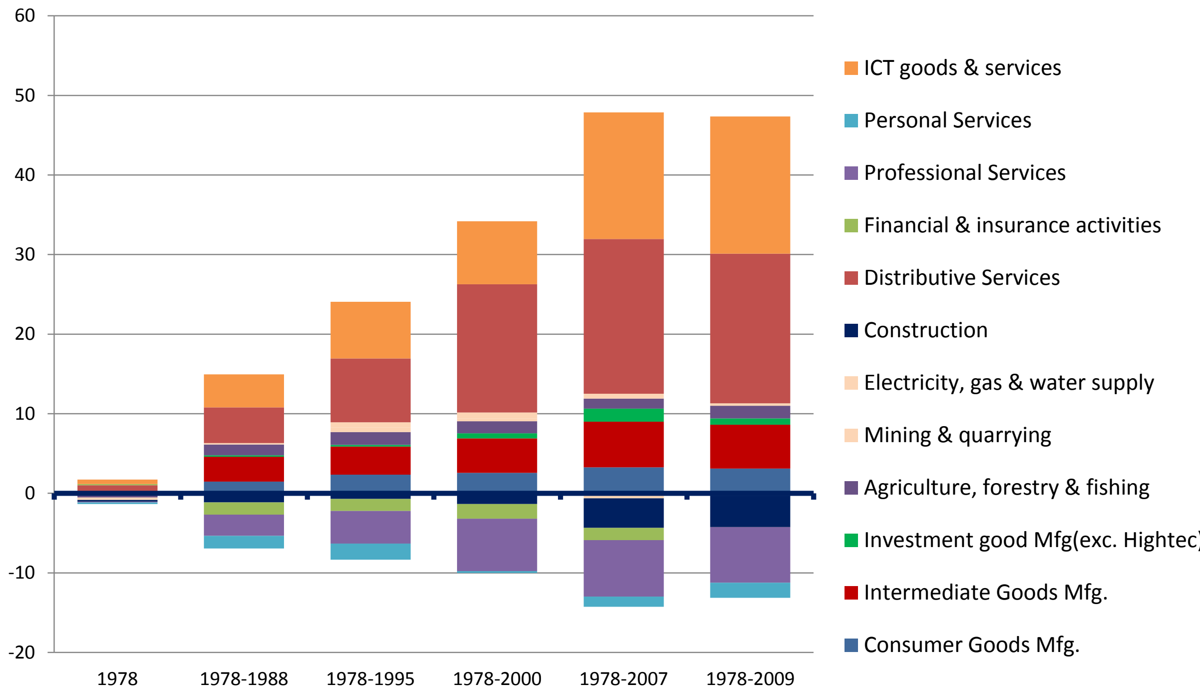
Sources: EU KLEMS, The Conference Board International Labor Comparison program, The Conference Board Total Economy Database

We measure productivity as real value added (value added deflated using respective industry value added deflator) divided by total hours worked. Wage rates are measured as total compensation per hour worked, deflated by consumer price indices (the prices of typical goods and services workers purchase in the market). Real wages can also be derived using value added deflators (this is consistent with the production function theory, which argues that the marginal product of labor should be equivalent to real wages, measured in the price of output the workers produce) or GDP deflator (prices of all goods and services that all workers in the economy produce).

Figure 2 depicts the wage-productivity gap in United States market economy using three different price deflators as mentioned above, which are the CPI, the value added price for each industry, and the aggregate GDP deflator. The gap between wage growth and productivity growth is the smallest when we use the value added deflator, and is highest when we use the CPI. Yet, it should be noted that irrespective of the chosen deflator, the gap does exist and is widening over time, particularly in the United States, Japan and France. In the subsequent analysis, we use consumer prices to deflate worker compensation, which are more relevant from a welfare perspective.

Figures 3 to 7 provide the contribution of major sectors of the economy to the aggregate market sector wage-productivity gap for several countries. In the United States, the largest contributor is distributive services, which account for 58 percent of total accumulated gap during the period 1978-2005 (i.e. 18 percentage point out of 32.5 percent gap). The second largest contributor is ICT goods and services, which account for another 53 percent (more than 17 percentage point). The gap was negative in personal services, professional services and construction. Together these sectors contributed about 40 percent to lower the aggregate gap. In sectors like construction, it appears that workers were paid even higher than their productivity, whereas in most other sectors of the economy their wages were growing much slower than their average productivity.

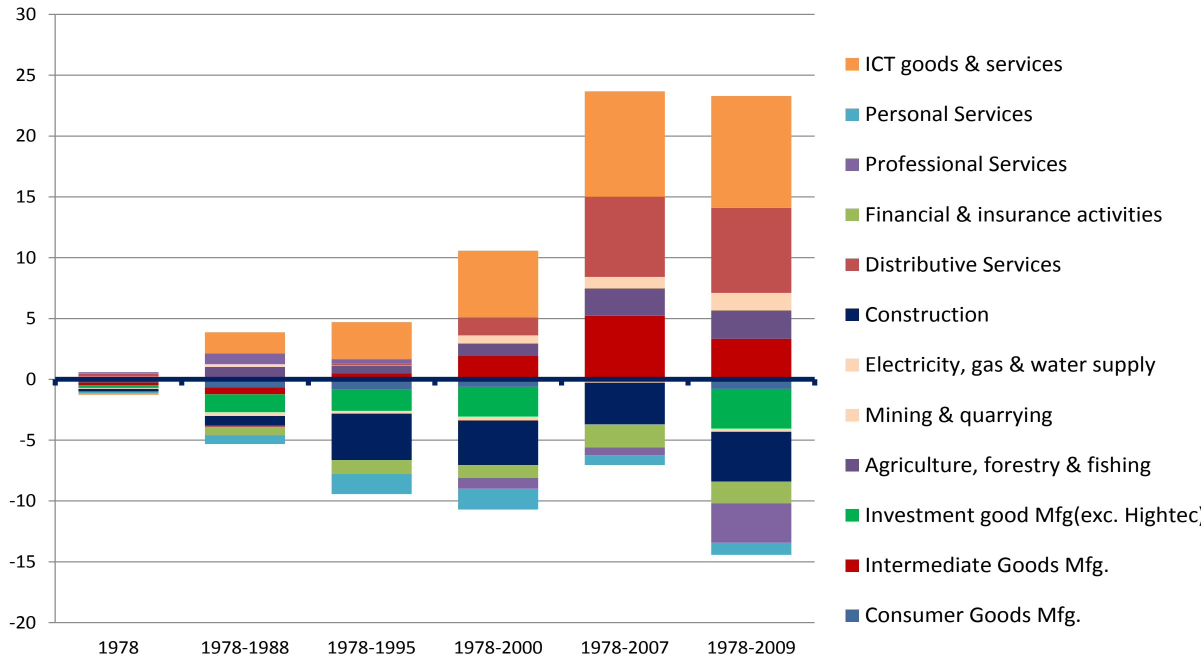
Figure 3: Industry Origins of Market Economy Productivity - Wage Growth Gap: United States



Note: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI. The overall size of the bar is the difference between cumulative real wage growth and cumulative labor productivity growth.
Source: EU KLEMS

The picture is quite different in Germany (Figure 4). Earlier we observed that German manufacturing showed no gap between productivity and wage until the 2000s, which is somewhat manifested in the aggregate market economy as well, where we see no gap until the late 1990s. However, there have been sectors where productivity grew faster than wages, though the gap was smaller. Agriculture, distributive services and ICT goods and services started developing the gap since 1980, which however was offset by faster wage growth compared to productivity in many other sectors. In general the gap was quite minimal until the 1990s. However, since 2000s the gap started widening faster in distributive services, the ICT and the intermediate manufacturing sector. In the post-crisis years, however, wages started increasing faster again in several industries, which reduced the overall gap in the aggregate market economy

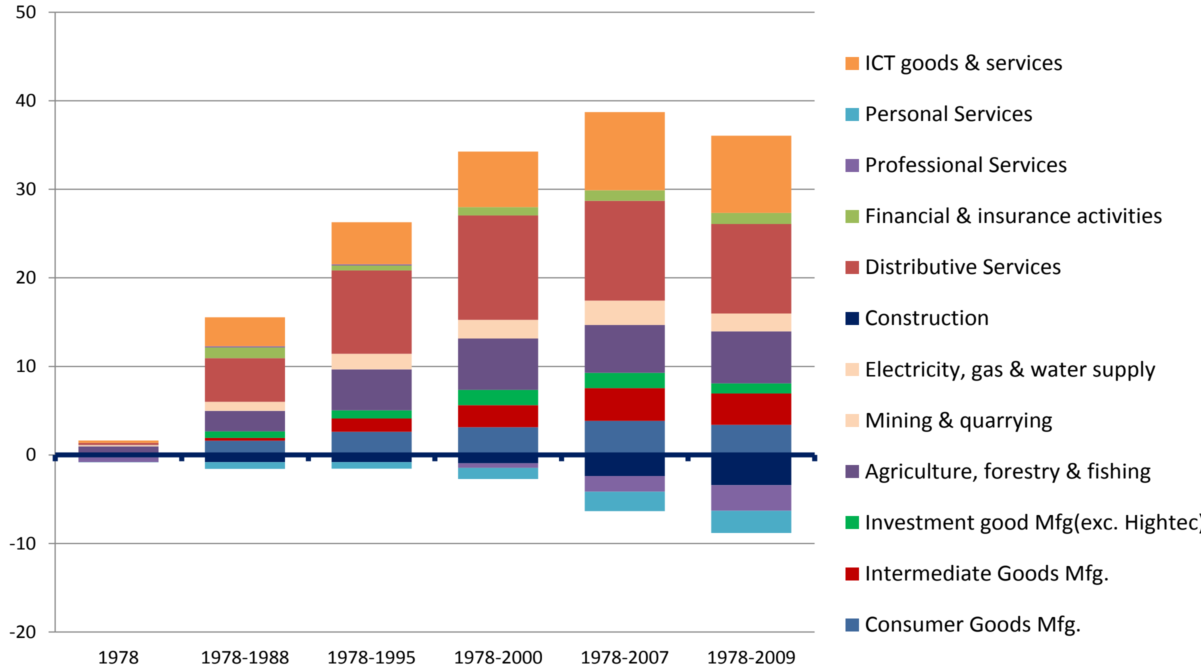
Figure 4: Industry Origins of Market Economy Productivity - Wage Gap: Germany



Note: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

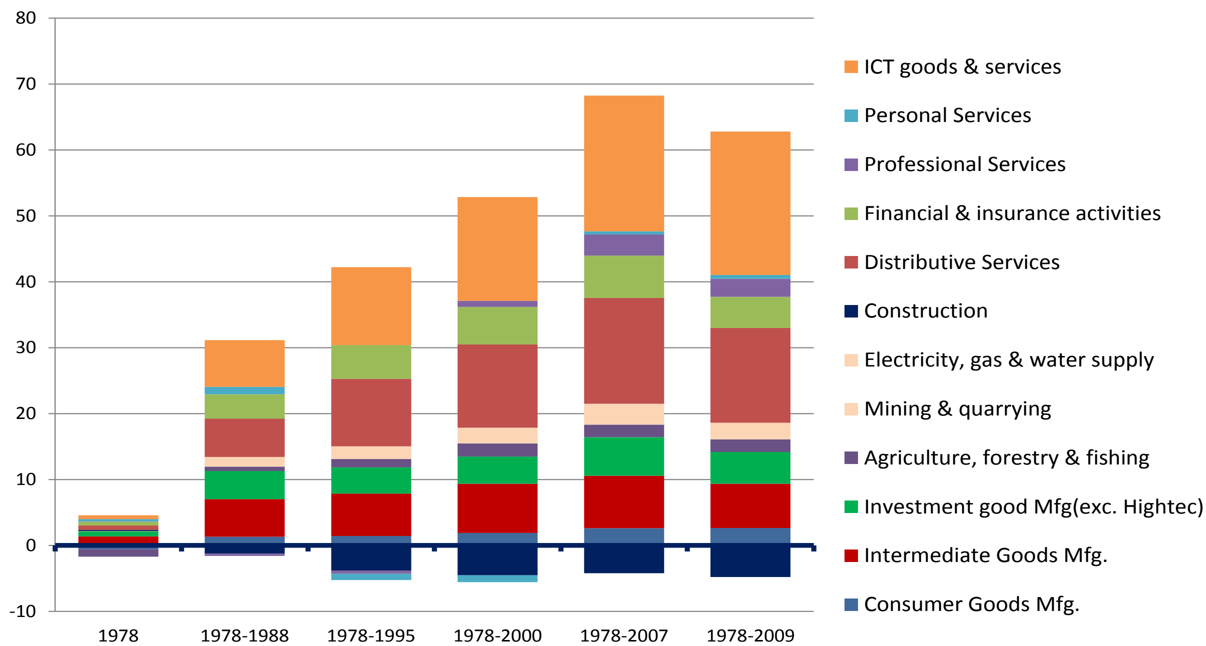
France also started developing the gap since early 1980s, with distributive service dominating, followed by ICT goods and services, agriculture and intermediate goods (Figure 5). Together they constituted more than 100 percent of the aggregate market economy wage-productivity gap. The overall gap between cumulative real wage growth and cumulative labor productivity growth in the market economy during 1978-2009 was 28 percent. Professional and personal services and construction industries have contributed to reduce the overall gap, as wages grew faster than productivity in these industries.

Figure 5: Industry Origins of Market Economy Productivity - Wage Gap: France



Note: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

Figure 6: Industry Origins of Market Economy Productivity - Wage Gap: Japan

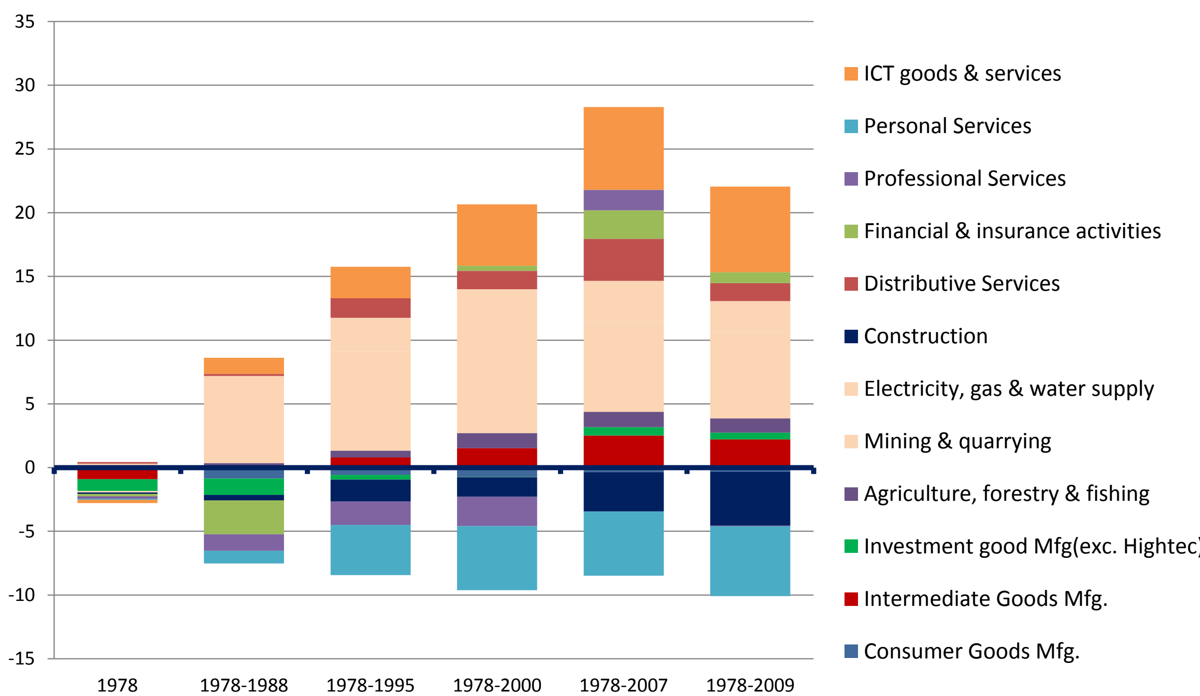


Note: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

Japan (Figure 6) had more industries with a positive gap, including ICT goods, distributive services, investment goods, financial services, whereas only construction had a negative gap. In general, Japan had the highest wage-productivity gap among the sample of countries. In addition to ICT goods and distributive services, sectors which we also observed to contribute largely in other countries, investment goods manufacturing also contributed to Japanese wage-productivity gap.

In the UK (Figure 7) the gap has been quite small, and until the late 1980s wages were growing faster than productivity. Even though productivity started growing faster in several industries, dominated by ICT, mining, electricity, gas and water supply, many other industries, such as personal services, construction, distributive services helped reduce the aggregate gap.

Figure 7: Industry Origins of Market Economy Productivity - Wage Gap: United Kingdom



Note: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

In general, except in the UK, there seems to be a pattern, which suggests that ICT goods and services and distributive trade services are the major drivers behind the increasing gap. The former is perhaps an effect of technology, which has contributed substantially to achieving higher labor productivity, through faster accumulation of high quality capital, and accelerated total factor productivity growth. The increased capital deepening in the sector must have caused a decline in the wage share in GDP, which might have contributed to the increasing gap. In addition, the prices of ICT goods have declined drastically over time, due to faster technological change (Jorgenson, 2001) which have indeed benefitted consumers, but has created an increasing wedge between consumer price indices and value added price indices, thus making the terms of trade unfavorable to workers. The role of ICT sector is larger in the U.S and Japan in creating a relatively larger wage-productivity gap. The absolute percentage point contribution of ICT sector was 18 and 22 percentage points respectively in the U.S and Japan, whereas it was between 6 to 9 percentage points in European countries. These two countries have much larger semiconductor industries than Europe (Houseman, Bartik, and Sturgeon, 2015). It appears that both in ICT industries and in distributive services, productivity gains were largely passed on to consumers. Fierce competition in the distributive services, though created many jobs, seem to have made firms pass on cost pressures to workers. The observed larger gap in intermediate goods sector, particularly in the United States, is consistent with the argument that increased outsourcing and offshoring of production of intermediate goods have affected jobs and wages in this sector. In the next section we examine the contribution of terms of trade and wage share to measured wage-productivity gap in these industries.

6. Sources of the wage-productivity gap: The wage share and terms of trade

Next to the sectoral contributions, the total productivity-wage gap can also be decomposed into terms of trade (the change in the ratio of GDP deflator/CPI) and the change in the share of nominal wage compensation in GDP:[7]

$$G = \Delta lny - \Delta lnw = -\left(\Delta ln\, s_L + \Delta ln \frac{P_y}{CPI}\right) \quad (9)$$

$$\text{with } y = \frac{(Y^*/P_y)}{H} = Y/H;\ w = \frac{(C/CPI)}{H};\ \text{and } s_L = \frac{C}{Y}$$

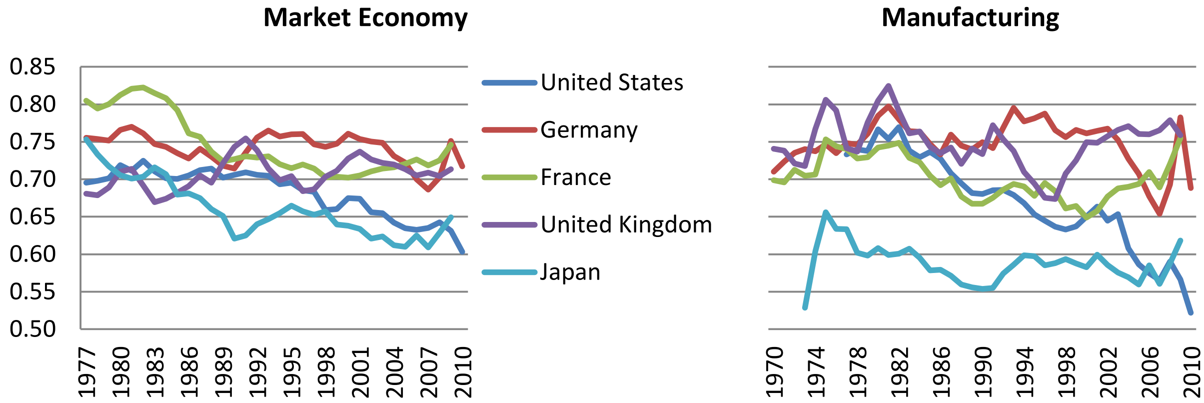
where Y^* is nominal GDP, *Py* is the GDP price deflator, *H* is total hours worked, *C* is total nominal labor compensation, *CPI* is the consumer price index, *sL* is the labor income share in nominal GDP. Therefore, $\frac{P_y}{CPI}$ – the ratio of GDP deflator (P_y) to consumer price indices (CPI) – is the terms of trade.

We analyze the wage-productivity growth gap at the industry level, and for the aggregate market economy, and therefore, industry value added is deflated using industry value added price deflators (i.e. *Py* is industry value added deflators), which can be quite different from the aggregate GDP deflator. Following equation (9) an increase in the wage share will reduce the wage-productivity growth gap, whereas a faster increase in consumer prices relative to industry value added prices, which makes the terms of trade unfavorable to workers, will increase the gap.

The labor share in market economy value added has been declining dramatically in the United States since the late 1980s (Figure 8). It declined by 10 percent from 1977 to 2010. The decline has been even more staggering in the manufacturing sector – from 73 percent to 52 percent –, which might clearly be a major factor in driving the gap between productivity and wages. In European countries, however, the wage share in general has been higher and has been stable with little fluctuation, except for a drop in France from mid-1980s to early 1990s, and in Germany during 2006-2007. In particular, the German manufacturing sector has seen a large decline in wage share in 2006 and 2007 when the labor market was freed up for low-wage service sector employment.

[7] As mentioned before, Bivens and Mishel, (2015) consider median compensation growth, which allows them to decompose the total gap into changes in labor income share and changes in terms of trade, along with the contribution of compensation inequality. It is not possible to do with our aggregate data, which allows us to use only average real wages.

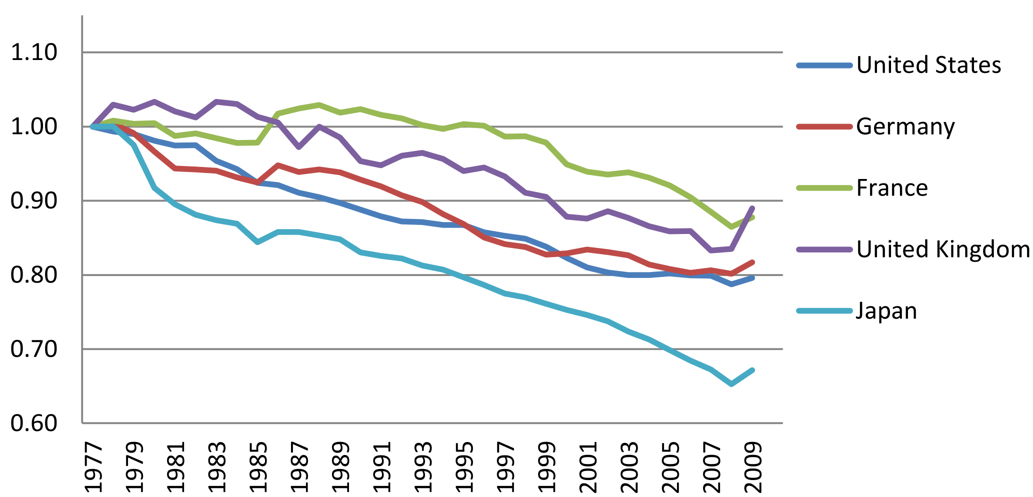
Figure 8: Labor income share in Market economy and Manufacturing value added



Source: EU KLEMS

The United Kingdom has even shown a marginal increase in the labor income share from 68 to 71 percent for the market economy and from 74 to 76 percent in manufacturing sector, from 1977 to 2009. Japanese manufacturing seem to have had the lowest labor income share in GDP throughout the period, though it has not declined substantially – it declined from 63 percent in 1977 to 62 percent in 2009. However, the market economy as an aggregate has witnessed a drop in labor income share from 75 percent in 1977 to 65 percent in 2009.

Figure 9: Labor's terms of trade (ratio of value added deflator / Consumer Price Indices)



Source: EU KLEMS

Figure 9 presents the trend in labor's terms of trade. Consumer prices grew much faster than output prices, thus making the terms of trade unfavorable to workers. This trend is apparent in all countries analyzed. However, the pace of worsening terms of trade has been faster in Japan and the United States, followed by Germany and U.K. On average, the relative market economy value added prices declined annually by 0.7 percent in the United States, while Japan saw a 1.2 percent annual decline. Both the UK and France witnessed an annual average decline of 0.4 percent and Germany at 0.6 percent during 1977-2009.

Table 3 provides the contributions of the wage share and terms of trade to the total market economy wage-productivity growth gap for the period 1973-2009. Columns 2 through 8 present the average gap (measured as average productivity growth minus average real wage growth) and the contributions from wage share and terms of trade, and the last column presents the cumulative gap over 1978-2009. For the entire period, 1978-2009, the average gap for the United States was 1.02, with the total cumulative gap being 32.5. Out of this total gap, 30 percent was due to a declining wage share and 70 percent due to a worsening of the terms of trade. During the 1978-1985 period the U.S had a gap of 0.89, almost all of which was due to worsening terms of trade, whereas the wage share had contributed negatively. The gap widened during the 1995-2000 period, registering an average gap of 1.33, with both wage share and terms of trade contributing respectively, 34 and 66 percent. This was the period of rapid expansion of the ICT sector in the U.S economy. During 2001-2006, the gap further worsened to 1.56, with nearly 70 percent of it emanating from labor income share.

The total gap in France is lower than the U.S, at 0.87, with a cumulative gap of 27.75 during 1978-2009. Over the entire period, 73 percent of this total gap was due to worsening terms of trade. Except during 1986-1994, worsening terms of trade was the largest driver of total gap. The gap was, on average, negative in the early 1970s, during 2001-2006 and 2007-2009, with all these periods witnessing negative contribution from wage share, and the last period seeing negative contribution from both terms of trade and wage share.

Table 3: Contributions of terms of trade and wage share to total wage-productivity growth gap (averages)

	AVERAGE OF ANNUAL GROWTH RATES							CUMU-LATIVE
	United States							
	1973-1977	**1978-1985**	**1986-1994**	**1995-2000**	**2001-2006**	**2007-2009**	**1978-2009**	**1978-2009**
Total Gap	-	0.89	0.82	1.33	1.56	0.21	1.02	32.49
Contributions from:								
Wage share	-	-0.09	0.12	0.45	1.08	0.07	0.30	9.67
Terms of trade	-	0.99	0.71	0.88	0.48	0.14	0.71	22.82
	France							
Total Gap	-0.75	1.17	1.59	1.46	-0.04	-1.47	0.87	27.75
Contributions from:								
Wage share	-0.96	0.19	1.06	0.42	-0.57	-0.88	0.24	7.57
Terms of trade	0.21	0.98	0.52	1.04	0.53	-0.59	0.63	20.18
	Germany							
Total Gap	0.00	0.62	-0.54	0.73	2.19	-1.34	0.43	13.62
Contributions from:								
Wage share	-0.37	0.34	-0.33	-0.09	1.39	-2.36	0.02	0.55
Terms of trade	0.36	0.27	-0.21	0.82	0.80	1.02	0.41	13.07
	United Kingdom							
Total Gap	-0.88	-0.19	0.38	0.73	0.90	-1.56	0.22	6.93
Contributions from:								
Wage share	-0.26	-0.03	-0.27	-0.68	0.53	-0.40	-0.15	-4.75
Terms of trade	-0.62	-0.17	0.64	1.41	0.38	-1.17	0.36	11.68
	Japan*							
Total Gap	-0.51	3.41	0.91	1.58	1.93	-0.63	1.71	54.64
Contributions from:								
Wage share	-3.01	1.29	0.42	0.43	0.34	-1.27	0.46	14.84
Terms of trade	2.50	2.12	0.50	1.16	1.58	0.64	1.24	39.80

Note: Total gap is calculated as the growth rates of labor productivity minus the growth rate of real compensation growth rates, averaged across years. Last columns contains cumulative growth rate over the entire period.
Source: EU KLEMS

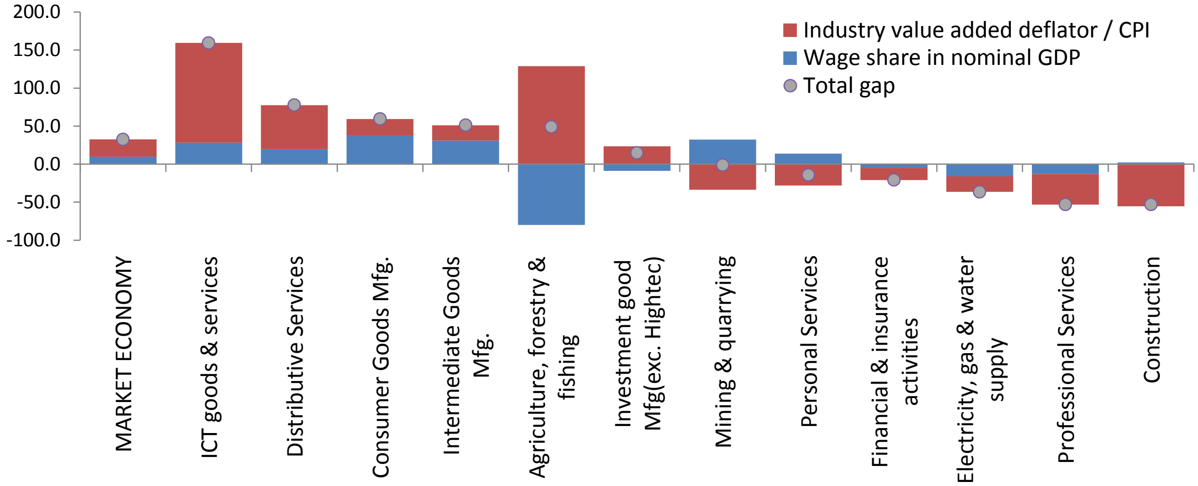
The gap was relatively lower in Germany and U.K. In Germany, the cumulative gap is only 13.62, which is less than half of what has been observed in the United States. The average gap for the entire period was 0.43, with 96 percent of this gap explained by terms of trade. The gap was zero during 1973-1977 period, as wage share contributed negatively with nearly the same magnitude as the positive contribution from terms of trade. The gap was negative again during 1986-1994 and 2007-2009, with both factors contributing negatively. The U.K had the lowest gap among all the five countries in our analysis, with about 7 percent cumulative gap over the entire period. Both components – terms of trade and wage share - were favorable to workers in the U.K, except during 2001-2006.

Japan seems to have had the highest cumulative gap over the 1978-2009 period, with the cumulative gap being 54.6 and average at 1.7. Nearly three quarters of this gap resulted from worsening terms of trade. The gap was negative during 1973-1977 and 2007-2009 as the wage share had a negative contribution in both these periods. In Figures 10 to 14 we further examine the contributions of terms of trade and wage share over the period, in each of the industries.

Figure 10 presents the sources of the total wage-productivity gap in the United States, cumulative over 1978-2009, by industries. In the ICT sector, much of the wedge arose from the difference between industry value added price and CPI. The same holds for the entire market economy and distributive services, where as in consumer and intermediate manufacturing it is driven by the declining wage share. The driving forces in sectors with a non-existent or negative gap have been terms of trade, whereas a declining wage share has been contributing a smaller share.

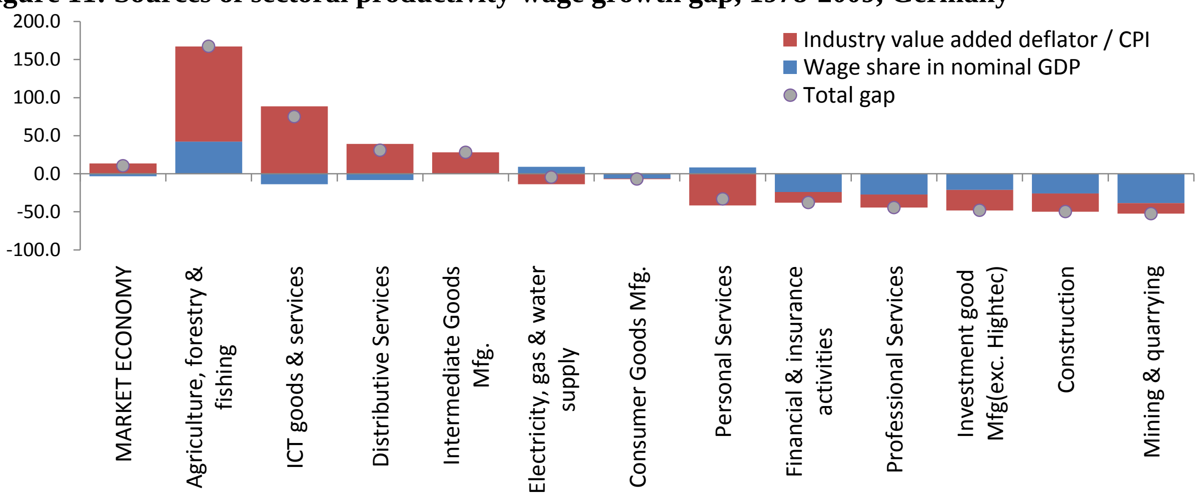
A similar picture is seen in Germany as well (Figure 11). A worsening of the terms of trade is the largest contributor in agriculture, ICT goods and services and distributive services. The highest gap between productivity growth and real compensation growth is observed in the agricultural sector, as the consumer prices grew much faster than output prices in that sector. There are several industries in Germany, which had a negative gap, most of which is driven by larger growth in wage share, though the role of terms of trade is indispensable.

Figure 10: Sources of sectoral productivity-wage growth gap, 1978-2009, United States



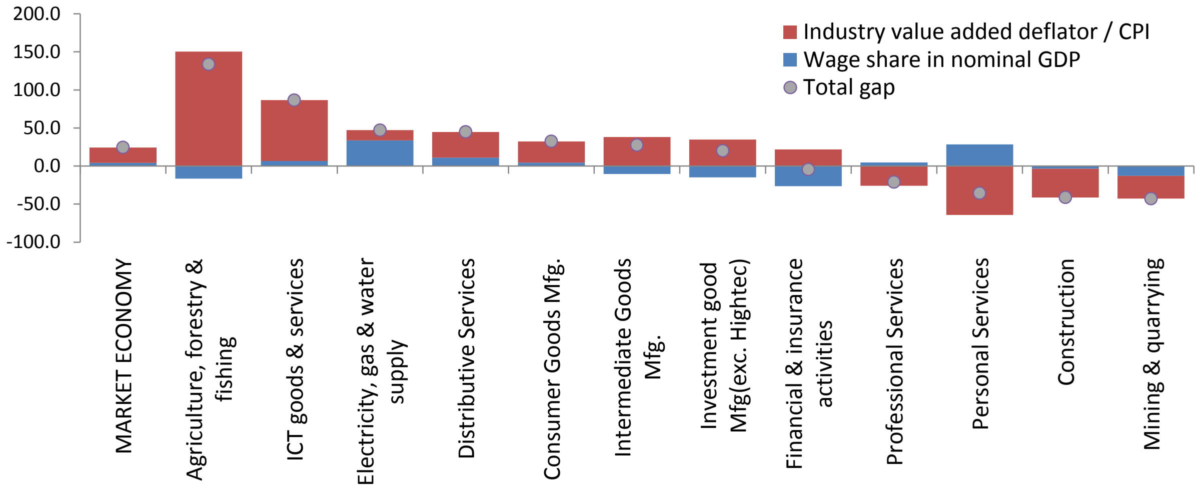
Notes: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

Figure 11: Sources of sectoral productivity-wage growth gap, 1978-2009, Germany



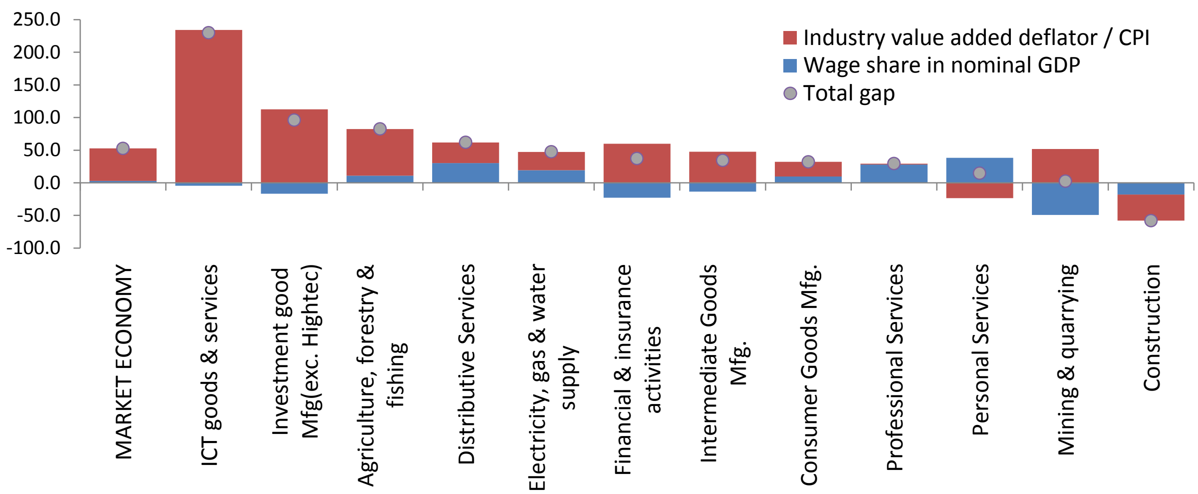
Notes: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

Figure 12: Sources of sectoral productivity- Wage gap, 1978-2009, France



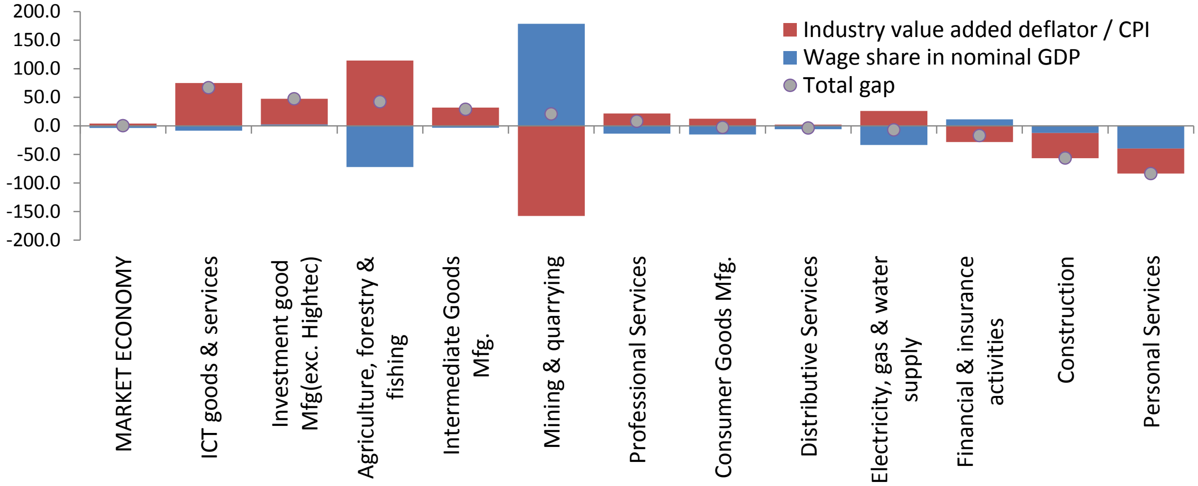
Notes: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

Figure 13: Sources of sectoral productivity-wage growth gap, 1978-2009, Japan



Notes: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

Figure 14: Sources of sectoral productivity-wage growth gap, 1978-2009, United Kingdom



Notes: Gap is calculated as the cumulative difference between growth rates of labor productivity and growth rates of real wages; Real wages are deflated using CPI.
Source: EU KLEMS

The impact of the wage share is almost nil or negative in most French industries (Figure 12), except in electricity gas and water supply and personal services. The largest gap is observed in agriculture, followed by ICT goods and services, electricity, gas and water supply and distributive services. Whereas in agriculture terms of trade contributed more than 100 percent of the total gap, in ICT goods and services terms of trade explains 92 percent of the total gap. In electricity, gas and water supply, however, about 70 percent of the gap is due to a declining wage share. In most other industries, the gap was quite negligible, yet the prime source was terms of trade. In several industries, the wage share contributed negatively to total gap, which includes financial intermediation, intermediate and investment goods manufacturing and mining.

ICT goods and services sector had the highest gap between productivity and wage growth in Japan over the period 1978-2009 (Figure 13). Most of this gap is also due to worsening terms of trade. Unlike the United States or Germany, the gap is higher in the Japanese investment goods sector, which is one of the largest exporting sectors in the country, and almost all this gap is due to a faster increase in consumer prices compared to producer prices. Similarly, the agriculture and financial intermediation sectors both had high terms of trade effect, while the wage share was dominant only in personal services.

The lower growth gap in the UK (Figure 14) is due to both terms of trade (mining, construction, personal services, financial services) and wage share (personal services, electricity, gas and water supply, consumer goods, professional services, agriculture). The mining sector had the highest impact from declining wage share, which however was largely offset by an improved terms of trade in the sector. Agriculture had the highest terms of trade effect, followed by ICT goods and services sector.

It appears that in almost all countries, the agricultural sector had a relatively high productivity-wage gap, predominantly due to worsening terms of trade. However, given the small size of this sector in the overall market economy, its contribution to aggregate economy gap is quite trivial. With a larger gap and increasing size in the overall GDP, the ICT sector seem to be the dominating sector in most economies in contributing to aggregate gap.

7. Summary and Conclusions

This paper documents the wedge between real hourly compensation growth and average hourly labor productivity growth in the United States over 1970-2009, in comparison with other mature economies. We show that the gap has been increasing more rapidly in the United States, in both the manufacturing and the aggregate market economy, compared to European countries. The paper then examines the sources of the aggregate market economy wage-productivity gap, in terms of industry origins and the sources of industry wage-productivity gap in terms of wage share in GDP and laborer's terms of trade. We find that the ICT goods and services producing industry is a common sector in all countries in driving the wage-productivity gap, though the magnitude of its contribution varies substantially across countries. Another sector that is dominant in most countries is distributive services. While measurement of real value added in margin industries is an important aspect that warrant further investigation, the findings are still plausible, for instance in the case of the U.S, given the changes in the structure of this sector in terms of consolidation of large chains, deregulation of transportation, development of logistics/supply chains, and increasing outsourcing and franchising etc. The dominance of ICT industries, which is one of the largest contributing sectors to aggregate productivity growth, in driving the gap is *prima facie* suggestive of the importance of rapid technological change, higher capital intensity, and worsening terms of trade in driving the wage-productivity gap. Wages in this sector seem to be not keeping pace with their technological change. Future analysis should focus on industry specific factors, such as technology intensity or skill intensity in driving the wedge between productivity and real wage growth. For most industries, worsening terms of trade seem to be the biggest driver of wage-productivity gap, as the consumer prices increased faster than producer prices, thus making real wage growth lower than productivity growth. This pattern holds across countries, and in particular in ICT industries.

In general, we observe a consistent pattern across countries that in two industries – distributive services and ICT goods and services –the productivity gains were passed on to the consumers through lower prices, whereas wages of workers in these sectors were not increased in tandem with their productivity growth. Therefore, workers were hurt on the nominal side of wages. In the intermediate goods sector offshoring may have held nominal wages low. In other industries the workers were hurt on the real side of wages, as they benefited less from lower output prices. Given that ICT prices play a substantial role in the proper measurement of ICT sector's productivity, future research should consider the measurement of ICT prices more seriously.

While the paper is a preliminary demonstration of different ways of looking at the complex problem of wage-productivity gap, using various internationally comparable datasets, it still needs further refinement and thus opens more avenues for future research. For instance, the increased role of technology, trade and global fragmentation of production in driving wage-productivity gap is an important matter to consider in the future research. This gains particular importance given the ongoing debates on the digital transformation and its relationship with future jobs – be it complementary or competitive. More importantly, in looking forward, what are the economic implications of this increasing wedge between income and productivity? The importance of this question stems from the very fact that real wages are the main source of purchasing power, whereas productivity is the main source of output growth. Therefore, a further increase of the wedge might lead to a situation of 'excess-capacity', leading to a crisis of supply exceeding demand.

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