PRODUCTIVITY GAINS AND ITS LINKAGE WITH COMPENSATION AND CAPITAL – A SECTORAL ANALYSIS

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Introduction

Labor productivity is a key economic indicator, closely linked to economic growth, competitiveness, and living standards within an economy (International Labor Organization, 2024). While economic growth and living standards are associated with labor productivity (hereafter referred to as productivity), productivity growth has failed to translate into rising wages and benefits to the employees. Since the 1970s, it has been observed that a divergence between productivity and compensation exists, suggesting that compensation has failed to keep pace with productivity. This divergence, commonly referred to as productivity-compensation gap, signals that the employees are not benefitting from the increasing economic growth. This raises important question about channels to which productivity gains are being distributed – particularly, raising the question whether productivity gains are flowing into capital investment instead of compensation.

The US Bureau of Labor Statistics (BLS) publishes the widening gap between labor productivity and real hourly compensation in the non-farm business sector over the years. Figure 1 from BLS provides evidence of the widening gap on average in the US for non-farm business sectors for the years 1973 to 2023 (US Bureau of Labor Statistics, 2024). Although the divergence reflects a declining share of income, it also indicates that the increased revenues

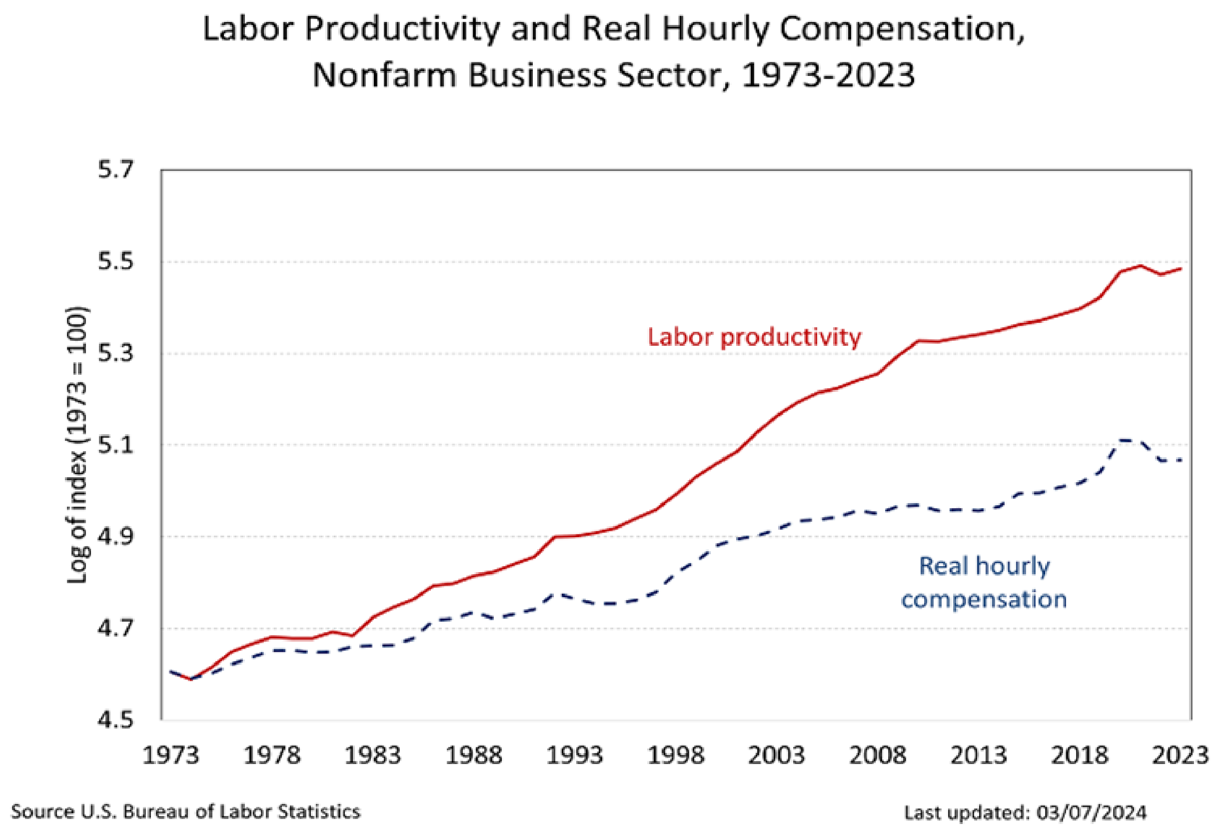

Figure 1: Demonstrates the widening gap between labor productivity and real hourly compensation on average in US for nonfarm business sectors over the years 1973 to 2023.

(productivity gains) might be diverted to capital, energy or other intermediate inputs. (Brill et al., 2017).

Stansbury and Summers (2017) introduced a linkage-delinkage spectrum model to understand the widening disparity between productivity and compensation. They establish this framework to assess how strongly productivity growth translates into compensation growth by looking at the coefficient associated with productivity. A coefficient of 1 implies a complete linkage – productivity gains are completely transmitted to compensation – while a coefficient of 0 implies a complete delinkage. A value between 0 and 1 shows a transmission of productivity into compensation to certain extent with other factors blocking the transmission. Their empirical analysis for the years 1990 to 2016 estimates the coefficient between 0.4 and 0.8, suggesting that productivity gains are transmitted to compensation to certain extent with other factors blocking this transmission. One such factor towards which productivity gains could be channeled is capital investment. A recent article in *Business Insider* reports that productivity is increasing and inspiring firms to invest in basic equipment to increase the speed of work (Dutta, 2024). This indicates that productivity gains could be diverted towards capital investment instead of compensation.

In this paper, I adopt the linkage-delinkage spectrum model proposed by Stansbury and Summers (2017) to establish the linkage of productivity into capital in manufacturing sector and transportation and warehousing sector. This analysis looks at sectoral output to analyze the two sectors, manufacturing sector and transportation and warehousing sector, to understand the flow of productivity gains into compensation and capital. While most studies look at declining labor share of income to understand the diversion of productivity gains towards technology, I look at capital intensity to understand the diversion of productivity gains towards technology. To understand this diversion, I analyze the contribution of productivity gains towards technology. While analyzing the contribution of productivity in compensation and capital intensity, I compare the productivity-compensation linkage and productivity-capital linkage to observe that the productivity-compensation linkage is stronger than productivity-capital intensity linkage in manufacturing sector and weaker than productivity-capital intensity linkage in transportation and warehousing sector.

Literature Review

Since 1970s, the divergence between productivity and compensation has been observed with more focus on nonfarm business sectors. Brill et al. (2017) discuss productivity-compensation gap at industry level rather than nonfarm business sectors. They study the trends in the widening gap between productivity and compensation in 183 industries from 1987 to 2015. Part of their analysis demonstrated that largest gap between productivity and compensation is found in industries with largest productivity gains like the IT industry. Brill et al. (2017) attribute the divergence of productivity and compensation to two components – difference between two deflators and labor's share of income. The difference between two deflators is the difference between compensation adjusted by Consumer Price Index (CPI) and compensation adjusted by the output deflator specific to each industry. They point to the fact that compensation adjusted by the output deflator better aligns with productivity compared to compensation adjusted by CPI. Furthermore, they found that the gap between productivity compensation decreased for 87% of industries, which had shown productivity was rising faster than compensation (Brill et al., 2017). The second component, labor's share of income measures the part of revenue going to workers compared to other factors of production including capital and intermediate goods. They conclude that after accounting for the difference in CPI and output deflator, the productivity-compensation gap came from labor's share of income. In other words, when the same deflator was used, they found that the gap between productivity and compensation was explained by labor's share of income.

Extending on their work, Fofack and Temkeng (2021) assess and compare the link between productivity and pay in four industries in the European Union including air transport, electronics, finance, and telecommunication using the Autoregressive Distributive Lag (ARDL) model. They analyzed these four industries in 25 member states of the European Union from 2000 to 2014. Fofack and Temkeng (2021) conduct an in-depth analysis of the heterogeneous relationship between productivity and compensation using pooled mean group estimation, mean group estimation, and dynamic fixed effect estimators (Fofack & Temkeng, 2021). They also conduct their estimation by using value-added per hour worked as the proxy for productivity. Their analysis of the heterogeneity of the gap between productivity and compensation confirms the existence of the gap as well as confirming that the link between productivity and compensation is not broken. Fofack and Temkeng (2021) claim that their results support the results from Stansbury and Summers (2017) suggesting that there are other factors that "prevent productivity gains to be reflected on paycheck" (Fofack & Temkeng, 2021).

Fofack and Temkeng (2021) compare their results with Stansbury and Summers (2017) to confirm the existence of productivity-compensation gap. Stansbury and Summers (2017) investigate the extent to which productivity growth translates into compensation growth for the typical American. They find substantial evidence of linkage between productivity and compensation over 1973 – 2016. Stansbury and Summers (2017) approach the question through the linkage-delinkage spectrum, where they view that at the simplest level, the estimate associated with productivity shows where the relationship falls on the spectrum. If the estimate equals 1, the relationship between productivity and compensation is viewed as the "strongest linkage", while if the estimate equals 0 it is seen as the "strongest delinkage" (Stansbury & Summers, 2017). The value of the estimate between 0 and 1 is viewed as a point on the linkage-delinkage spectrum. They look at three concepts of compensation – typical compensation, average production/nonsupervisory compensation, and average compensation to test their hypothesis (Stansbury & Summers, 2017). Their baseline specification regresses the three-year moving average of change in the log of compensation on three-year moving average of change in productivity and current and lagged three-year moving average of the unemployment rate (Stansbury & Summers, 2017).

Expanding on the work from Stansbury and Summers (2017), Greenspon et al. (2021) study the productivity-pay relationship in the United States and Canada to understand the divergence and delinkage of productivity and compensation. They compare the degree of divergence with the degree of linkage and delinkage between compensation and productivity across the United States and Canada along different metrics and different time periods (Greenspon et al., 2021). They describe divergence as "the degree to which levels of productivity and pay have diverged" and delinkage as "the degree to which incremental increase in the rate of productivity growth translate into incremental increases in the rate of growth of pay, holding all else equal" (Greenspon et al., 2021). They find that in both countries, the pay of typical workers diverged substantially from average labor productivity, which they attribute to three trends – decline in labor's share of income, rise in labor inequality, and decline in labor's term of trade in both countries. They define decline in labor's share of income as "divergence between labor productivity and average compensation, deflated by the same price deflator", rise in labor income inequality as “divergence between average compensation and the compensation of typical workers”, and decline in labor’s term of trade as “divergence between consumer and producer price deflators” (Greenspon et al., 2021). They also suggest that in the US the decline in labor share is further attributed to technological changes, globalization and labor offshoring, reduction in worker bargaining power, higher firm concentration, increased markups, and housing market dynamics.

To study the productivity-pay relationship Greenspon et al. (2021) estimate the linkage-delinkage spectrum model by running a regression of the three-year moving average of the change in log compensation on the change in log productivity while controlling for unemployment. Their findings show that “over recent decades a one percentage point increase in the rate of productivity growth in the US has been associated with a 0.6-0.8 percentage point faster average compensation growth, a 0.5-0.7 percentage points faster median compensation growth, and a 0.3-0.9 percentage points faster growth in the compensation of production and nonsupervisory workers” (Greenspon et al., 2021). Furthermore, they find evidence suggesting that in both countries higher productivity growth rate is associated with significant increases in compensation growth rate, with higher linkage in the United States (US) as opposed to Canada. Their further exploration suggests that international factors such as global commodity prices could play a role in explaining the gap between productivity and pay.

Diving deeper into the productivity-compensation gap and exploring falling labor’s share of income, Stansbury and Summers (2017) argue that from the perspective of technology-focused theory, if the primary cause of productivity-divergence is technological progress then the periods with faster productivity growth should coincide with faster growth in divergence of productivity and compensation. To test this theory, Stansbury and Summers (2017) examine the co-movement of labor productivity with labor share and with mean-median compensation ratio. Against the technology-focused theory, they find "little evidence of a significant relationship between productivity growth and changes in the labor share for any period except 2000" (Stansbury & Summers, 2017). Elsby et al. (2013) did not find the timing of capital deepening aligning straightforwardly with the timing of movements in labor's share in their data.

Elsby et al. (2013) test five hypotheses that focus on detailed examination of magnitude, determinants, and implications tested decline in labor share. Aside from statistical procedures used to impute labor income of self-employed, they attribute decline in labor's share of income to movement of labor shares within the industry dominated by trade and manufacturing sector, supply chain, offshoring labor-intensive components, and capital deepening. Focusing on capital deepening, they explore the relation between productivity-compensation gap and capital intensity through neoclassical theory. When the elasticity of substitution is greater than 1 $(\sigma > 1)$, the shrinking labor's share of income must be traced through capital deepening. They find that to exploit technological change in new capital goods unskilled labor is replaced by capital when capital gets cheaper. They further explain that for a given growth rate of labor augmenting technological progress, the decline in labor's share of income is consistent with the additional growth in output outstripping additional growth in real wages. While testing the theory, they find that decline in labor share from 1980s to mid-1990s was characterized by rising growth in the 1980s, which was characterized by average labor productivity growth surpassing hourly compensation growth. However, they did not find the timing of capital deepening aligning straightforwardly with the timing of movements in labor's share in their data. They conclude from their analysis that “either neoclassical theory is unable to provide a coherent account of the decline in labor’s share, or a simple aggregate production function is too crude to capture the relevant economic forces” (Elsby et al., 2013).

Supporting the idea of capital deepening not aligning with labor’s share of income, Glover and Short (2020) estimate the aggregate elasticity of substitution between labor and capital. Glover and Short (2020) highlight that one of the potential reasons for declining labor’s share of income is capital intensity, which is defined as capital to labor ratio. Glover and Short (2020) analyze the declining trend of labor’s share of income from the perspective of capital deepening, which is defined as increasing capital intensity. They look at the aggregate elasticity of substitution between capital and labor to test if capital deepening can explain the global decline in labor share. Glover and Short (2020) conduct a cross-country analysis of declining labor share to argue that as investment goods become cheaper, countries accumulate more capital relative to labor, hence increasing capital intensity. They theoretically derive a proxy for the rental rates which is dependent on investment prices and consumption growth. They use the inter-temporal Euler equation for investment and a transitional term that reflects gradual rise in consumption as a response to lower investment prices. Their results conclude that the estimate of aggregate elasticity of substitution between labor and capital is near or below one which implies that capital deepening cannot explain the global decline in labor’s share. But their estimation provides support for explanations such as falling labor share along with rising product-market concentration. It also supports Elsby et al. (2013) who estimate a strong correlation between inter-industry trends in labor share and import competition.

While labor productivity and compensation have been widely studied, capital deepening is another factor studied to understand productivity gains. Basri et al. (2020) examine how shocks in wage, capital intensity and human capital affect labor productivity in Malaysian manufacturing sector. They adopted a Panel Vector Autoregressive (PVAR) Model to examine the impact of these shocks on labor productivity growth. The main finding, labor productivity growth, shows an expected positive and significant response to one standard deviation in shock in the change of wage, capital intensity and human capital. Moreover, they find that capital intensity and wage have the largest explanatory power for labor productivity. The forecast variance decomposition (FEVD) proves that the weighting of capital against labor and wage has a large explaining power over labor productivity over ten years.

Analyzing labor productivity and capital intensity, Wolff (1991) presents estimates of labor productivity and total factor productivity (TFP) growth at three different levels over the years 1948 – 86: (1) US insurance industry, (2) whole economy and (3) selected subsectors. They explain that despite the rapid growth of capital intensity in the insurance industry, poor productivity performance had been noticed during the postwar period. In their analysis they use the sum of total factor productivity (TFP) growth and growth in capital-labor ratio to measure labor productivity growth. They find that in 1948 – 86 there was a strong growth in capital intensity in insurance industry which led to relatively modest growth in labor productivity. Wolff (1991) further conclude that it was only through capital intensity that the insurance industry was able to achieve its relatively modest growth in labor productivity for the year 1948 – 86.

Overall, Stansbury and Summers (2017) establish a linkage between productivity and compensation to draw conclusion that productivity gains are not completely translating to compensation. This has been verified by Fofack and Temkeng (2021), but Greenspon et al. (2021) dive deeper into the linkage between productivity and compensation attributing the gap to falling labor's share of income. They suggest that in the US declining labor share is further attributed to technological changes, globalization and labor offshoring, reduction in worker bargaining power, higher firm concentration, increased markups, and housing market dynamics. Stansbury and Summers (2017) hypothesize the primary cause of productivity- pay divergence is technological progress. They address their hypothesis by examining the co-movement of labor productivity with labor share and with mean-median compensation ratio. However, past literature has found that declining labor's share of income could not be attributed to capital intensity by checking for elasticity of substitution and co-movements of declining labor's share of income and technological progress. This explains that capital intensity may not be influencing productivity-compensation gap through declining labor's share of income. However, Wolff (1991) and Basri et al. (2020) explain the role of capital intensity in productivity growth. Thus, there's a potential to analyze the linkage between productivity gains and capital intensity. This linkage can explain the diversion of productivity gains from compensation to capital intensity.

Data

The Office of Productivity and Technology (OPT) data from the Bureau of Labor Statistics (BLS) comprises detailed industry-level data for the years 1987 – 2022. The output is the sectoral output which is constructed from the annual-weighted (Fisher-Ideal) index by the Bureau of Economic Analysis (BEA) from GDP. BLS excludes output from general government, non-profit institutions, paid employees of private households, rental value of owner-occupied dwellings, and farm output. The sectoral output is constructed by removing intra-industry transactions. The output data is used to compute labor productivity, which is defined as the efficiency of producing goods and services through labor hours. For labor productivity, the BLS Current Employment Statistics (CES) program collected data for 83 three-digit-level industries under the North America Industry Classification System (NAICS) in the private nonfarm sector. Employment of non-production and non-supervisory workers in each industry is computed by taking a difference between employment of all employees and employment of production workers. The CES program collected average weekly hours on an hour-paid basis including the time when employees are not at work. These hours are then adjusted to ensure that changes in vacation, holiday, and sick pay do not affect growth in hours.

In this paper I am focusing my analysis on 2 sectors – manufacturing sector and transportation and warehousing sector for the years 1989 to 2019. Table 1 presents the description of the variables used in the models. BLS defines labor productivity as the efficiency with which goods and services are produced via labor hours or as output per hour and hourly compensation as the sum of wage and benefits paid per hour of work. Capital Intensity, as defined by BLS, is the ratio of the amount of capital input used relative to the amount of labor hours used to produce output of goods and services (*Productivity Glossary*, 2023). The lag of productivity is created for the percentage change in labor productivity from previous year for year prior to the referred year. Table 2 provides detailed summary statistics for percentage change in labor productivity, percentage change in compensation, percentage change in capital intensity, and percentage change in lag of labor productivity in manufacturing sector and transportation and warehousing sector.

Table 1: Description of Variables

Variable Name	Description of variables
LProductivity	Percentage change in labor productivity from previous year.
Compensation	Percentage change in hourly compensation from previous year.
KIntensity	Percentage change in capital intensity from previous year.
LProductivity_lag1	Percentage change in labor productivity from previous year lagged 1 period

Table 2: Summary Statistics

VARIABLES	n	mean	sd	median	min	max	range	se
LProductivity	6,586	1.781	7.957	1.3	-40.0	105.6	145.6	0.098
Compensation	6,586	2.830	5.978	2.7	-44.5	55.2	99.7	0.074
Gap	6,586	-1.049	6.742	-1.4	-56.9	100.0	156.9	0.083
KIntensity	4,278	1.781	6.576	1.3	-33.7	40.9	74.6	0.101
InputIntensity	4,278	1.761	9.039	1.6	-45.6	90.4	136.0	0.138
LProductivity_lag1	6,577	1.860	7.929	1.4	-40.0	105.6	145.6	0.098

Methodology

Stansbury and Summers (2017) introduce the linkage-delinkage spectrum to evaluate the linkage between productivity and compensation. They follow the approach similar to Feldstein (2008) who investigated linkage between productivity and average compensation by regressing change in log of average compensation on current and lagged change in log of productivity to find a strong and close to one-to-one relation (Stansbury & Summers, 2017). On one end of the spectrum is the possibility of productivity growth delinking from compensation and other factors may be blocking the transmission. This suggests that increases in productivity growth do not systematically translate into increases in compensation with other factors blocking the transmission. Stansbury and Summers (2017) refer to this as “strong delinkage”. The other end of spectrum shows while other factors may have severed the connection between productivity and compensation, an increase in productivity growth translates directly into compensation. Stansbury and Summers (2017) refer to this as “strong linkage”. The strong linkage implies that when productivity growth raises compensation, productivity-compensation gap can be explained by other orthogonal factors that could be reducing compensation growth. While these two are the extreme ends of the spectrum, there are a range of possibilities on the spectrum in between that show some degree of linkage exists between productivity and compensation. Stansbury and Summers (2017) use a simple linear model to show the linkage between productivity and compensation. The linkage between productivity and compensation at simplest level is shown in Equation 1.

$$compensation\ growth_t = \alpha + \beta productivity\ growth_t \qquad \text{Equation 1}$$

The foundation for the linkage-delinkage spectrum for productivity and compensation and productivity and capital can be expressed using Cobb-Douglas production function. The Cobb-Douglas production function ensures constant returns to scale and linear homogeneity, which ensures a proportional relationship between inputs and output. Labor productivity is defined as the output per labor hour which is the average output per unit of labor. Cobb Douglas production function ensures that marginal product of labor is proportional to the average product of labor, in which case the wages paid by the competitive firm should increase at the same pace as productivity growth (Feldstein, 2008).

Consider a simple two-input one output production function which takes the form of Cobb Douglas production function as shown in Equation 2. Let Y represents the sectoral output, K represents capital, L represents labor input and A represents the total factor productivity. In the Cobb-Douglas function α is the market share of capital and β is the market share of capital.

$$Y = AK^{\alpha}L^{\beta} \qquad \text{Equation 2}$$

A firm's maximization problem takes the difference between the output and sum of the value of its inputs. w is the wage rate (or hourly compensation) given to the workers per labor hour worked. r is the rent (or investment) paid towards the capital assets. Hence, the maximization problem for this setup for a firm is

$$\max_{L,K} Y_t - wL_t - rK_t$$
$$such\ that\ Y_t = A_t K_t^{\alpha} L_t^{\beta} \qquad \text{Equation 3}$$

The first order derivative with respect to L from the maximization problem shows the relation between productivity and compensation as shown in Equation 4.

$$\beta\left(\frac{Y_t}{L_t}\right) = w \qquad \text{Equation 4}$$

The first order derivative with respect to K from the maximization problem shows the relation between output and capital as shown in Equation 5

$$\gamma Y_t = K_t \qquad \text{Equation 5}$$

where $\gamma = \frac{\alpha}{r}$. To show the relation of capital with productivity, Equation 5 is modified to show the relation between productivity and capital intensity.

$$\gamma \frac{Y_t}{L_t} = \frac{K_t}{L_t} \qquad \text{Equation 6}$$

Equation 4 and Equation 6 build the foundation for linkage-delinkage spectrum. Equation 4 builds the foundation for linkage-delinkage spectrum for productivity and compensation. Equation 6 builds the foundation for linkage-delinkage spectrum for productivity and capital intensity.

Empirical Model

a. Linkage-Delinkage Spectrum Model for Productivity and Compensation

Linkage-Delinkage Model for productivity and compensation shows the linkage (or delinkage) between productivity and compensation. The linkage-delinkage spectrum model for Productivity and Compensation assumes that there exists a gap between productivity and compensation. Equation 7 relates the productivity and compensation growth using a simple linear model (Stansbury & Summers, 2017). Equation 8 represents the linkage-delinkage model for industry i in sector $s = \{Manufacturing, Transportation\ and\ Warehousing\}$ at time t.

$$compensation\ growth_t = \alpha + \beta productivity\ growth_t \qquad \text{Equation 7}$$

$$\Delta compensation_{ist} = \beta_0 + \beta_1 \Delta productivity_{ist} + \epsilon_t \qquad \text{Equation 8}$$

The estimate of β associated with productivity growth (β_1) demonstrates the transmission of productivity into compensation, explaining the contribution of productivity gains into compensation. The value of β ranges between $0 \; and \; 1$. When $\beta = 1$, there's "strong linkage" which shows that increase in productivity growth completely translates into compensation; for a value of 0, there is a "strong delinkage" which shows that increase in productivity growth is not translating into compensation (Stansbury & Summers, 2017). Strong linkage and delinkage are defined as the two extreme ends, there are a range of possibilities between the two ends where β ranges between $0 \; and \; 1$ (excluding 0 and 1). These possibilities explain that certain degree of linkage exists between productivity and compensation (Stansbury & Summers, 2017).

b. Linkage-Delinkage Spectrum Model for Productivity and Capital Intensity.

Building from the linkage-delinkage model for productivity and compensation, I look at linkage-delinkage spectrum for productivity and capital intensity. Equation 9 shows the relation between productivity growth and capital deepening, which is defined as growth in capital intensity. Equation 10 represents the linkage-delinkage spectrum model for capital and productivity in industry i in sector $s = \{Manufacturing, \; Transportation \; and \; Warehousing\}$ at time t:

$$capital \; deepening_t = \alpha + \beta productivity \; growth_t \qquad \text{Equation 9}$$

$$\Delta capital_{ist} = \beta_0 + \beta_1 \Delta productivity_{ist} + \epsilon_t \qquad \text{Equation 10}$$

Results

a. Unit Root Test

Before proceeding with empirical analysis, I examine whether there exists an underlying trend within the variables. For checking underlying trends and stationarity within a variable, I employ Augmented Dickey Fuller test to check for underlying trends and stationarity within productivity growth, compensation growth, and growth of capital intensity (or capital deepening). Augmented Dickey Fuller test is a unit-root test useful in checking for underlying trends and stationarity. The ADF test evaluates the null hypothesis that non-stationarity exists in the data against the alternative hypothesis of stationarity. The results from ADF test in Table 3 and 4 confirm stationarity in productivity in manufacturing sector and transportation and warehousing sector respectively. The results from ADF test in Table 5 and 6 confirm stationarity in compensation in manufacturing sector and transportation and warehousing sector respectively. The results from ADF test in Table 7 and 8 confirm stationarity in capital intensity in manufacturing sector and transportation and warehousing sector respectively. The lag length for Augmented Dickey Fuller tests in Table 3 to 8 is automatically selected based on Akaike Information Criteria (AIC).

Table 3: Augmented Dickey Fuller for Productivity in Manufacturing Sector confirm stationarity.

Variable	Estimate	Std..Error	t.value	Pr...t..	
z.lag.1	-0.49108	0.01289	-38.10185	<2e-16	***
z.diff.lag	-0.00060	0.01300	-0.04653	0.96289	

tau1	Critical_1pct	Critical_5pct	Critical_10pct
-38.10185	-2.58000	-1.95000	-1.62000

Table 4: Augmented Dickey Fuller for Productivity in Transportation and Warehousing Sector confirm stationarity.

Variable	Estimate	Std..Error	t.value	Pr...t..	
z.lag.1	-0.48566	0.03703	-13.11356	<2e-16	***
z.diff.lag	0.06473	0.03873	1.67156	0.09508	.

tau1	Critical_1pct	Critical_5pct	Critical_10pct
-13.11356	-2.58000	-1.95000	-1.62000

Table 5: Augmented Dickey Fuller for Compensation in Manufacturing Sector confirms stationarity.

Variable	Estimate	Std..Error	t.value	Pr...t..	
z.lag.1	-0.53040	0.01340	-39.57209	<2e-16	***
z.diff.lag	-0.00210	0.01300	-0.16169	0.87156	

tau1	Critical_1pct	Critical_5pct	Critical_10pct
-39.57209	-2.58000	-1.95000	-1.62000

Table 6: Augmented Dickey Fuller for Compensation in Transportation and Warehousing Sector confirms stationarity.

Variable	Estimate	Std..Error	t.value	Pr...t..	
z.lag.1	-0.38683	0.03523	-10.97885	<2e-16	***
z.diff.lag	-0.05377	0.03889	-1.38258	0.16726	

tau1	Critical_1pct	Critical_5pct	Critical_10pct
-10.97885	-2.58000	-1.95000	-1.62000

Table 7: Augmented Dickey Fuller for Capital Intensity in Manufacturing Sector confirms stationarity.

Variable	Estimate	Std..Error	t.value	Pr...t..	
z.lag.1	-0.45485	0.01411	-32.23426	< 2e-16	***
z.diff.lag	0.07792	0.01536	5.07244	4.1e-07	***

tau1	Critical_1pct	Critical_5pct	Critical_10pct
-32.23426	-2.58000	-1.95000	-1.62000

Table 8: Augmented Dickey Fuller for Capital Intensity in Transportation and Warehousing Sector confirms stationarity.

Variable	Estimate	Std..Error	t.value	Pr...t..	
z.lag.1	-0.54743	0.14781	-3.70362	0.000476	***
z.diff.lag	-0.13448	0.13151	-1.02257	0.31076	

tau1	Critical_1pct	Critical_5pct	Critical_10pct
-3.70362	-2.60000	-1.95000	-1.61000

b. Linkage-Delinkage for Productivity and Compensation

I employ a simple linear regression model to estimate the relation between productivity and compensation as developed in Equation 8. I report the Newey-West heteroskedasticity and autocorrelation robust standard errors that account for heteroskedasticity and autocorrelation in the error term. The results from OLS estimation in Table 9 estimate the relationship between productivity and compensation to report the contribution of productivity growth and compensation growth for manufacturing sector and transportation and warehousing sector for the years 1989 to 2019. The dependent variable $Compensation$ reflects the percentage change in hourly compensation, where hourly compensation is the sum of wages and benefits paid per hour of work. In the first two columns numbered (1) and (2) I report the estimates from OLS for manufacturing sector to show the relation between productivity and compensation in manufacturing sector. In the last two columns numbered (3) and (4) I report the estimates from OLS for transportation and warehousing sector to show the relation between productivity and compensation in transportation and warehousing sector. Columns (1) and (3) demonstrate the relationship between productivity in time t and compensation in time t, columns (2) and (4) demonstrate the relationship between productivity in time t and compensation in time t after accounting for the lagged productivity growth.

For the years 1989 to 2019, β associated with change in labor productivity are in the range of 0.32 to 0.46. This establishes the linkage between productivity and compensation, consistent with the work of Stansbury and Summers (2017), who report a range of 0.7 to 0.91 from 1973 to 1990 and a range of 0.4 to 0.79 for the years 1990 to 2016 for average compensation in the US (Stansbury & Summers, 2017) for the linkage between productivity and

Table 9: OLS Models estimating relation between productivity and compensation for Manufacturing Sector and Transportation and Warehousing Sector for the years 1989 to 2019. The standard errors reported are the Newey-West heteroskedasticity and autocorrelation robust standard errors

	Manufacturing Sector		*Transportation and Warehousing Sector*	
	(1)	(2)	(3)	(4)
(Intercept)	2.072 ***	2.141 ***	2.155 ***	2.168 ***
	(0.085)	(0.091)	(0.206)	(0.206)
LProductivity	0.427 ***	0.459 ***	0.330 ***	0.321 ***
	(0.047)	(0.040)	(0.047)	(0.051)
LProductivity_lag1		-0.066 **		0.018
		(0.025)		(0.036)
N	5921	5921	665	656
R2	0.323	0.329	0.188	0.186
AIC	36076.088	36026.073	3474.110	3434.452

*** p < 0.001; ** p < 0.01; * p < 0.05.

compensation. The estimates for the manufacturing sector are aligned with the range by Stansbury and Summers (2017) but the estimates for transportation and warehousing sector are slightly lower, yet closer to the range. The results confirm the existence of the link between productivity and compensation, suggesting that productivity growth is not completely translating to compensation. This also suggests that there are other factors that are blocking this transmission. Furthermore, the results indicate a 42.7% contribution of productivity growth to compensation growth in manufacturing sector and a 33% contribution in transportation and warehousing sector. After accounting for lagged productivity growth, the results indicate a 45.9% contribution of productivity growth in compensation growth in manufacturing sector and a 32.1% contribution in transportation and warehousing sector.

c. Linkage-Delinkage for Productivity and Capital

To estimate the relation between productivity and capital, I employ a simple linear regression model as developed in Equation 10. The dependent variable, change in $Capital$, in Equation 10 reflects the change in capital intensity, where capital intensity is the ratio of amount of capital input relative to amount of labor hours. An increase in capital intensity is called capital deepening, so the growth in capital intensity will be referred to as capital deepening. In Table 10, columns (1) and (2) I report the estimates from OLS for manufacturing sector to show the relation between productivity growth in time t and capital deepening in time t for manufacturing sector. In columns (3) and (4) I report the estimates from OLS for transportation and warehousing sector to show the relation between productivity growth in time t and capital deepening in time t for transportation and warehousing sector. Columns (1) and (3) demonstrate the relation between productivity and capital intensity in time t and columns (2) and (4) demonstrate the relation between productivity and capital intensity in time t after accounting for the lagged productivity growth.

For the years 1989 to 2019, β associated with capital intensity is in the range of 0.26 and 0.43 establishing a linkage between productivity and capital. This linkage is slightly weaker than

Table 10: OLS Models estimating relation between productivity and capital for Manufacturing Sector and Transportation and Warehousing Sector for the years 1989 to 2019. The standard errors reported are the Newey-West heteroskedasticity and autocorrelation robust standard errors

	Manufacturing Sector		Transportation and Warehousing Sector	
	(1)	(2)	(3)	(4)
(Intercept)	1.257 ***	1.289 ***	1.841 *	2.467 **
	(0.161)	(0.196)	(0.836)	(0.879)
LProductivity	0.262 ***	0.280 ***	0.404 *	0.424 *
	(0.033)	(0.033)	(0.175)	(0.169)
LProductivity_lag1		-0.033 *		-0.206
		(0.015)		(0.136)
N	4216	4216	62	62
R2	0.115	0.116	0.142	0.180
AIC	27357.729	27353.572	377.011	376.236

*** p < 0.001; ** p < 0.01; * p < 0.05.

the linkage between productivity and compensation but reflects the relation between productivity and capital intensity. The results demonstrate linkage between productivity and capital relative to labor. Since the β estimate associated with productivity growth is less than 1, it demonstrates a limited translation of productivity gains towards capital. A one-to-one correlation between productivity and capital intensity (β=1) would have indicated a complete translation of productivity gains towards capital. Instead, a limited transmission indicates that productivity gains are diverted towards both compensation and capital intensity. Thus, the productivity gains are not only enjoyed by workers but are also diverted towards capital investments. Furthermore, looking at the contribution of productivity growth into capital deepening, the results indicate a 26.2% contribution in manufacturing sector and a 40.4% contribution in transportation and warehousing sector. After accounting for the lagged productivity growth, the results indicate a 28% contribution in manufacturing sector and a 42.4% contribution in transportation and warehousing sector.

Conclusion

Since 1970s productivity compensation gap, on average in the US, has been on the rise. Literature has pointed out that the gap can be attributed to technological change from the perspective of technology-focused theory, however there is little to no evidence found to support theory. With the fast-growing technology, it has become important to understand the transmission of economic growth to compensation as well as capital. Labor productivity is a key economic indicator of economic growth and is closely linked to economic growth, competitiveness, and living standards within an economy (International Labor Organization, 2024). The indicator is essential to assess the efficiency of human capital in the production process, but the production process also includes physical assets. It is essential for economies to devote their resources optimally towards labor and capital.

In this paper I use BLS data from their Office of Productivity and Technology (OPT), who compute labor productivity as sectoral outputs instead of GDP per unit of labor hour. By using sectoral outputs, which helps in analyzing sectors individually and accounts for information lost in aggregate measures such as GDP. I build upon the work of Stansbury and Summers (2017) to examine the linkage between productivity and capital intensity. This provides insights into the linkage as well as contribution of productivity to capital deepening. While examining the linkage between productivity and capital intensity, I also confirm the existence of linkage between productivity and compensation. The β estimates from my OLS models for productivity and compensation are consistent with Stansbury and Summers (2017). Analyzing the linkage between productivity and capital intensity, I find that though the linkage is weaker than productivity and compensation in manufacturing sector, while stronger in transportation and warehousing sector. The linkage between productivity and capital intensity exists and indicates that the transmission is not one-to-one and might be blocked by factors other than capital. This shows that productivity gains are being diverted from compensation to capital intensity. Moreover, the results provide insights into how productivity growth is contributing to capital deepening in manufacturing sector and transportation and warehousing sector. While there's a 26% contribution shown in manufacturing sector, the transportation and warehousing sector shows a 40% contribution of productivity gains into capital deepening.

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