

The Effect of Remote Work on Productivity: Trends from the United States

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0. Abstract:

This paper examines the impact of telework on productivity in the post-pandemic United States labor force. With employers vying to return a majority of the workforce to on-site workplaces and the discourse created among employees over this decision, questions often arise about whether remote work can maintain, diminish, or enhance productivity. I utilize a dataset explicitly constructed for this paper that contains industry-level data on value added per employee and various telework metrics on employees from January through December of 2023. I employ OLS and fixed-effect regressions with this dataset to estimate the relationship between telework and value added per employee. The findings suggest that higher telework rates in telework-compatible industries are associated with increased value-added per employee, though diminishing returns become present as the share of telework in the labor force grows. These results imply that, rather than fully reverting to traditional workplaces, industries should be more receptive to selective, careful telework practices to improve productivity and reduce redundancies in the labor force.

1. Introduction:

Before the COVID-19 pandemic, telework and remote work were foreign to many employers across industries in the United States, as many jobs, no matter the task, were expected to be conducted on-site and in-person. However, during and after the pandemic, almost every industry in the United States has been forced to adopt some type of telework, from part-time hybrid jobs to full-time remote work positions. This shift was perceived differently: employees rejoiced in the ability to do their jobs from the comfort of their homes with flexible schedules and reduced commutes. At the same time, employers were concerned about performance, attendance, and monitoring. Some employees began to suffer from burnout, blurred work-life boundaries, and difficulty in coordination and task completion. In the post-pandemic era, employers across industries continue to push for returns to the workplace. As more and more teleworking opportunities are phased out, many employees are pushing back for the ability to work from home if they should choose to do so, but both sides fight over the benefits and woes from the pandemic-era. Thus, a key question arises: Was telework detrimental to productivity, or was it just poor circumstances and implementation that hampered productivity?

Therefore, this paper comprehensively analyzes the relationship between telework and productivity. Productivity is measured by Value Added Per Employee (VAPE), a measure of how much value an employee adds to an industry in the United States, and telework rates are an approximation of how many employees engaged in fully remote or hybrid work. This paper aims to utilize these two metrics, along with other employee and industry attributes like hours teleworked and telework compatibility, to provide an economically rigorous explanation of the relationship between value added per employee and telework rates and uncover whether there is

a detrimental, positive, or insignificant impact on productivity as a result of higher telework rates throughout industries across the United States from January through December of 2023.

The dataset in this analysis is a custom collection of monthly, industry-level metrics in the United States during 2023, collected from the U.S. Bureau of Labor Statistics (BLS), the Bureau of Economic Analysis (BEA), and the U.S. Census Bureau (USCB). The study's independent variable, telework rates, is derived from survey data from the USCB relating to working conditions and status and aggregated by the BLS and BEA. The dependent variable, value added per employee, is derived from value added per industry data published quarterly by the BLS, which has been averaged and adjusted to be monthly data according to seasonal and economic trends throughout 2023. Other metrics and classifications are established using dummy variables for a more comprehensive analysis. Utilizing the dataset, this paper employs OLS regressions with nonlinear adjustments to account for more nuanced relationships within the variables and, combined with fixed effects and panel data frameworks to further account for unforeseen trends in the data, this paper examines both the direct impact of telework rates and the nuanced industry characteristics that shape its effects on productivity and employee value added.

Utilizing these research methodologies, I conclude that, on average, higher telework rates, generalized across all industries, initially increase employee value added by \$1,004,676 but experience heavy diminishing returns as telework rates increase beyond industry-appropriate standards. Additionally, industries with employees participating in full-time, high telework hour average jobs experience a \$24,857 decrease in employee value added compared to industries with low average telework hours, furthering the diminishing returns at high telework rates and

roles. Industry types also play a significant role in the effects of telework rate, with industries more suited for telework utilization experiencing a \$44,413.46 increase in returns to telework compared to industries focused on physical labor.

These results contribute to the rapidly evolving field of telework analysis by focusing on quantitative, macroeconomic productivity analysis. Previous work on the subject utilizes more qualitative methods to estimate productivity, such as Galanti et al. (2021), who conducted studies on employee engagement and stress, and Aslan et al. (2022), who evaluated task completion times and telework satisfaction in call centers. Abdulrahim et al. (2023) and Monteiro et al. (2019) focused on international effects, finding mixed results across sectors like finance and banking. Toscano et al. (2021) explored post-pandemic productivity using similar regression analysis methods but emphasized qualitative factors such as home comfort and family dynamics. This paper examines the direct relationship between telework and productivity across all major industries in the U.S., measured by value added per employee, to contribute a more quantitative perspective to guide future policy and labor market decisions.

2. Data:

I constructed this dataset for this paper utilizing resources like the U.S. Bureau of Labor Statistics (BLS), the Bureau of Economic Analysis (BEA), and the U.S. Census Bureau (USCB). The timeframe for the dataset is from January through December 2023, with industries observed monthly. Each industry-month combination serves as an individual observation, resulting in a sample of 299 observations, each with robust characteristics. Due to differences in data-keeping and industry definitions across agencies, certain assumptions and aggregations were used to keep the data uniform and consistent. Agriculture telework figures are scaled down based on 2023 employment counts. Financial activity employment is split 70/30 between finance & insurance and real estate & housing. Professional Services and Administrative sectors are split 55/45. Health and education are divided into 4 categories: Health services, social assistance, education, and hospitals (40/10/20/30 split). Leisure and hospitality are split between food services and entertainment, with a 75/25 split. Finally, state and local governments have been combined into a single category. The primary dependent variable, Value Added Per Employee (VAPE), is derived from quarterly value added per industry divided by employment figures from the BEA and BLS and adjusted to a monthly frequency by accounting for economic conditions and externalities present in 2023. The independent variable, Telework Rate (TR), is sourced from the BLS and USCB, which records if and how long employees engaged in any form of telework. From this, Average Telework Hours (AvgTWH) are included in the data, capturing the average amount of telework performed by industry employees. A binary variable is constructed from this, `high_TWH`, which equals 1 when an industry has above-average telework hours per employee.

Industries are also classified by their general ability to accommodate telework with an indicator, `industry_type`, equalling 1 if an industry can easily accommodate telework.

Variable	Obs	Mean	Std. Dev	Min	Max
gen_industry_num (numbered names)	299	7.086957	3.493877	1	13
ValueAdded PerEmployee (\$)	299	118418.9	170096.2	18950.01	1025342
TeleworkRate (0-100)	299	.2383669	.1825926	.0213809	.714982
AvgTWH (hours)	299	27.20566	3.201778	17.73881	33.59817
industry_type (0 if TW incompatible, 1 if TW compatible)	299	.4347826	.4965595	0	1
high_TWH (0 if low TWH per emp, 1 if high TWH per emp)	299	.4949833	.500813	0	1

Summary Statistics for key dataset variables.

3. Empirical Specification:

This paper's primary model is a fixed-effects regression model accounting for unobserved differences at the industry level to minimize omitted variable bias and control for the large number of industries present in the dataset.

$$VAPE = \beta_0 + \beta_1 TeleworkRate + \beta_2 TeleworkSq + \beta_3 high_TWH + \beta_4 industry_type + \gamma + \epsilon$$

The dependent variable, Value Added Per Employee (**VAPE**), measures worker productivity at the industry level. The independent variable, **TeleworkRate**, represents the percentage of workers teleworking in an industry and captures the initial effects of telework on VAPE. To account for any nonlinear effects in this relationship, a squared term (**TeleworkSq**) is included to capture any diminishing or increasing returns in TeleworkRate. Additionally, two binary indicators are included. **highTWH** identifies industries where average telework hours are above the mean, while **industry_type** separates industries that are more compatible with telework as opposed to those reliant on physical labor and less easily adaptable to a remote setting.

4.1 Results–Single Regressor OLS:

The first iteration of the model is a simple OLS linear regression between VAPE and TR.

$$VAPE = \beta_0 + \beta_1 TeleworkRate$$

In the baseline model, a 1 percentage point increase in Telework Rate results in a \$56629.67 increase in Value Added Per Employee. This result is insignificant at a significance level of $\alpha = 0.05$. With no telework rate, the average intercept for value added per employee is \$104920.3. (See Figure 1, Regression 1).

4.2 Results–Multiple Regressor OLS:

In the first iteration of the multiple regressor model, we add a squared term on TeleworkRate to capture any significant nonlinear relationship in telework rate, like diminishing returns or increasing returns as we increase telework rate.

$$VAPE = \beta_0 + \beta_1 TeleworkRate + \beta_2 TeleworkSq$$

In the next iteration, we add binary indicator variables to see if the relationship between VAPE and telework rate extends beyond nonlinearity and into industry types, and to act as a control for other effects of the relationship between telework rate and VAPE.

$$VAPE = \beta_0 + \beta_1 TeleworkRate + \beta_2 TeleworkSq + \beta_3 high_TWH + \beta_4 industry_type$$

In the final iteration of the model, we include previous variables but log transform the primary continuous variables to try to normalize the data and see if relationships change via this normalization to reveal more nuances in the data.

$$\ln VAPE = \beta_0 + \beta_1 \ln TR + \beta_2 \ln TRsq + \beta_3 high_TWH + \beta_4 industry_type$$

4.3 Results–Interpretation of Multiple Regressor OLS:

For the first iteration of the multiple regressor model, a 1 percentage point increase in telework rate results in a \$547949.8 decrease in value added per employee, with increasing returns as telework rate increases due to the positive coefficient on TeleworkSq. The coefficient of TeleworkSq is significant at the 5% level, whilst the coefficient on TeleworkRate remains insignificant. The constant signifies that an industry with no telework rate ($TR = TRsq = 0$) has an average employee value added of \$164510.6. (See Figure 1, Regression 2).

For the second iteration of the multiple regressor model, a 1 percentage point increase in Telework Rate results in a \$564253.4 decrease in value added per employee, with again, increasing returns as it increases due to the positive coefficient on TeleworkSq. However, industries with high telework hours per employee ($high_TWH = 1$) are associated with a \$255.625 loss in Value Added Per Employee compared to industries with low telework hours per employee ($high_TWH = 0$). An industry type more oriented toward remote work ($industry_type = 1$) is associated with a \$6036.166 increase in value added per employee, compared to an industry more oriented toward manual labor ($industry_type = 0$). The constant represents a physically oriented industry ($industry_type = 0$) with no telework rate ($TR = TRsq = high_TWH = 0$) having a baseline value added per employee of \$165172.9. However, only TeleworkSq and $high_TWH$ remain significant. (See Figure 1, Regression 3).

For the final iteration of the model, a 1% increase in Telework Rate results in a 1.32% increase in Value Added Per Employee. This effect has increasing returns as well, continuing on from previous regressions. Now however, industries more oriented toward remote work ($industry_type = 1$) experience a 11.3% decrease in Value Added Per Employee compared to

industries more oriented toward physical labor ($industry_type = 0$). $high_TWH$ has also flipped to match the increasing returns, as an industry with high employee Telework Hours ($high_TWH = 1$) is associated on average with 21.48% more value added per employee compared to industries with low employee telework hours ($high_TWH = 0$). Here, everything except for $industry_type$ is significant. (See Figure 1, Regression 4.)

4.4 Results–Single Restriction Hypothesis Test:

Test if the independent variable in the baseline model ($VAPE = \beta_0 + \beta_1 TeleworkRate$) is significant. T-statistic from regression table (See Figure 2) is 1.04. $1.04 < 1.96$, c.v with significance level of 0.05. Fail to reject the null hypothesis ($H_0: \beta_1 = 0$), so the coefficient is insignificant. Represents a need to expand upon the initial model.

4.5 Results–Multiple Restriction Hypothesis Test:

Test if all regressors from the final iteration of the multiple regression model ($\ln VAPE = \beta_0 + \beta_1 \ln TR + \beta_2 \ln TRsq + \beta_3 high_TWH + \beta_4 industry_type$) are jointly significant. The joint F-statistic for this test is 19.21 (STATA: test $\ln TR = \ln TRsq = high_TWH = industry_type = 0$), so we reject the null hypothesis ($H_0: \ln TR = \ln TRsq = high_TWH = industry_type = 0$), the regressors are jointly significant. Represents the validity of the fixed effects approach in the regression.

4.6 Results–Omitted Variable Consideration:

There are potentially many omitted variables that could be positively biasing the effects of telework. Worker skill level, experience at the company, tech understanding, management practices, and economic conditions could all bring down the true impact of telework rates on productivity, since including them would result in telework rate not absorbing all of those effects,

signifying a positive bias in the regressor. This can be easily remedied by new, expansive data and a more robust dataset more focused on worker surveying that could include things like experience, tech knowledge, and adjusting for management practices and economic conditions. By including these in this regression model, we could see the effects of telework even become negative or change drastically, or just become insignificant.

4.7 Results—Final Model, Fixed Effects Regression:

In the final model that this paper is based on, we use a fixed effects regression model to account for time-invariant omitted variables that could be biasing the coefficients. Industries differ in countless ways that are difficult to measure fully, and these have many time-invariant effects, such as specific industries just having higher production and value-added than other industries or lower employee counts in particular industries and higher employee counts in others. By controlling for these differences by absorbing `gen_industry_num` into the data, we can eliminate a lot of omitted variable bias that could have been present in the original regressions.

$$VAPE = \beta_0 + \beta_1 TeleworkRate + \beta_2 TeleworkSq + \beta_3 high_TWH + \beta_4 industry_type + \gamma + \epsilon$$

4.8 Results—Interpretation of Fixed Effect Regression:

Holding time-invariant industry characteristics constant, a one percentage point increase in `TeleworkRate` within an industry is associated on average with a \$1,004,676 increase in VAPE. There are diminishing returns, as there is a negative coefficient on the variable `TeleworkSq`. If an industry moves from low TWH (`high_TWH` = 0) to having high TWH (`high_TWH` = 1), the VAPE would be \$24,857. Telework-compatible industries (`industry_type` = 1) are associated with a \$44,413.46 higher VAPE than if they were physically oriented

(industry_type = 0). All of these effects are statistically significant at the 5% level. This differs significantly from previous models, with TeleworkRate now being positive instead of negative, and TeleworkSq being negative instead of positive, indicating that a substantial amount of bias was eliminated with the fixed effect regression model. *(See Figure 2.)*

5. Conclusion:

This paper sought to reveal the true effects of telework rates on value added per employee in U.S. industries in 2023. By utilizing a custom-tailored dataset and evolving an OLS model into a fixed effects model, I conclude that increases in telework rate, holding time-invariant industry differences constant, result in high initial increases in VAPE but result in diminishing returns as more and more physically demanding jobs are forced into a telework framework. (*See Figure 3*). Extreme amounts of telework hours are associated with lower value added per employee, and industries more suited for telework result in higher VAPE. Logically, this makes sense and explains why some workers felt decreases in productivity over the COVID-19 pandemic, since all sectors being forced to endure telework at high levels resulted in loss of productivity, as the final fixed effect model suggests. This paper adds to an ever-growing field of research that should aid policy decisions at firms on whether or not to embrace telework.

6. Appendix:

Figure 1: Simple OLS Regression Results

	(1)	(2)	(3)	(4)
	VAPE	VAPE	VAPE	lnVAPE
TeleworkRate	56629.7	-547949.8	-564253.4	
	(1.04)	(-1.70)	(-1.83)	
TeleworkSq		938632.9*	946695.9*	
		(2.16)	(2.22)	
high_TWH			-255.6	0.215
			(-0.01)	(1.92)
industry_type			6036.2	-0.113
			(0.40)	(-1.17)
lnTR				1.324***
				(5.35)
lnTRsq				0.291***
				(3.82)
cons	104920.3***	164510.6***	165172.9***	12.28***
	(5.20)	(3.73)	(3.70)	(50.28)
N	299	299	299	299

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

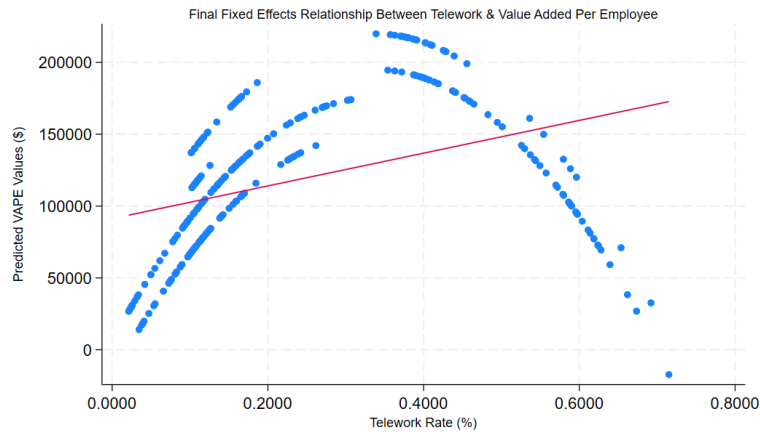
Figure 2: Final Fixed Effect Regression Results

	(1)
	ValueAddedPerEmployeePerInd
TeleworkRate	1004675.6***
	(8.80)
TeleworkSq	-1488901.8***
	(-9.14)
high_TWH	-24857.9**
	(-2.80)
industry_type	44413.5*
	(2.43)
cons	6003.1
	(0.40)
N	299

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3: Scatterplot



A scatterplot containing predicted values of Value Added Per Employee (VAPE) from a regression on Telework Rate, Telework Rate Squared, whether or not the industry is compatible with telework, and if the industry has high employee telework hours. The U-shape signifies a key implication from the regression: telework initially starts out with increases in VAPE but begins to taper off and experience diminishing returns after awhile.

7. References:

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- Link To Dataset: <https://tinyurl.com/ECN140Dataset>