Office of Inspector General | United States Postal Service

RISC Report

Geographic Variation in Productivity

Report Number RISC-WP-19-006 | August 19, 2019

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Executive Summary

To fulfill its mission of providing prompt, reliable, and affordable mail service to the American public, the Postal Service requires effective and productive operations. As such, it is important to examine the productivity of the Postal Service and the factors that influence it.

As a follow-up to previous work examining mail volume trends by geographic region, the U.S. Postal Service Office of Inspector General (OIG) analyzed total factor productivity (TFP) data.[1] The OIG found that productivity varies widely throughout the country. This leads to an important question: what factors explain this variation in productivity?

This research tested several possible factors and identified three main drivers: weather, cost of living, and terrain ruggedness. The OIG selected these factors for further analysis because they are not included in the calculation of TFP, yet clearly explain some of the geographic variation in postal productivity. While these factors are not under the direct control of local management, understanding their impact can yield important insights.

There is also a large unexplained portion of the variation in productivity across the country. This indicates that other potentially controllable factors, such as quality of management, facility design, or employee dynamics, may also be at work, leading to higher or lower than average productivity in specific areas. The Postal Service can address these factors by pinpointing and studying areas likely to yield substantial productivity improvements. Such analysis could also detect areas where productivity is higher than expected. The Postal Service could then identify and share best practices in opportunity areas.

Our analysis reached the following conclusions:

- Productivity varies significantly from geographic area to area. The principal measured determinants of productivity are weather, cost of living, and terrain ruggedness.
- The most important external determinant of productivity is weather. Places with more extreme weather conditions, other things being equal, exhibit lower productivity. While postal management does not have control over weather conditions, it can help reduce their impact. [2] In other words, the Postal Service can anticipate potential effects of weather in its decisions about how to invest in its facilities and vehicles. For example, efforts to equip postal vehicles with special tires and climate control appropriate for local weather conditions could improve productivity and safety in areas with severe weather.
- Given the Postal Service's nationally uniform pay scale, regional differences in cost of living affect real wages, and higher real wages are associated with higher productivity. While postal management must negotiate with its labor unions to collectively determine its pay schedules, the negative effects of unequal real wages on productivity is clear.[3]

Highlights

The productivity of the Postal Service, as measured by total factor productivity, varies significantly around the country.

This paper quantifies the effects of weather, cost of living, and terrain ruggedness on regional productivity variations.

Holding weather, cost of living, and terrain ruggedness constant reveals that other factors also cause productivity to vary around the country. Identifying these factors could give the Postal Service opportunities to pinpoint and address them.

1 U.S. Postal Service Office of Inspector General (OIG), *Declines in U.S. Postal Service Mail Volume Vary Widely across the United States*, Report No. RARC-WP-15-010, April 27, 2015, https://www.uspsoig.gov/sites/default/files/document-library-files/2017/RARC-WP-15-010_0.pdf and *What's up with Mail? How Mail Use Is Changing across the United States*, Report No. RARC-WP-17-006, April 17, 2017, https://www.uspsoig.gov/sites/default/files/document-library-files/2017/RARC-WP-17-006_0.pdf.

2 The Postal Service has a National Preparedness program which ensures that plans, procedures and protocols are in place to respond to emergencies that could disrupt postal operations and provides tools and resources to enable senior and line management to respond and resume operations quickly, safely and efficiently. This includes preparation guides for extreme weather events such as hurricanes and tornadoes, as well as earthquakes and wildfires. More information on guidance documents for major weather events can be found at https://blue.usps.gov/nationalpreparedness/welcome.htm.

- We find some evidence that places with the greatest difference between the highest and lowest points of elevation (ruggedness) are associated with lower productivity levels. Postal management does not have control over terrain ruggedness. However, it can consider the effects of rugged terrain on delivery routes and postal vehicles through measures like fitting vehicles with proper equipment. This way, vehicles could navigate tough terrain throughout the year.

Perhaps the most important result of this research is that when comparing the productivity of different geographical areas, the opportunity for improvement will not be uniform. One location may have low productivity that is largely driven by factors beyond the Postal Service's control. The opposite is also true — other locations may benefit from good weather or flat terrain. Therefore, once the influences of these three external factors are removed, the Postal Service can study the unexplained portion of productivity. This report identifies areas where productivity is much higher or lower than would be expected given their weather, cost of living, and ruggedness. These unknown drivers warrant further study to determine what they are and how management can address them or share best practices to enhance productivity

Observations

Introduction

To ensure that it is operating as efficiently as possible, the Postal Service tracks its productivity annually. The principal productivity measure used for this purpose by the Postal Service is called total factor productivity (TFP). It is a comprehensive measure comparing work completed (e.g., delivered volumes) with the labor, capital, and materials used to complete it.[4]

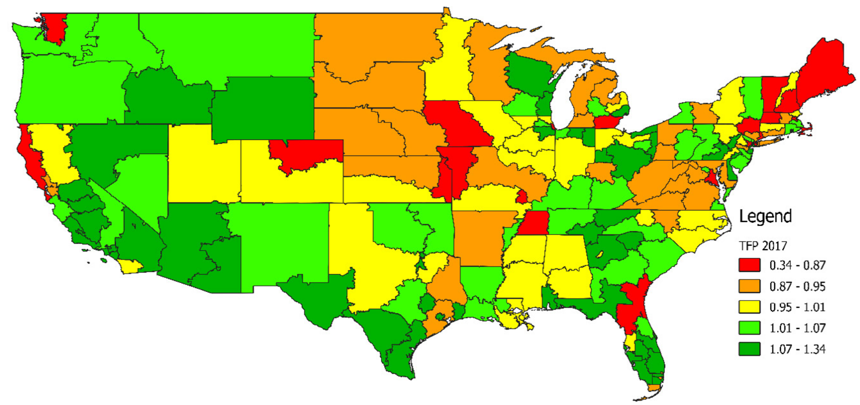
In its 2017 Annual Report to Congress, the Postal Service points out that by tracking TFP over a period of years, it can accurately assess the several initiatives it has taken to improve productivity.[5] However, many other factors affect productivity beyond the Postal Service's own improvement initiatives, and it is valuable to consider those as well.

While some of these factors are typically examined over time at the national level, the influence of other factors is clearer when comparing productivity across specific geographic regions. In fact, productivity varies substantially by geographic region.[6] Figure 1 below shows TFP for FY 2017. A TFP greater than one means that, in that location, the Postal Service provides an above-average amount of services relative to the labor, materials, and capital it uses to do so. Where TFP is less than one, the opposite is true.

Figure 1: TFP in the United States (FY 2017)

TOTAL FACTOR PRODUCTIVITY VARIES SIGNIFICANTLY ACROSS THE UNITED STATES

This map shows regional differences in the total factor productivity of the Postal Service. The areas in green have higher levels of productivity, while the areas in red have lower levels of productivity.



Source: Christensen Associates

However, simple productivity differences among regions do not tell the entire story. Variations in productivity may reflect management initiatives or standardization, but also depend upon factors that are external to local management. For example, regions such as southern California or parts of Texas enjoy above average productivity, but to what extent does productivity reflect good weather? Similarly, would productivity in North Dakota look different, were it not for the effect of cold weather?

4 TFP measures how much output (mail volume) the Postal Service produces with the inputs it uses (labor, materials, and capital). For a discussion on TFP, see U.S. Postal Service Office of Inspector General (OIG), *Peeling the Onion: The Real Cost of Mail*, Report No. RARC-WP-16-009, April 18, 2016, https://www.uspsoig.gov/sites/default/files/document-library-files/2016/RARC-WP-16-009.pdf, pp. 4-5.

5 Some of these programs include implementation of Lean Six Sigma management concepts through the Lean Mail Processing initiative. Lean Mail Processing is an effort to reduce cycle times and improve efficiency by implementing a series of 11 standardized practices. U.S. Postal Service, "FY 2018 Lean Mail Processing Review," September 17, 2018 and U.S. Postal Service, "Lean Mail Processing achievements," January 9, 2015, https://link.usps.com/2015/01/09/lean-mail-processing-achievements/ and PostalReporter.com, ÚSPS Implements New Program to Transform Way Mail is Processed at Plants," November 21, 2013, http://www.postal-reporter.com/blog/usps-implements-new-program-to-transform-way-mail-is-processed-at-plants/.

6 The productivity measure we primarily use in our analysis is the Origin and Destination Information System Area (ODIS) Total Factor Productivity Index or "ODIS Area TFP," which measures TFP for 180 regions that are collections of three-digit zip codes. In FY 2017, TFP measured at the ODIS level ranged from a low of 0.34 to a high of 1.34. A detailed account of the analysis that arrives at these results is included in Christensen Associates' full report to the OIG, included as Appendix A.

To answer such questions and conduct meaningful comparison across areas, we examined the impact on productivity of factors that also vary substantially by geographic region. The OIG worked with Christensen Associates, a postal economic consulting firm, to conduct a statistical analysis of the relationship between three of these factors and TFP.

Of the factors that can influence productivity, the three we quantify here are weather, cost of living, and terrain ruggedness. The OIG selected these three factors because they are not included in the calculation of TFP, yet they clearly demonstrate a measurable effect on TFP. We find that:

- Extremes in weather, such as high levels of precipitation and significantly high or low temperatures, reduce productivity. We find that weather is responsible for approximately 59 percent of the variation in productivity that we can explain and about 14 percent of the total variation in productivity.[7]
- Differences in the cost of living throughout the country create differences in the real wages of postal employees, and, all else equal, places with lower real wages have lower productivity than places where these wages are higher. We find that cost of living is responsible for approximately 23 percent of the variation in productivity that we can explain and about 5 percent of the total variation in productivity.
- We find some evidence that places with more rugged terrain exhibit lower productivity, although this effect is smaller. We find that terrain ruggedness is responsible for approximately 18 percent of the variation in productivity that we can explain and about 4 percent of the total variation in productivity.

Factors like weather and cost of living vary substantially across the country, and so do their effects on the Postal Service's productivity. Weather, for example, is seen to have different impacts on productivity in different areas. Measuring the effects of weather and other factors on productivity can enable the Postal Service to take steps to address productivity in places where it is low and learn from best practices where productivity is high.

Notably, these three factors can explain approximately 23 percent of the total observed variation in TFP. The remaining 77 percent of TFP variation represents a significant opportunity for the Postal Service to improve its productivity. The factors that contribute to this remaining productivity variation may be more difficult to quantify than weather, cost of living, and terrain ruggedness. However, after removing their effects, it becomes easy to identify locations where unidentified factors cause productivity to be much higher or lower than average. Such locations are suitable for additional study, and would likely reveal existing best practices, as well as opportunities for improvement.

Factors Influencing Productivity

The OIG's research explored what influences productivity and its variation across geographic regions.[8] The results provide a clear view of the effects of weather, cost of living, and terrain ruggedness on this metric.

How Weather Affects Productivity

Of the factors we identified, weather exercised by far the largest influence on productivity. Our analysis of weather accounted for average total rainfalls and snowfalls, average temperatures, and average differences between the minimum and maximum temperatures of the places we studied. Places associated with extreme temperatures and heavy rain had lower TFP than places with milder temperatures and less rain.[9]

This is likely because extremes in temperature and weather conditions make the transportation and delivery of mail more challenging than it is in areas with milder temperatures and weather conditions. And of course, there is a tension or trade-off between productivity and safety, which makes the delivery of mail more nuanced. Simply put, interruption of mail delivery in the event of unsafe weather or natural disaster conditions will decrease productivity in the short term but is needed to ensure employee safety. For example, this past winter, the Postal Service suspended mail delivery in parts of ten states in response to dangerous and record-breaking low temperatures. Temperatures reached dangerous lows in specific parts of North Dakota, Nebraska, Illinois, and Ohio.[10]

7 For purposes of rounding to 100 percent and 23 percent respectively, we adjusted these results to the nearest digit.
8 In our analysis, we are not addressing factors such as volume and the size of delivery areas because these are already accounted for in the calculation of TFP. The factors we are addressing — weather, cost of living, and terrain ruggedness — are not used in the calculation of TFP.
9 For modeling purposes, these variables are based on multi-year averages specifically to capture the effect of climate. The realizations of weather in 2016 and 2017 specifically are not included as separate controls. This approach was chosen since we are primarily interested in the persistent effects of weather on productivity, as opposed to transitory effects found in a single year.
10 *NPR, USPS Suspends Mail Delivery In Parts Of 10 States Because Of Dangerous Polar Vortex*, January 30, 2019, https://www.npr.org/2019/01/30/689890149/usps-suspends-mail-delivery-in-parts-of-10-states-due-to-dangerous-polar-vortex.

High temperatures have also proven disruptive and even deadly: a mail carrier in Woodland Hills, California was found dead of hyperthermia, or over-heating, in her delivery vehicle in July 2017.[11] Additionally, the Department of Labor's Occupational Safety and Health Administration (OSHA) proposed fining the Postal Service $129,336 in response to letter carriers in Jacksonville, Florida being "exposed to the hazards of high ambient temperatures while delivering mail."[12] It is therefore unsurprising that relative TFP is negatively affected by extreme climate, as our findings show.

To examine USPS actions in response to extreme weather, the OIG studied the Postal Service's Response to extreme weather events in the Southern Area. In 2016, the Southern Area was impacted by extreme weather events that inundated large areas with severe flooding, wind damage, and storm surges. The OIG found that area and district personnel in the Southern area implemented emergency management preparedness plans for operations, monitored the weather daily (sometimes more frequently), provided guidance to the stations prior to the event, monitored operations before, during, and after these extreme events, and helped restore operations.[13]

Cost of Living Has an Impact on Productivity

Cost of living also has a significant effect on postal productivity. In areas with high cost of living, TFP is relatively low compared with low cost-of-living areas, and vice-versa. Specifically, we found that, with weather and other factors held constant, a region with a 10 percent higher cost of living will have up to 3.6 percent lower productivity.[14]

Unlike other national employers, including the federal government and many private sector companies, the Postal Service does not adjust its employees' wages based on local markets and cost of living.[15] This means that real wages, wages adjusted for their buying power based on cost of living, are significantly different depending on where the employees live. As shown by cost-of-living data, differences in real wages are correlated with differences in productivity: higher real wages are associated with higher productivity.[16]

Terrain Ruggedness and Productivity

The U.S. has many different types of physical geography, from coastal and central plains to rugged mountains and deep valleys. As with weather, these characteristics influence the ease or difficulty with which the Postal Service completes its workload.[17] Terrain ruggedness reduces TFP, while places with more flat terrain are associated with higher TFP.[18] Obviously, Postal Service management does not have control over terrain ruggedness. But, it can consider the effects of rugged terrain on delivery routes and postal vehicles through measures like fitting vehicles with proper equipment. However, we note that the effects of ruggedness on productivity are weaker than the effects of weather and cost of living.

Additional Factors: Knowing What We Don't Know

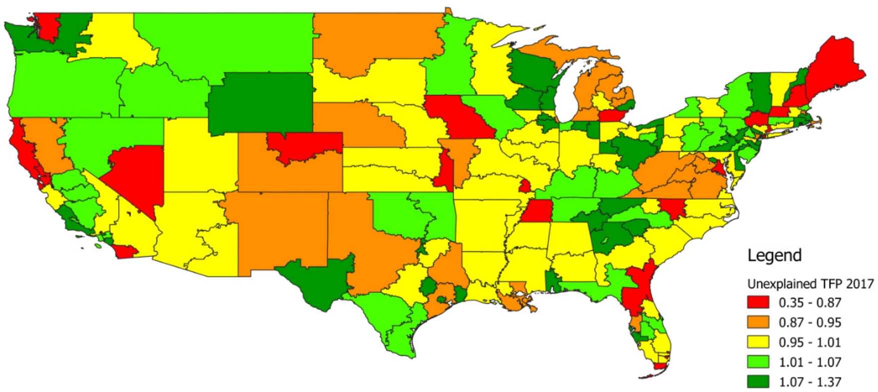
Our analysis shows that weather, cost of living, and terrain ruggedness each have an impact on an area's TFP. However, these three factors do not explain all the variation in regional productivity; unknown factors are at work. Figure 2 below shows differences in TFP across the country by Origin and Destination Information System (ODIS) areas, as Figure 1 does, but in Figure 2, the effects of weather, cost of living, and terrain ruggedness are removed. The remaining variation in productivity are caused by factors other than those captured in our analysis.

11 *CBS Los Angeles*, "USPS Hit With $150K Fine For Heat-Related Death Of Woodland Hills Mail Carrier," January 10, 2019, https://losangeles.cbslocal.com/2019/01/10/usps-hit-with-150k-fine-for-heat-related-death-of-woodland-hills-mail-carrier/.
12 *Miami Herald*, "U.S. Postal Service fighting $129,336 fine for making mail carriers delivery in heavy heat," March 6, 2019, https://www.miamiherald.com/news/state/florida/article227218519.html.
13 OIG, Response to Extreme Weather Events — Southern Area, Report No. DR-AR-17-003, April 3, 2017, https://www.uspsoig.gov/sites/default/files/document-library-files/2017/DR-AR-17-003.pdf.
14 To validate the robustness of their approach, Christensen Associates studied the impact of cost of living on productivity as measured by different indicators of cost of living and of productivity. Across the five models, the analysis revealed nearly uniform results, with the effect of a higher cost of living on productivity consistently negative. Considering just the models which use TFP as the dependent variable, a region with a 10 percent higher cost of living will have 1.3 to 3.6 percent lower productivity. The models used to arrive at these results are described in Appendix A.
15 OIG, *Locality Pay*, Report No. RARC-WP-14-008, February 7, 2014.
16 A detailed account of the cost-of-living data and its sources are included in Christensen Associates' full report to the OIG, included as Appendix A.
17 We accounted for small-scale terrain irregularity at the county level, measuring the change in elevation that would occur in a given area by moving in a given compass direction. A detailed account of this methodology is included in Christensen Associates' full report to the OIG, included as Appendix A.
18 While our main model indicates terrain ruggedness has a weak negative effect on productivity, subsequent regressions suggest otherwise. This may be due to the various aspects of productivity captured by each regression and may warrant further investigation using more sophisticated measures of terrain. For the technical results, see Appendix A.

Figure 2: Variations in Productivity from Unknown Factors (FY 2017)

MANY OTHER FACTORS INFLUENCE PRODUCTIVITY

Removing the effects of weather, cost of living, and terrain ruggedness clearly demonstrates that other factors have significant influences on productivity. These factors, and the locations where their influences are greatest, would be good candidates for further study by the Postal Service.



Source: Christensen Associates

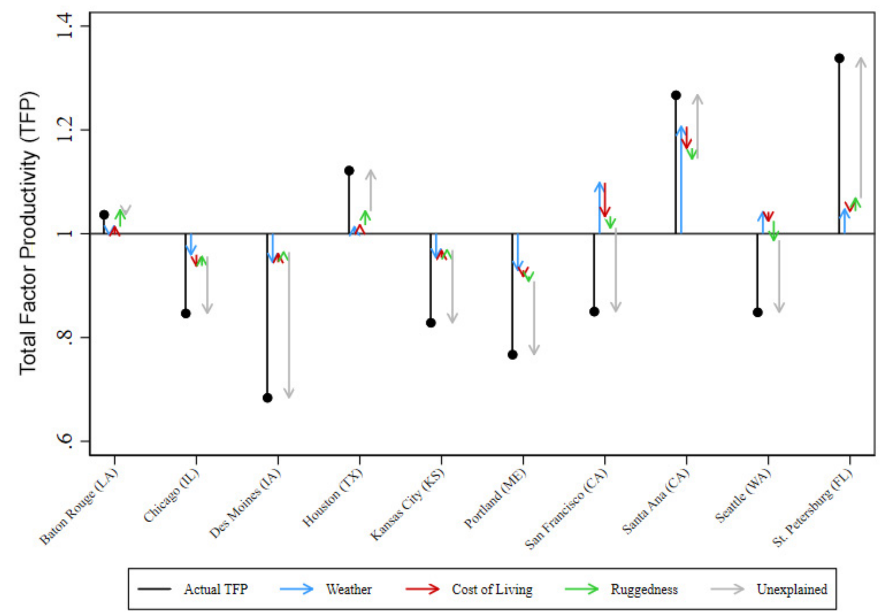
For example, we see that while southern California appears very productive in Figure 1, once the impact of weather, cost-of-living and ruggedness are removed, that region shows about the same productivity as the mid-Atlantic. We see similar results in south Florida and parts of Texas. In other areas, such as Michigan, productivity changes vary little as we remove the effects of weather, cost-of-living, and ruggedness. This means there are other explanatory factors at work in those areas that are not included in the model. Such areas are good candidates for further study, because, in those areas, the factors we can quantify do not fully explain productivity.

Figure 3 helps us see how weather, cost of living, and ruggedness explain productivity in specific locations.[19] It shows TFP in selected locations indexed to the national average, removing the relative impacts of the explanatory factors.

Figure 3: Influences on TFP in Selected Locations (Indexed to National Average = 1)

DIFFERENT FACTORS HAVE GREATER AND LESSER EFFECTS AROUND THE COUNTRY

This graph shows the magnitude of the effects that different factors have in selected locations, as well as whether they increase or decrease productivity in those locations. In places where the effects of unknown factors are greatest, such as Des Moines and St. Petersburg, the Postal Service could study potential improvement areas and identify examples of best practices, respectively.



Source: Christensen Associates

The national average TFP is represented by the 1 line in this graph. TFP in Santa Ana, California, for example, is about 0.3 index points above the national average, indicated by its corresponding black line ending in a dot. The blue arrow shows that much of its higher productivity is explained by weather, the red arrow

19 The examples selected in Figure 3 represent ODIS areas, rather than the exact city limits.

shows that cost of living reduces its productivity, and the green arrow shows the small negative effect of terrain ruggedness in that location. The grey arrow shows the impact of unknown factors on its productivity.

An important element of these findings is that the impacts of each of the factors — including the factors we cannot explain with the available data — are not uniform across the country. That means that any attempts to address or to better understand these factors should likely focus on the places where they have the greatest impacts. As discussed earlier, in some locations, such as Baton Rouge, the effects of unexplained factors (represented by the length of Baton Rouge's grey arrow) are small. We can account for the productivity of Baton Rouge through the three factors we identify. However, in other locations, like Des Moines, San Francisco, and St. Petersburg, unexplained factors exercise a large impact. Such places are good candidates for further study. Des Moines has lower productivity than we would expect to see, while St. Petersburg's productivity is higher than we would expect. The Postal Service may find areas of improvement and examples of best practices, respectively, by exploring operations in places like Des Moines and St. Petersburg.

In addition to the examples noted in Figure 3, we also looked at the top twenty areas that had the largest unexplained variation in TFP. For comparison purposes we included both those areas that are below the national average TFP, and those that are above the national average. Even after removing the impact of weather and the other variables in the model, for example, Springfield's TFP is still 58 percent lower than the national average. Correspondingly, the area around St. Petersburg has a TFP 27 percent higher than the national average. This information is displayed in Table 1.

Table 1: Areas with Greatest Unexplained Variation in TFP

	ODIS Areas that are Below the National Average TFP *Unexplained Variation from National Average*		ODIS Areas that are Above the National Average TFP *Unexplained Variation from National Average*
1	Springfield, MA (district CT) *-58.3%*	1	St. Petersburg, FL *27.0%*
2	Des Moines, IA *-28.0%*	2	Lakeland, WI *24.3%*
3	Southern Maryland, MD (district DC) *-25.6%*	3	Brooklyn, NY *24.2%*
4	Mid-Hudson, NY *-24.6%*	4	Fort Wayne, IN *20.3%*
5	Jacksonville, FL *-21.8%*	5	Lehigh Valley, PA *19.7%*
6	Queens, NY *-21.5%*	6	South Suburban, IL *19.1%*
7	Manchester, NH (district ME) *-21.0%*	7	El Paso, TX *17.4%*
8	South Florida, FL *-20.9%*	8	Staten Island, NY *16.7%*
9	Colorado-Wyoming, CO *-18.2%*	9	South Bend, IN *16.2%*
10	Detroit, MI *-18.2%*	10	Lancaster, PA *15.9%*

Notes: (1) These areas are listed in order of unexplained variation in TFP, from the greatest unexplained variation, to the least.

(2) ODIS areas are generally referred to using three-digit zip codes. They are often named after the largest city in their territory. However, occasionally they are named after regions as in the case of several in this table such as Mid-Hudson, Colorado-Wyoming and Lakeland. In one case, Staten Island, the name was changed for clarity purposes.

Source: Christensen Associates

Several different factors could be at work in places like St. Petersburg, ranging from the adoption of best practices by supervisors and employees, the physical configuration of mail processing facilities and equipment, the implementation of the Postal Service's Lean Mail Processing standards, and many others.[20] An examination of these factors is beyond the scope of this study. However, for locations where TFP variation is largely unexplained by the variables in the model, further field research could identify opportunities to improve productivity. For the factors that improve productivity, the Postal Service could attempt to implement them more broadly, where applicable. For the factors that reduce productivity, the Postal Service could attempt to restrict their influence.

Implications

The Postal Service tracks national TFP and other productivity data, highlighting key drivers. Our results suggest that the Postal Service has several opportunities to improve productivity around the country by examining local level data. Such work could identify specific locations where the Postal Service can enhance or diminish the effects of identified factors, even if they cannot control the factors themselves. For example, while terrain and weather are factors outside of the Postal Service's control, local productivity data could help the Postal Service to better target related capital improvement initiatives such as spending for climate control for postal vehicles.

Our regional analysis can help the Postal Service target specific factors in the places where their impacts are likely to yield better results. For example, steps taken to address the effects of severe weather on productivity are likely to yield results in locations where weather is the driving force behind TFP variation — rather than a less efficient, nationwide implementation.

Identifying and studying the locations where different factors — the ones described in our study and others we have not identified — have the greatest effects is a key step in addressing them. This scrutiny will highlight the locations where factors influencing productivity should be addressed as well as highlight locations where best practices, such as high-quality management and effective practices of employees, may be at work. Once identified, these best practices could be more widely adopted, especially in the places where they will improve productivity the most.

Conclusion

Using ODIS-level data, the OIG illustrated that the Postal Service's TFP varies significantly throughout the country. A number of factors appear to contribute to this variation, but the nature and degree of these factors themselves vary significantly. This analysis can help the Postal Service improve productivity in places where it is below average by identifying and addressing these factors. Likewise, by identifying and studying the factors that improve productivity in specific places, the Postal Service can apply them to others where appropriate. Through the continued tracking of regional productivity data and study of the factors that influence it, the Postal Service has a promising set of opportunities to improve its productivity. By giving the right attention to the right places, it can provide the highest level of service to the American public at the lowest possible cost.

20 See U.S. Postal Service, *FY 2018 Lean Mail Processing Review*.

Appendices

Click on the appendix title below to navigate to the section content.

Appendix A: Christensen Associates Technical Report

CHRISTENSEN ASSOCIATES

Summary of Methods for Computing National and Regional Total Factor Productivity

Prepared by
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For

The Office of Inspector General (OIG) of the
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1. Introduction

Productivity is an important metric for firms, particularly those in regulated industries. In firms such as the USPS that service large geographic areas with highly decentralized tasks, it is often of interest to examine the relative efficiency of different regions. For example, such comparisons may be used to pinpoint operational inefficiencies or particular offices with best practices. This paper examines some key determinants of productivity that are external specifically to USPS that may influence the comparison between regions. As with any firm, some regions may over- or underperform for idiosyncratic reasons such as manager quality, facility design, or employee interpersonal dynamics. But some portion of productivity differentials may vary systematically according to factors that are not traditionally incorporated into productivity measures. This paper quantifies the productivity differentials explained by three key external factors not traditionally incorporated into economic measures of productivity used by USPS: weather, cost of living differentials, and terrain ruggedness.

The key insight of this paper is that in comparing the productivity of different regions, the scope for improvement may not be identical in all locations. A location may have low productivity that is largely driven by factors beyond its control. Other locations may benefit from endowments of favorable fundamentals, such as mild climate.

These findings may be relevant for a variety of performance improvement tasks. For the comparison of productivity between regions it would be advisable to remove the influence of these systematic external factors. Individual USPS facilities have no ability to influence climate, cost of living, or terrain ruggedness; and for analysis looking deeper at the performance of individual locations, it would be best to focus on the “unexplained portion” of productivity in this analysis. While it may not be possible for USPS management to control these factors, understanding them may help the USPS more broadly find ways to reduce their impact. For example, knowing the importance of climate for productivity may help guide capital investments related to processing plant climate controls or when evaluating delivery schedules of carriers. Other policies such as locality pay may help offset the effects of cost of living differentials between locations. Vehicle investments may help mitigate any challenges of terrain ruggedness. These results may also help in targeting. Where limited funds exist for investments that reduce the exposure to climate, the results of this paper can pinpoint which locations suffer most. They would also help prioritize which locations suffer most acutely from cost of living differentials. We are able to decompose each of these effects location by location and show that the effect of components is far from uniform nationally.

The central productivity results rely on a sophisticated measure of productivity, grounded in economic theory, known as total factor productivity (TFP). These methods have been used for many years by the USPS to track annual productivity changes. Related methods have been employed by the Bureau of Labor Statistics to track the productivity of the US economy. In a simplified model of a firm we would ideally compare inputs to outputs between locations. High productivity offices will produce more outputs with fewer inputs. In practice, firms use a variety of inputs including numerous types of labor, materials, and capital. They also produce a variety of outputs. For firms like the USPS, these outputs include many different types of mail, but it also maintains a delivery point network—a type of fixed cost, which can be influenced by population density, that requires resources regardless of how much mail is actually collected and delivered. All of these considerations are well integrated into TFP. What this research has not done to date is correct for factors such as climate, cost of living, and terrain ruggedness. This paper fills this gap. We also consider less sophisticated measures of productivity such as delivery points per carrier hour, and our results are broadly consistent with our central specification using TFP.

Our analysis addresses the following questions:

- “What factors explain the relative differences in productivity across regions?”
- “How important is each of these factors in explaining productivity patterns?”
- “How does the productivity of regions compare when removing these systematic factors?”

In our main results we leverage a comprehensive TFP measure used within the Postal Service, which can be accurately measured at a detailed level across regions of the lower 48 states.[21] We include, as outputs, measures used in prior Postal Service TFP by region work (i.e., mail volume, delivery points, and population density), but our

21 Because of their distinctive geographic obstacles, we do not calculate TFP for Alaska, Hawaii, and overseas US territories. We view their cost structure as substantially distinct from that of the regions included in this analysis. Furthermore, we do not have weather measures to generate climate variables for these regions through the sources outlined below.

paper examines how much of the variation in that calculation can be explained by our novel controls for cost of living, climate variation, and terrain.

Each set of variables has a plausible channel of causation. Extreme climate may directly hinder the ability of the USPS to deliver the mail. The polar vortex in late January 2019 shut down postal delivery in a wide swath of states from Ohio to North Dakota.[22] High heat has also had negative effects on carriers.[23] The lack of periodic disruptions in mild climates may allow for tighter schedules as delivery is unlikely to be interrupted or slowed due to weather. While processing plants and offices may generally have climate controls, to the extent these fail to keep up with unusual events, extreme temperatures are known to affect the output of workers in a variety of professions (Graff Zivin and Neidell, 2014).

Cost of living is the economic concept that a certain standard of living requires a different level of spending in different locations. Because USPS offers a single wage across all regions for a given job, we would not expect to see the same skill set available in all service locations (Risher and Fay, 1991; Office of the Inspector General USPS, 2014). To the extent that the skills of postal employees translate to productivity, this dynamic will have implications for the relative productivity[24] of postal offices in different locations in proportion to the local cost of living. In locations with low cost of living, comparatively high Postal Service wages will attract more applicants (Krueger, 1988), allowing for the hiring of higher ability workers and, consequently, a set of employees with higher productivity. Conversely, USPS offices in areas with high cost of living will have difficulty attracting and retaining high-productivity workers because the same salary provides for less purchasing power (Borjas, 2002). Other employers, offering higher wages to people with that skill set, will attract the most productive employees.[25]

22 NPR, *USPS Suspends Mail Delivery In Parts Of 10 States Because Of Dangerous Polar Vortex*, January 30, 2019, https://www.npr.org/2019/01/30/689890149/usps-suspends-mail-delivery-in-parts-of-10-states-due-to-dangerous-polar-vortex.

23 *Miami Herald*, "U.S. Postal Service fighting $129,336 fine for making mail carriers delivery in heavy heat," March 6, 2019, https://www.miamiherald.com/news/state/florida/article227218519.html.

24 We take "productivity," as a general concept, to be a measure of economic efficiency that shows how effectively economic inputs are converted into goods and services. We use productivity more generally than the term TFP discussed below.

25 A related phenomenon has been extensively studied in the wage effects of natural resource extraction and discovery as part of the "Dutch Disease" literature. One particular focus, among several, in this literature has been the extent to which a sudden increase in demand for labor in a resource extracting market can adversely affect the development and productivity of related employment sectors competing for workers. Specifically, the manufacturing sector may suffer as the most productive employees move to the resource extraction market

Ruggedness may also influence productivity in that terrain may affect the collection and delivery of mail. Rugged terrain may make individual delivery points more difficult to access. To navigate such terrain, road networks may be more circuitous resulting in less efficient road networks.

Our main findings are:

- Relative TFP is negatively affected by extreme climate. Regions with a large annual difference between maximum and minimum temperature and high precipitation all experience reduced USPS output per unit of resource input.
- Relative TFP between regions is consistently and negatively related to the relative cost of living between regions, as measured by a comprehensive index of cost-of-living differentials between regions. In areas with high cost of living, productivity is relatively low compared with low cost-of-living areas. We find that the negative relationship between cost of living and TFP is not only statistically significant but also large in effect size and consequently important, particularly in locations with very high cost of living.
- We find similar results for various alternative measures of productivity based on mail per worker hour, although statistical imprecision and individual shortcomings of these measures suggest caution in their interpretation. Nevertheless, they are negatively related to cost-of-living differentials.
- We find a small and inconsistent effect of terrain ruggedness on output, whereby locations with uneven terrain may suffer a small output reduction in our primary model. Some alternative productivity measures show a small positive effect which may be due to the aspects of productivity captured by those measures or shortcomings in our ruggedness index. Where significant, the effect is small in magnitude but may be important in some locations.

2. Method of Investigation

To examine these questions, we use linear regression analysis. Regression analysis is a statistical, data-driven method of establishing relationships between

with potentially adverse effects for the broader economy. See Van der Ploeg (2011) for an overview of this literature.

different variables. In this case, we are interested in explaining the extent to which productivity of USPS regions can be explained by various factors.

The overall structure of the regression attempts to explain a productivity measure with a set of control variables. The productivity measure we primarily use is the Origin and Destination Information System Area Total Factor Productivity index or "ODIS Area TFP," which measures TFP for 180 regions that are collections of three-digit zip codes.[26] Conceptually, TFP converts the various products delivered and services provided by the Postal Service into a common unit of output, called workload, and compares this to the amount of input, called resource usage, which is an aggregate of all Postal Service inputs including labor, capital, and materials.[27] While this measure of productivity has numerous conceptual benefits, it is a theory-driven measure with many nuances. To address a possible concern with the potential unfamiliarity of TFP to certain interested parties, we also examine a series of simpler but less complete measures that take the form of pieces of mail or delivery points per hour of employee labor.[28]

3. Data

ODIS Area TFP

Our primary measure of productivity is ODIS Area TFP. TFP, which is also referred to as multifactor productivity by the Bureau of Labor Statistics (BLS), compares the amount of output in terms of goods and services produced by a business or sector to the inputs used in terms of labor, capital, and materials. Dr. Laurits Christensen published TFP studies on the U.S. economy, the railroad and telecom industries, as well as many other industries. As part of the Postal Service Strategic Planning Department, Christensen Associates was hired to develop postal TFP in 1983, a measure which was ultimately adopted in 1985. The ODIS Area TFP results build on

26 See Appendix A1 for more details.

27 The allocation of input costs of capital, labor, and materials and outputs including mail volume and delivery points at the 3-digit level will, of course, be imperfect. For an econometric study such as this, the key concern is how any data errors are specifically correlated with outcomes of interest. While specific concerns of data unreliability could be addressed with more sophisticated statistical corrections, these corrections are unnecessary given the robustness of our results across sophisticated measures of productivity like TFP and a variety simple transparent measures of productivity such as delivery points per carrier hour. We see little cause for concern that specific measurement error at the ODIS level of a particular input or output is driving our result.

28 We note that the modeling choices made in the development of the Postal TFP measure are part of ongoing work with a long history of use by the Postal Service, long predating the present cost-of-living study.

that work to measure TFP differences among ODIS areas, which represent groups of three-digit zip codes.[29]

Here we briefly discuss some of the major features of our TFP calculation, specifically the conversion from pieces of mail by type to weighted mail volume and the conversion of labor hours by employee type to labor input, with more detail presented in Appendix A1.

The basic goal of TFP is to compare the quantity of output ("workload") to the quantity of input ("resource usage") over time or among regions. This task is complicated by the fact that the Postal Service does not produce a single uniform output and does not use a single uniform input. The Postal Service delivers not only a large variety of types of mail, but also maintains a network for that delivery. The Postal Service also uses employees in a range of occupations (such as postmasters, clerks, and mail carriers), statuses (such as career and non-career), and experience levels; uses various types of capital (such as buildings, vehicles, and equipment); and uses a variety of different materials inputs (such as transportation, utilities, and maintenance).

While a complete accounting of the variety of methods used to convert all outputs into a common workload measure, and all inputs into a common resource usage measure, is beyond the scope of this section, we present a brief, intuitive overview of the procedures used for mail volume and labor.

The ideal weighting factor for generating a common measure of weighted mail volume from the variety of different types of mail provided by the Postal Service would be a measure of the relative difficulty of handling each particular type of mail from collection through delivery. The weighting factor used is the volume variable unit costs as reported in the CRA and ICRA. These costs represent the best available measure of the difficulty of processing and delivering each mail type using the system. We multiply the piece count of each mail type by the cost to get a measure called weighted mail volume. This measure accounts for roughly 60 percent of our workload measure, with the remaining portion predominantly representing maintenance of the delivery network. Miscellaneous output represents a small share of workload in the national

29 See Caves, Christensen and Diewert (1982) for more discussion of the theoretical methodology used in multilateral TFP measurement.

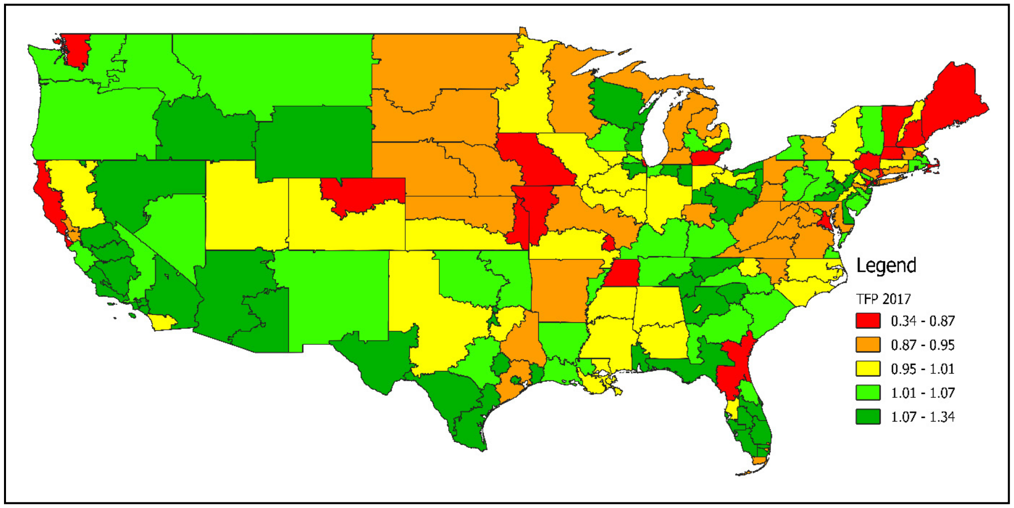
TFP measure. The benefit of this theoretically driven measure of weighted mail volume is that it does not treat all mail types as equal, which is important in our setting because the mail mix may vary substantially between locations.

While the Postal Service uses labor, capital,[30] and materials[31] as inputs, here we describe the key measurement of labor. Labor comprises roughly 80 percent of Postal Service costs and is the primary channel through which cost-of-living would influence productivity. Analogous to weighted mail volume, different types of labor are aggregated to a common measure of resource usage through a cost measure, which here takes the form of wages. We account for 16 crafts[32] with up to seven levels of experience.[33] Annual hours for each craft-experience level are multiplied by the wage, inclusive of benefits, to generate a common unit of labor input. The advantage of this measure is that it accounts for the difference in activities performed by each craft and the productivity increase that occurs with experience (Hellerstein, Neumark, and Troske, 1996).

From these elements, and several others, we calculate the ratio of workload to resource usage in each ODIS area for two years of data, 2016 and 2017. The ODIS area calculation, up to this point, follows the national calculations tracked by the Postal Service each month, but each element is disaggregated to the ODIS area based on finance number.[34] The ODIS area workload measure captures (weighted) mail volume and (weighted) delivery points,[35] and it captures the impact of population density by adding square miles of area. Finally, while some ODIS areas have significant mail processing operations while others do not, we include first handled pieces ("FHP") to measure the work directly associated with mail processing. TFP levels are mapped in Figure 1 for 2017.

30 Capital is the amount of physical assets (equipment, structures, inventories, and land) and intellectual property used to produce output.
31 Materials are the amount of commodities, in the form of intermediate inputs, used to produce output.
32 These include postmasters; supervisors full-time, part-time, and non-career clerks; career and non-career mailhandlers; career and non-career city delivery carriers; career and non-career rural carriers; vehicle service drivers; vehicle maintenance; building service; professional, administrative, and technical; and other.
33 Less than 5 years, 6 to 10 years, 11 to 15 years, 16 to 20 years, 21 to 25 years, 26 to 30 years, and more than 30 years.
34 There are a few other key differences noted in Appendix A1, including the differentiation of originating and destinating mail, differentiation of delivery point type, and the exclusion of transportation costs.
35 Different types of delivery points (e.g. city curb, rural box, city P.O. box, rural P.O. box, etc.) are weighted by their cost of delivery.

Figure 1: TFP by ODIS for 2017



Notes: Map depicts our Area TFP measure at the ODIS level. Red regions have low TFP while green regions have high TFP.

Other Measures of Productivity

One concern with our ODIS Area TFP measure is its complexity and that, while well-grounded in economic theory, it may not be fully understood by a broader audience. To address this concern, we examine three alternative measures of productivity. These measures, while transparent, each pose individual shortcomings. Nevertheless, they provide a check on our primary findings.

Destinating Volume per Carrier Hour

The first alternative productivity measure examines the ratio of destinating mail volume to carrier hours (both city and rural). The delivery of the mail comprises a significant portion of total cost, and mail delivery is significantly more labor intensive than mail processing operations. One would expect the delivery of mail to have a heavy labor component as it is difficult to mechanize. Some roles, such as postmaster with relatively few positions, may be subject to idiosyncratic conditions or prestige considerations as much as wages. But the need for large numbers of carriers would require the Postal Service to hire a more representative sample of workers from the local market where the phenomenon of interest may be more influential.

There are, of course, deficiencies with this measure. The measure, by design, only examines the work of some segments of employees. Perhaps more problematically, all volume is counted equally. Letters are treated as just as difficult and time consuming to deliver as packages. Additionally, all labor hours are counted equally. Fresh hires are assumed to have as much productive capability as an employee with 35 years of experience.

Delivery Points per Carrier Hour

The second alternative productivity measure examines the ratio of delivery points serviced to carrier hours (both city and rural). This measure should rise with more productive workers as they are able to service their routes with less time. As with destinating volume per carrier hour, this measure will depend strongly on labor and is difficult to mechanize. The drawback of this measure is that it does not account for variation in mail volume delivered or the mix of that mail between different areas. It also does not account for the difference in delivery point cost by type that is captured by the weighting factors in our weighted delivery point measure. Finally, this measure ignores other inputs beyond labor, and it treats all craft and experience hours identically.

Weighted Mail Volume / Total Work Hours

The third alternative productivity measure moves one step towards TFP in its use of weighted mail volume, which as noted above uses volume variable cost as a weight to reflect the fact that costly units such as packages are harder to deliver and process than letters. The drawbacks of this compared to TFP are that it treats all hours by all crafts and all experience levels equally, it ignores some output of the Postal Service, and it will not capture inputs besides labor.

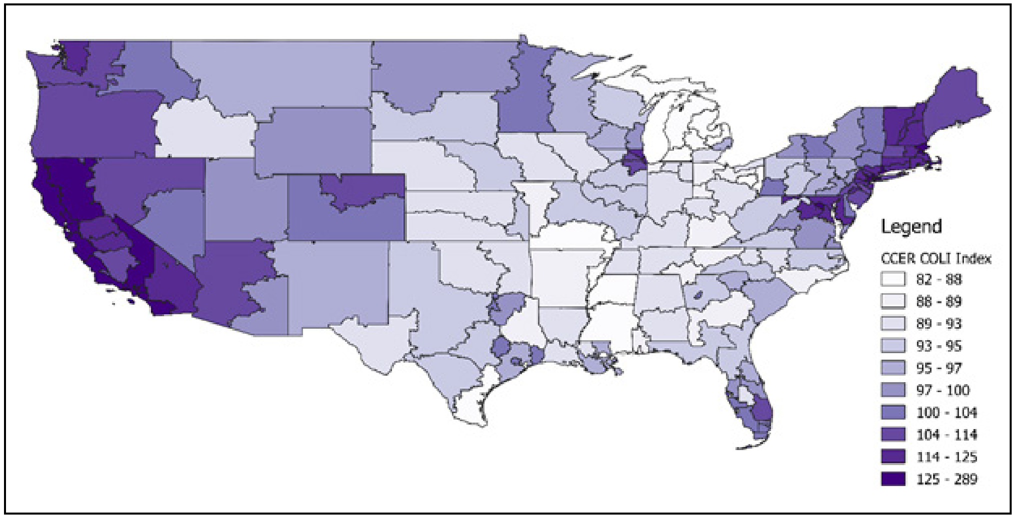
Cost-of-Living Measures

We measure cost of living primarily using the cost-of-living index published by the Council for Community and Economic Research (CCER COLI), which is derived from observed costs for goods and other services. We also examine the robustness of those results using another measure, General Schedule Locality Adjustment (GSLA), that is based on government employee wages that are adjusted to keep pace with cost-of-living differences between cities.

Cost-of-Living Index (CCER COLI)

Our first measure, the CCER COLI, was obtained from the Council for Community and Economic Research, a non-profit organization that generates a measure of the cost of living for each county in the U.S. on an annual basis.[36] The index is calculated for each county in the United States and captures the relative price levels for food, housing, utilities, transportation, healthcare, and miscellaneous goods and services. It has been used by other institutions such as the U.S. Census Bureau, the Bureau of Labor Statistics, and many others. The measure is provided for 2016 at the county level.

Figure 2: CCER Cost of Living Index by ODIS Area



Notes: Map depicts CCER COLI measure aggregated to the ODIS level. Dark purple regions have high cost of living while light blue regions have low cost of living.

36 See http://coli.org/about for further details.

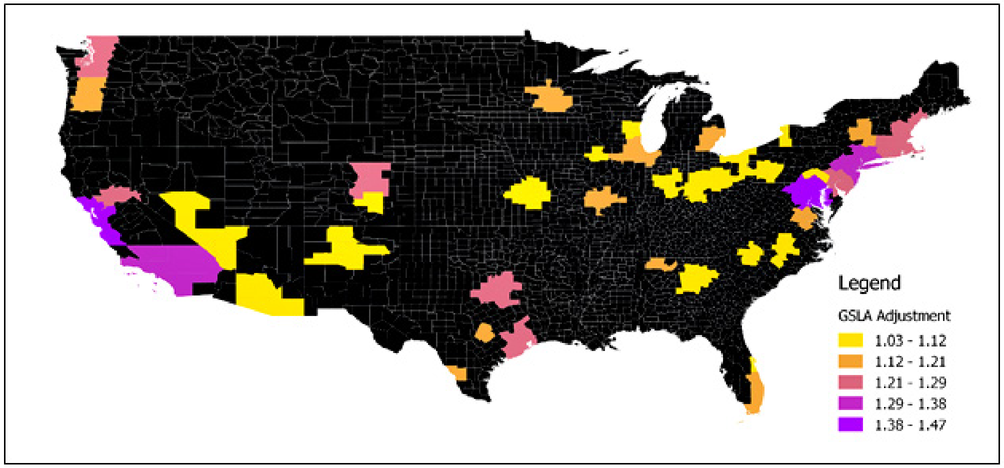
Figure 2 shows this measure converted to the ODIS level and as expected, cost of living is high in large cities, particularly along the coasts, with lower cost of living in rural areas, particularly in the interior of the country. This reinforces the point noted earlier that it will be important to also control for climate, which may bias our estimated effect on the cost of living if not properly controlled for. One additional concern with the CCER COLI is that, as a county-level measure, it does not necessarily capture a labor market. While Washington, DC and Arlington, VA are different counties, they form a common labor market. This can generate a stronger relationship between two variables than actually exists because the two counties are drawing on a common labor market and are not independent. Our second cost-of-living measure helps to address this concern.[37]

General Schedule Locality Adjustment

While the Postal Service does not currently adjust wages for cost of living, federal workers subject to the General Schedule do have wage adjustments as part of the General Schedule Locality Adjustment (GSLA). These adjustments are based on observed wages for non-federal workers in the same geographic area based on BLS survey data with the intention of maintaining competitive salaries with other employers. While each county has a locality pay adjustment, the most significant wage increases are concentrated in relatively few counties. We use the relative locality pay adjustments to construct a variable that represents wage level differences across counties. These adjustments are depicted graphically in Figure 3.

37 We also examine a spatially correlated model in Appendix Table A2.2 using our CCER COLI measure to address this concern and found no substantive differences from our primary model.

Figure 3: GSLA Wage Adjustment by County



Notes: Map depicts GSLA wage adjustments. Black regions receive a baseline adjustment, while metropolitan regions in color receive an additional adjustment. Large adjustments are in purple with small adjustments in yellow.

The map in Figure 3 depicts counties with the baseline adjustment in black, while counties with an additional upward adjustment are in color. GSLA areas are groups of counties organized around a city. This measure presents two possible benefits over the CCER COLI. Because each GSLA area is organized by metropolitan area, it represents something closer to a labor market than a county and is a region where one would expect wages to equalize. Second, it is a currently existing wage adjustment used for federal workers. The potential drawbacks are that it represents wage adjustments for a limited number of counties and that it is an adjustment for a set of workers who may differ in profile from typical postal employees.[38]

Climate Measures

Climate is a factor that would be expected to directly affect productivity. It may also covary with cost of living. Mild coastal climates tend to have relatively high cost of living, while more extreme interior climates have lower cost of living. To control

38 One additional concern is that under some circumstances, local prevailing wages may not fully reflect cost of living. For example, in an attractive place to live such as Hawaii, which is not included in our study, excess demand will increase the cost of housing but depress local wages.

for these effects, we generate a variety of controls for climate from daily weather observations.

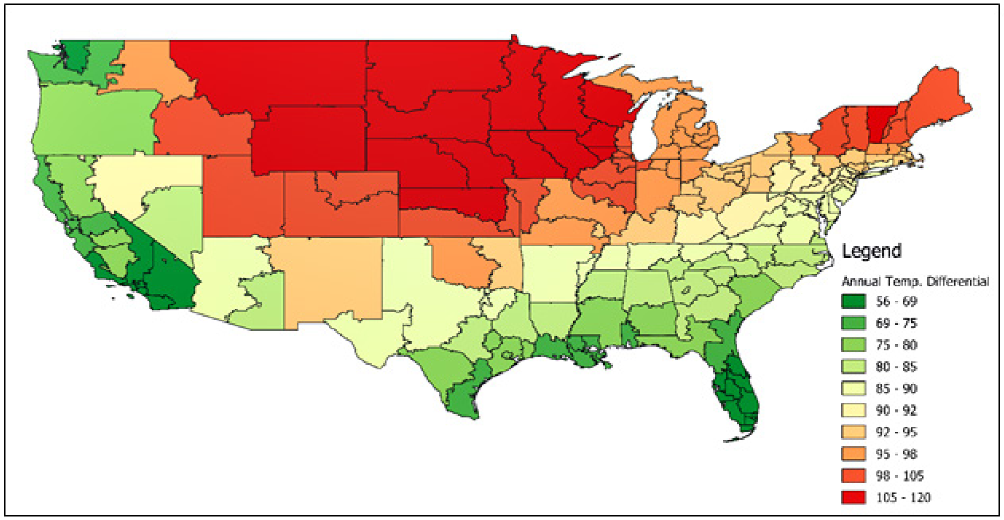
Daily weather data were obtained from Leard and Roth (forthcoming). These data were derived from daily observations of temperature, rainfall, and snowfall at the National Climatic Data Center (NCDC) Global Historical Climatology Network-Daily,[39] which provides measures for weather stations in the United States. This database collects and performs quality control for weather data from land-based weather stations around the globe and is archived by the National Oceanic and Atmospheric Administration. Data from 2,607 stations were used, located in the lower 48 states and the District of Columbia.[40]

Weather observations from these stations are then averaged to derive daily county-level weather using inverse distance weighting to the county's population centroid. This average uses all detectors within 200 km of the population centroid. This yields a set of weather data for 3,140 counties from 1975 to 2015.

We then generate climate variables including average annual total rainfall, total snowfall, average annual temperature, and the average difference between the maximum and minimum temperature as a measure of climate extremes. We then convert these county level measures to ODIS level measures. Figure 4 depicts climate extremes for each ODIS area (maximum annual temperature minus minimum annual temperature). Red regions experience large climate extremes while green areas are mild in their temperature fluctuations.

39 See https://www.ncdc.noaa.gov/ghcn-daily-description for more detail and source data.
40 Some additional minor quality control was performed — in some instances, outliers appear to be misplaced decimals. All observations with snow or rain greater than 1000 cm were replaced with imputed values, and a detector in Nevada was dropped that reported several temperatures above 5000 degrees Celsius.

Figure 4: Climate Extremes, Maximum Temperature – Minimum Temperature



Notes: Map depicts temperature extremes (maximum – minimum annual temperature) with large annual temperature differentials in red and smaller, milder annual differentials in green.

Ruggedness Index

Another possibly important factor in productivity might be terrain ruggedness. Difficult terrain may hinder postal collection and delivery. If flat terrain correlates with weather or cost of living, omitting terrain may bias the estimated relationship between productivity and weather or cost of living.

County-level terrain ruggedness index measures were developed from detailed grid-cell-level terrain index maps as calculated by Nunn and Puga (2012). The authors provide these grids, which were converted to county-level average ruggedness measures using GIS software. Nunn and Puga's measure calculates small-scale terrain irregularities by examining the change in elevation that would occur in moving in any of the eight major compass directions. They calculate this measure for each point in a 30-by-30 arc-second grid, and we average the values within a county to generate a ruggedness index for our model. Thus, it attempts to capture the average difficulty of navigating the local terrain, since rugged locations may have more irregular routes, delivery points may be more irregularly spaced, or roads may be more difficult to drive.

It is important to note that terrain ruggedness is not a measure of elevation. Low lying terrain can be rugged, as is found in northwestern Arkansas, while some areas can have high elevation but be comparatively less rugged, such as eastern Wyoming.

Conversion of County-Level Measures to ODIS-Level Measures

While our dependent variable, TFP, is measured at the ODIS-area level, weather, our primary cost of living index (CCER COLI), and terrain ruggedness are county-level measures.

To convert these measures to ODIS areas, we use the U.S. Census Bureau's Zip Code Tabulation Area (ZCTA) data that convert census blocks to zip codes. Census blocks are geographical units used by the Census Bureau to divide the United States into small statistical units. They are the "building block" of larger census units (e.g., census block groups or census tracts), with boundaries that align with major roads or geographical features and never cross boundaries for cities, school districts, or counties. They are generally small in area but can be large in remote rural regions.[41]

To assign a zip code to a census block the census determines the most common zip code for residents within the block. While this assignment method can create minor inconsistencies at the five-digit zip code level, these errors are minimized in this study because we aggregate to the ODIS level.

From these data, we create a data set that represents the intersection of counties and three-digit zips with the total population residing in each unit. We then aggregate these "county-zip code intersection pieces" to ODIS areas using population weighting. For example, if a particular ODIS area has a population of 100,000 people, 90% from county A and 10% from County B, then the ODIS area cost of living, weather, or other variable will be the weighted average of those two counties following those population proportions.

Conversion of TFP ODIS Measures to GSLA Regions

Because wages are only adjusted for a select number of regions for the GSLA measure of cost of living, regressions using the GSLA as the measure of cost of living

41 See https://www.census.gov/newsroom/blogs/random-samplings/2011/07/what-are-census-blocks.html for further details on census blocks.

use GSLA regions as the unit of analysis. This necessitates converting ODIS level TFP measures to county-level measures of TFP as each GSLA area is a collection of counties.

The unit of analysis in this study was altered because most counties receive the baseline adjustment as part of the GSLA system and are effectively grouped together as a single non-adjusted region. This region contains such diverse areas such as remote and rural counties of western states and populous cities such as Orlando, FL and New Orleans, LA that are not part of a GSLA area. Many ODIS areas will have a small intersection with a GSLA county but largely reside in this baseline area. Reconfiguring the data at the GLSA area allowed us to exclude this baseline region and to retain the "single labor market" unit aspect of the data that is its key advantage over the CCER COLI.

To create GSLA TFP measures, the population weights from the ZCTA file were used to average across TFP values for ODIS areas up to the county level, and counties were combined accordingly to form GSLA units.

4. Empirical Specification

The general specification used regresses the natural log of productivity on the natural log of control variables. The natural log is used to allow for interpretation of estimated coefficients in percentage terms as described below.

Our primary specification regresses our TFP measure on the explanatory variables:

$$\ln(TFP_j) = \beta_{climate} \times \ln(climate_j) + \beta_{cost\ of\ living} \times \ln(cost\ of\ living_j) + \beta_{ruggedness} \times \ln(ruggedness_j) + other\ controls + \varepsilon_j \quad \text{[Eq1]}$$

The subscript j indexes ODIS areas by year. In this regression the dependent variable already incorporates our standard area TFP output measures including delivery points, land area, and measures of mail demand such as first handled pieces. The control variables of interest are those that capture climate, cost of living, and ruggedness. Other controls that we generally use but suppress in our output tables include a fixed effect for each time period of data[42] and an intercept.[43]

An alternate regression changes the unit of analysis to a GSLA area, dropping the baseline "rest of country" region.

$$\ln(TFP_g) = \beta_{climate} \times \ln(climate_g) + \beta_{cost\ of\ living} \times \ln(GSLA_g) + \beta_{ruggedness} \times \ln(ruggedness_g) + other\ controls + \varepsilon_g \quad \text{[Eq3]}$$

The subscript g indexes the 44 GSLA areas by year.

A final set of regressions replaces our TFP measure with other measures of productivity, that, while lacking some key benefits of TFP, are perhaps more easily understood by a broader audience.

$$\ln(Productivity\ Measure_j) = \beta_{climate} \times \ln(climate_j) + \beta_{cost\ of\ living} \times \ln(cost\ of\ living_j) + \beta_{ruggedness} \times \ln(ruggedness_j) + other\ controls + \varepsilon_j \quad \text{[Eq4]}$$

Because the dependent variable is no longer our standard ODIS Area TFP measure, "other controls" now include some additional variables, such as delivery points and ODIS area in square miles, which are implicitly captured in our dependent variable in our main regressions.[44]

5. Results

Table 1 and Table 2 present the results of our regressions. Models 1 and 2 presented in Table 1 use the log of TFP as the dependent variable while Models 3, 4, and 5 presented in Table 2 use alternative productivity measures as the dependent variable. The bottom of the table details the additional controls and indicates how they are incorporated. For example, Weighted Mail Volume, Delivery Points, and Square Miles of Area are all incorporated in the output measure in TFP and are implicitly included. For Models 3, 4, and 5 these may be incorporated into the dependent

42 Because we have two years of data, 2016 and 2017, this effectively is a control for data in 2017.
43 Appendix Table A2.2 presents an alternative regression that accounts for spatial autocorrelation estimating qualitatively similar results as the OLS regression.
44 We cluster all standard errors at the ODIS area level since TFP measures are derived at this level.

variable or included as an explicit control (the coefficients of which are not shown). All regressions include a fixed effect for 2017 (the second year of our data) and a constant.

Table 1: Regression of TFP on Explanatory Variables

Dependant Variable:	TFP	
	Model 1	Model 2
Climate		
ln(Max temp. - Min temp.)	-0.281**	-0.192*
standard error	(0.115)	(0.100)
ln(Mean temp.)	0.021	-0.196
standard error	(0.142)	(0.231)
ln(Annual Rainfall)	-0.100***	-0.041*
standard error	(0.021)	(0.024)
ln(Annual Snowfall)	0.001	-0.016
standard error	(0.009)	(0.011)
Cost of Living		
ln(Cost of Living Index)	-0.132***	
standard error	(0.058)	
ln(GSLA Index)		-0.363***
standard error		(0.109)
Ruggedness		
ln(Ruggedness Index)	-0.015*	-0.010
standard error	(0.008)	(0.011)
Additional Controls		
Weighted Mail Volume	**Implicit**	**Implicit**
Delivery Points	**Implicit**	**Implicit**
Square Miles of Area	**Implicit**	**Implicit**
Year Fixed Effect?	**Yes**	**Yes**
Observations	360	88
R-squared	0.231	0.337

Note: Stars on coefficient estimates indicate statistical significance at the 10% (*), 5% (**), and 1% (***) levels. Model 1 clustered on ODIS, Model 2 is clustered at the GLSA area.

Table 2: Regression of Alternative Productivity Measures on Explanatory Variables

Dependant Variable:	Dest. Mail per Carrier Hour	Delivery Points per Carrier Hour	WMV per Employee Hour
	Model 3	Model 4	Model 5
Climate			
ln(Max temp. - Min temp.)	-0.243*	-0.432***	-0.468***
standard error	(0.143)	(0.115)	(0.175)
ln(Mean temp.)	-0.157	-0.051	-0.366
standard error	(0.187)	(0.152)	(0.223)
ln(Annual Rainfall)	-0.095***	-0.066***	-0.121***
standard error	(0.022)	(0.021)	(0.030)
ln(Annual Snowfall)	-0.009	0.003	-0.007
standard error	(0.013)	(0.009)	(0.014)
Cost of Living			
ln(Cost of Living Index)	-0.155	-0.737***	-0.248**
standard error	(0.107)	(0.098)	(0.113)
Ruggedness			
ln(Ruggedness Index)	0.022*	0.022***	0.011
standard error	(0.011)	(0.008)	(0.014)
Additional Controls			
Weighted Mail Volume	**Dep. Var.**	**No**	**Dep. Var.**
Delivery Points	**Control**	**Dep. Var.**	**Control**
Square Miles of Area	**Control**	**Control**	**Control**
Year Fixed Effect?	**Yes**	**Yes**	**Yes**
Observations	360	360	360
R-squared	0.244	0.587	0.146

Note: Stars on coefficient estimates indicate statistical significance at the 10% (*), 5% (**), and 1% (***) levels. All regressions clustered on ODIS.

Model 1 is our preferred model. It uses TFP as the dependent variable and the CCER COLI cost-of-living index. This index is preferred because it allows us to include all regions of the country. This model estimates a number of negative coefficients for our weather controls, two of which are statistically significant at the 5 percent level as indicated by the stars on the coefficient. Because the specification is a “log-log” specification in which the natural log is applied to both the dependent variable and the explanatory variable, this coefficient is interpreted as an elasticity. For a region A with 10 percent more spread between annual max and min temperature than region B, productivity will be 2.8 percent lower in region A. Similarly, 10 percent more rainfall would be associated with 1.0 percent lower productivity. The coefficient on Cost of Living indicates that if region A has a cost of living that is 10 percent higher than region B, region A will have TFP that is 1.3 percent lower. Finally, the coefficient on the ruggedness index indicates that for a region with 10 percent more rugged terrain, productivity will be 0.2 percent lower.

Model 2 presents estimates of a regression similar to Model 1, except the GSLA index of cost of living is used and the unit of analysis is the GSLA area. The results are qualitatively similar, but the coefficients on weather indicate lower statistical precision. The coefficient on the GSLA index indicates that for a 10 percent higher adjustment in region A compared to region B, the productivity of region A will be 3.6 percent lower. The coefficient on ruggedness is similar to that of Model 1 but is statistically insignificant.

Models 3 through 5 are presented in Table 2 and use the CCER COLI as the measure of cost of living as in Model 1, but these models alter the dependent variable from TFP to the alternative measures of productivity.

Model 3 examines the effects of controls on destinating mail per city and rural carrier hour. This represents a simplified measure of how many units of mail can be delivered per hour. Weather measures are qualitatively similar to Models 1 and 2—extreme temperature and rainfall depress mail delivered per hour. The coefficient on Cost of Living is -0.155. This effect is statistically insignificant but is consistent in sign with prior models. There is a slight positive relationship between ruggedness and mail delivery per hour. The positive effect is not exceptionally strong but may be the result of shortcomings of the productivity measure which omits, for example, originating mail, processing, and other labor tasks.

Model 4 uses a dependent variable that is the ratio of delivery points to carrier hours. The weather effects are negative in direction, indicating that extreme temperatures and high snow fall reduce productivity as measured by delivery points per carrier hour. The coefficient on the cost-of-living index of -0.74 indicates that a region with 10 percent higher cost of living will be able to service 7.4 percent fewer delivery points with a given number of carrier hours. The effect of ruggedness on this measure of productivity is statistically significant and indicates offices in rugged areas can service more delivery points per hour. The shortcomings of this measure are that it omits all functions besides carrier activities, no measure of delivered or collected mail is used, and all capital and materials inputs are ignored.

The final column, Model 5, moves somewhat in the direction of TFP. The dependent variable is now the weighted mail volume per employee hour. This measure, in effect, standardizes mail based on its cost, consequently capturing the difficulty of delivering and processing mail of differing characteristics.[45] Weather effects are very similar to those estimated in Model 1 where extreme temperature and rainfall are associated with reduced productivity. The point estimate on cost of living is -0.25. Thus, for a region with 10 percent higher cost of living, a "standardized" unit of mail output will require 2.5 percent more time. The effect of ruggedness on this measure of productivity is again statistically insignificant. The primary shortcomings of this measure are that it treats all employee hours identically and excludes all capital and materials used.

Broadly speaking these supplemental productivity regressions align with our primary specifications in that climate and cost of living are key factors in local productivity. The implications of terrain ruggedness are limited and inconsistent across measures. While our main specification indicates ruggedness has a weak negative effect on productivity, subsequent regressions suggest otherwise. This may be due to the various aspects of productivity captured by each regression and may warrant further investigation using more sophisticated measures of terrain. Generally speaking, extreme temperatures and precipitation exert negative pressure on TFP, and locations with high cost of living will have lower TFP compared to those with low cost of living.

It is also important to recognize that the importance ranking of results from the national regression may not translate to the local level. While weather is consistently shown to exert a reduction in productivity, some locations may suffer or gain more from cost of living. To demonstrate this, Figure 5 plots the decomposition of effects following Model 1 for ten ODIS locations. The black line indicates the location's TFP compared

45 The cost used is the volume variable cost of delivery. Our standard measure of output will add the cost of maintaining a larger network of delivery points to account for the difficulty of servicing more delivery points holding mail volume fixed.

to the national average. The colored arrows break that effect into each category of control and the gray arrow gives the residual or unexplained portion.

Examining individual locations, we can see how each category of control has different effects. Santa Ana, CA benefits from warm, mild weather, and most of its positive productivity can be explained by this factor. Other locations such as San Francisco see large negative effects due to high cost of living. In some ODIS areas such as Des Moines, IA and St. Petersburg, FL most of the productivity differential cannot be explained by our model. Thus, policies that remove or mitigate the effects of each covariate detailed in this paper will likely have uneven benefits.

Figure 6 below plots the unexplained residual, following Model 1, for all ODIS areas nationwide in 2017. Thus, the gray lines in Figure 5 correspond to the shading in Figure 6 (however adjusted such that the national average is 1.0). Compared to Figure 1, many regions are now closer to the national average indicating that there is somewhat less regional variation after removing the effects of our controls. Additionally, there is less geographic clustering. For example, the southwest is now less uniformly above average compared to Figure 1, presumably because weather effects boost the baseline TFP in this region — an effect removed in this map.

Figure 5: Factors Affecting TFP by ODIS Location

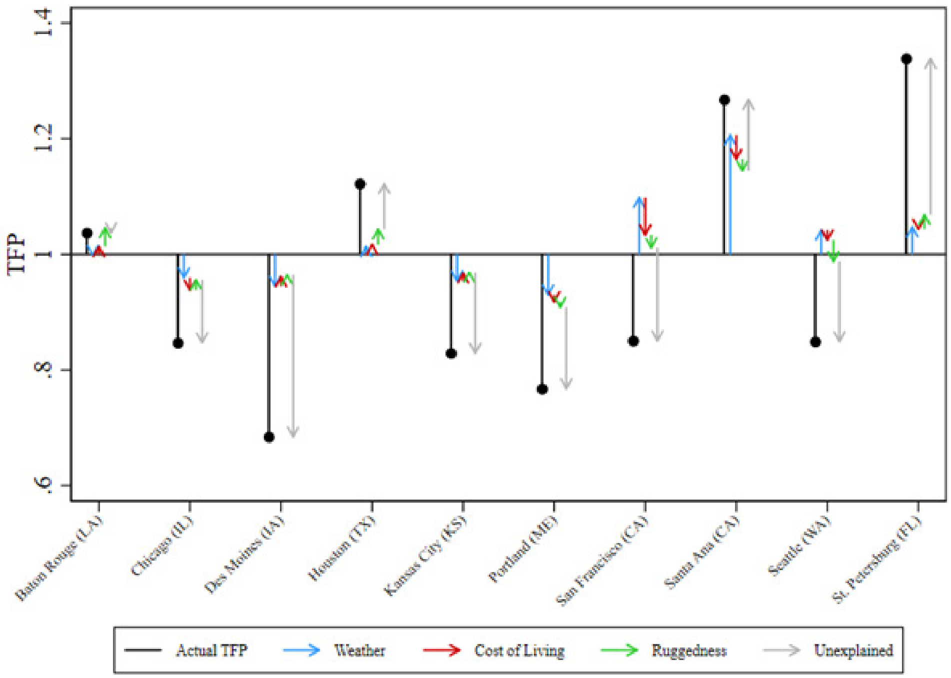
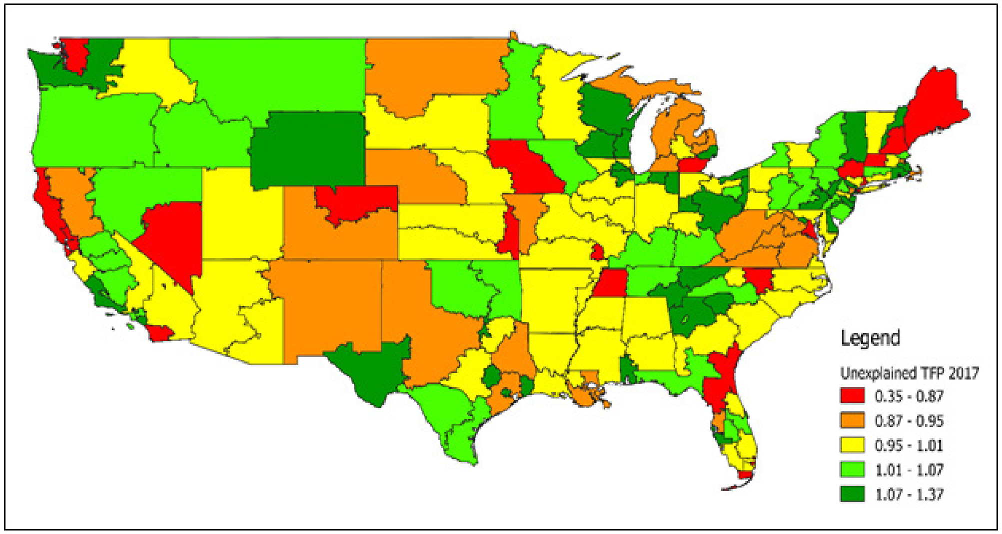


Figure 6: Residuals — Variation from Factors not in the Model



Notes: Map depicts the unexplained residual for each ODIS for 2017 derived using Model 1. Values indexed to a national average of 1.0.

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Appendix A1: Details of Total Factor Productivity (TFP) Index

This appendix provides a detailed overview of postal TFP, which is the primary productivity measure used in the present study of factors that help explain regional differences in postal productivity. This overview discusses the history of the Postal Service's use of TFP, the data sources and methods used to construct TFP, and why TFP is a more reliable productivity measure than simpler alternatives such as workhours per mail piece. The discussion begins with a review of national TFP, which introduces the key building blocks of TFP, and then moves on to a discussion of the regional TFP measure used in the present study ("ODIS Area TFP"), and finally highlights some special considerations that arise in the context of regional TFP measurement.

National Total Factor Productivity

Overview

Total factor productivity ("TFP") is a well-established measure of comprehensive operational efficiency. The Postal Service has used TFP as its official measure of overall productivity since 1985. The postal TFP calculation is developed and maintained by Christensen Associates, grounded in the seminal work of Dr. Lau Christensen, who published TFP studies on the U.S. economy, the railroad industry, the telecom industry, as well as other industries.

Broadly speaking, TFP measures the generation of outputs relative to the usage of inputs, or resources. "Workload" is the measure of all outputs USPS produces, while "resource usage" captures all inputs used to generate workload. While TFP may affect postal profitability, it is not a measure of financial performance. TFP is a quantity-based measure, which disregards changes in profitability caused by pricing factors such as postage rates and input prices, and instead captures the real economic costs of resources used to generate real workload.

Workload

In the national TFP measure, workload captures three types of postal output: weighted mail volume ("WMV"), miscellaneous output, and delivery points. While most TFP outputs are revenue-generating activities, one key output is meeting the obligation to service all delivery points (also known as universal service obligation), and TFP factors that in as a distinct and costly service that the Postal Service provides. The methods for computing each of these outputs are discussed below.

First, to calculate WMV, which accounts for the largest share of national workload, mail volume is broken down into subclasses, such as First-Class Single-Piece letters and Priority Mail. Quantities come from the Revenue, Pieces, and Weight ("RPW") report. Pieces in each subclass are weighted by unit costs from the Cost & Revenue Analysis ("CRA") and International Cost & Revenue Analysis ("ICRA") reports. Volume variable cost per piece for a subclass represents the relative level of effort required to handle that type of mail and is the appropriate basis for aggregating mail volume into a single WMV measure.[46] For example, a typical package requires more effort to handle than a typical letter, and this added difficulty will be reflected in a higher unit cost for packages relative to letters. Weighting pieces by unit cost appropriately takes the mail mix into account by giving more weight, for example, to higher-cost packages than lower-cost letters, and as a result WMV provides a much more accurate picture of postal workload than a simple count of mail pieces can offer.

Next, miscellaneous output, which typically accounts for less than five percent of national workload, is comprised of various categories of special services and other income-producing activities, such as Certified Mail and Post Office Box Service. As with WMV, RPW quantities and CRA unit cost weights are used when available. For other services, "constant dollar" methods are used, which involve deflating "current dollar" revenues by an appropriate price index. The various miscellaneous outputs are aggregated into a single measure using the same indexing method used to compute WMV and many other elements of TFP.

The final component of national workload is delivery points, which in recent years has accounted for 37% of postal workload nationally. Workload needs to capture output associated with the Postal Service's obligation to service an expanding delivery network because it still needs to be served on a daily basis, even if mail volume is declining. In national TFP, this is captured by the total number of city delivery, rural

46 When evaluating TFP over time, this aggregation is performed using the Tornqvist index, which weights the logarithmic growth rates of volume in each mail category by its average share of total costs between two periods. For example, if Priority Mail accounted for an average of 16% of total mail costs between two periods, then the volume growth for Priority Mail would be given 16% of the weight when determining WMV growth, even if Priority Mail only accounted for 1% of total mail pieces.

delivery, and highway contract route delivery points, as reported by the Address Management System ("AMS") Delivery Statistics Report. The weighting factor to give delivery points relative to other outputs is determined from an econometric analysis of costs, which estimates the effort required to service delivery points relative to the effort required to provide mail and services. While these relative weights have proven fairly stable over time, analysis is conducted annually to determine whether they should be updated.

Resource Usage

In the national TFP measure, resource usage captures the three major components of postal input: labor, materials, and capital. Quantity measures are developed for each of these components using "constant dollar" methods that adjust costs for price changes over time. The methods for computing each of these inputs are discussed below.

Labor input, which accounts for the largest share of postal resource usage, is built up from categories of employees that are distinguished by occupation (e.g., clerks), employment status (e.g., career), and experience level (e.g., 0-5 years' experience). The quantity of labor input is based on a breakdown of workhours by employee category. Rather than simply summing total workhours, different employee categories receive different weights based on the compensation per workhour for each category. For example, management workhours have a higher weight assigned to them than mailhandler workhours; non-career (e.g., city carrier assistant) employee workhours are assigned less weight than career employee workhours; and new employee workhours are assigned less weight than experienced employee workhours.

Employee workhour and compensation data by category are collected from various postal sources. The National Consolidated Trial Balance ("NCTB") provides the control total for labor costs, while the National Workhour Reporting System ("NWRS") provides the control total for workhours. Total labor cost and workhours are distributed to employee categories based on the National Payroll Hours Summary Report ("NPHSR"), which contains data by occupation and employment status, and the Active Employee Reference File ("AERF"), which contains data by experience level.

While labor input is by far the most significant driver of national resource usage, materials input is also an important factor. The quantity of materials input is based on “constant dollar” methods, which adjust expenses by price indexes to identify real changes in materials usage over time, independent of price inflation. In the national TFP measure, materials expenses are grouped into 28 categories, including transportation expense categories such as domestic network air transportation and highway transportation, as well as non-transportation categories such as professional services and supplies. Nominal expenses for these categories are built up from the detailed accounts maintained as part of the USPS’s system of accounting and reported in the NCTB. Then, constant-dollar measures are derived from these NCTB expenses using appropriate price indexes. Most of these price indexes come from Bureau of Labor Statistics. For example, highway transport expenses are deflated by the producer price index for the general freight trucking industry (long-distance, truckload). The resulting quantity measures are aggregated into total materials input based on the real (inflation-adjusted, constant-dollar) costs incurred within each category.

Finally, capital input, which accounts for a small share of national resource usage, captures the Postal Service’s usage of owned and rented capital, including land, buildings, vehicles, and equipment. Rented capital costs for buildings and postal support equipment are handled like material inputs in that NCTB-derived rental expenses are deflated by appropriate price indexes to arrive at constant-dollar measures. Owned capital input usage is based on estimates of what the Postal Service would have to pay in rent for the use of its owned capital assets. As such, the owned capital input measure captures the relevant economic factors affecting the cost of using capital assets, including asset price inflation, economic depreciation or efficiency loss, and the opportunity cost of capital.

Summary

National TFP is calculated as a ratio of total workload to total resource usage, where total workload represents a cost-weighted aggregation of weighted mail volume, miscellaneous output, and the provision of daily service to all U.S. delivery points regardless of volume; total resource usage represents a cost-weighted aggregation of input quantities for labor, materials, and capital. The result is a TFP index that captures changes in USPS efficiency over time.

ODIS Area TFP

Overview

So far, the discussion in this appendix has been focused on the application of TFP concepts to the evaluation of the USPS's overall productivity over time. However, these same concepts can also be applied to evaluate relative postal efficiency among regions, allowing TFP rankings by region either in levels at a snapshot in time or in terms of growth over time. In fact, regional TFP also has a long history of use by the Postal Service, which regularly evaluated field TFP results during the 1990s and later commissioned special studies to compute regional TFP over the 2004-2005 period, and again over the 2016-2017 period. All TFP-based analysis in the present study makes use of the most recent 2016-2017 update of regional TFP, which is referred to as "ODIS Area TFP" based on the regional unit of analysis for this TFP measure. The methods used to compute ODIS Area TFP are described below.

The development of regional measures of workload and resource usage begins with an analysis of ODIS areas. ODIS areas are a collection of three-digit zip codes and come from the ODIS-RPW sampling system, which stands for the Origin and Destination Information System for Revenue, Pieces, and Weight. This sampling system is part of the USPS process for developing RPW totals by rate category, and the geographic sample areas defined in this system represent the smallest areas for which the Postal Service can generate reliable RPW measures. As such, these ODIS areas provide the most detailed unit of analysis available for the evaluation of regional TFP.

Workload

ODIS area workload is made up of four components: weighted mail volume, weighted delivery points, first-handled pieces ("FHP"), and square miles of area served. To estimate weighted mail volume, ODIS area originating and destinating mail volumes assembled from various postal sources[47] are aggregated based on the weighting factors used in USPS field budgeting. Similarly, to estimate weighted delivery points, the ODIS area counts of the different types of city and rural deliveries from the AMS are weighted by their USPS field budgeting weights, and the weighted

47 Data sources include the ODIS-RPW, PostalOne, NCTB, Product Tracking Report ("PTR"), and National Meter Accounting & Tracking System ("NMATS").

values are summed. This approach to weighting mail volume and delivery points allows workload to vary by ODIS area based on the mix of mail and the mix of delivery types handled within each ODIS area. First-handled pieces are included in the model in addition to mail volumes to give extra credit to those ODIS areas that have mail processing operations. Some ODIS areas do not do any mail processing, while others do only limited mail processing. FHP is rolled up from the Management Operational Data ("MODS") by ODIS area, with certain MODS operations classified as "tertiary" or "function 4" separated out to avoid double counting FHP. Square miles of area by ODIS area are collected from a dataset produced by Claritas.

Total ODIS area workload is derived from the four workload measures through econometric analysis. The econometric analysis determines the appropriate weighting for the four different workload measures to calculate total workload.

Resource Usage

Total ODIS area resource usage is based on constant-dollar measures of labor, materials, and capital. The same postal accounting system that reports expenses by detailed category also distinguishes expenses by a detailed location-specific finance number, which is then mapped to the level of the ODIS area to allow expenses to be rolled up to the ODIS area level and hence aligned with the workload measures.

To measure constant-dollar labor input, ODIS area employees are distinguished by occupation, employee status, and years of experience, using the same categories used for national TFP. At a point in time, labor input by ODIS area is based on total compensation expenses booked to each ODIS area. In a given ODIS area, labor input growth is measured using constant-dollar methods parallel to the national measure, which computes real changes in labor cost independent of wage inflation.

The constant-dollar materials input measure is based on expenses booked to the same materials input categories used in national TFP, with the following exceptions: 1) materials expense categories (e.g., research and development) that are not booked to field finance numbers are excluded; and 2) transportation expense categories, which reflect a mix of ODIS-area-level and servicewide-level bookings, are excluded from the analysis.

The constant-dollar measures for owned capital input are derived by distributing Postal Service owned capital input across finance numbers. Capital distributed to finance numbers within an ODIS area then constitutes the ODIS area owned capital input. Owned land and building capital inputs are distributed across finance numbers based on building square footage, as reported in the Facility Master System ("FMS"). Owned vehicle capital input is distributed across finance numbers using the property records in the Vehicle Master System ("VMAS"). The various categories of owned capital equipment are distributed across finance numbers using the property records in the Property and Equipment Asset System ("PEAS"). Finally, constant dollar rented buildings and postal support equipment are based on the NCTB expenses booked to each ODIS area.

Special Considerations for Regional TFP Calculation

One issue that arises in the calculation of area TFP has to do with the interpretation of the "base" measure. Typically, in a setting where TFP growth is tracked over time, the growth in the ratio of workload to resource use is a comparison of a particular time period to an arbitrarily chosen base period. In a setting such as this, where there are multiple regions in a time period, there is no natural base region. Instead, the base is the average ratio across all regional observations in all time periods. This allows for consistent comparison of TFP between any two regions or time periods in a setting without a natural base.

Another issue that arises in the calculation of area TFP, where regional differences are a focus, is the potential for spatial variation in factors that affect TFP by region that, on a national level, are relatively fixed over time and less relevant to a national TFP calculation. The first such factor is population density, which we capture using delivery points and land area. The second is that mail may be processed in a region that is not its origin or destination. Thus, originating and destinating mail do not account for the fact that pieces mailed from ODIS area A to area B may be processed in a third ODIS area C. To capture this, we include First Handled Pieces as a measure of significant processing activity. We regress the workload-to-resource-use ratio on these factors (land area, delivery points, and FHP) and adjust TFP for these factors. In effect, TFP is compared not to the average ODIS area, but rather the average ODIS area if it were identical to the unit in question in terms of land area, delivery point, and FHP.

Summary

Applying the methods discussed above, TFP indexes are computed that allow productivity comparisons between ODIS areas. A summary of these results is presented in Figure 1 in the main text. As discussed in the main report, these relative TFP indexes provide the dependent variable in the baseline regression analyses evaluating the extent to which factors such as climate and cost of living help explain regional differences in postal productivity.

Appendix A2: Supplemental Regressions

Table A2.1: Normalized Variable Regression

CCER Cost of Living Index Dep. Var.: z(ln(Area TFP))	
Climate	
z(ln(Max temp. - Min temp.))	-0.347***
standard error	(0.111)
z(ln(Mean temp.))	0.023
standard error	(0.130)
z(ln(Annual Rainfall))	-0.357***
standard error	(0.055)
z(ln(Annual Snowfall))	0.020
standard error	(0.138)
Cost of Living	
z(ln(Cost of Living Index))	-0.190***
standard error	(0.055)
Ruggedness	
ln(ln(Ruggedness Index))	-0.156***
standard error	(0.061)
Observations	360
R-squared	0.231

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2.1 presents results for our central model with all dependent and independent variables transformed to normal variables, that is, with a mean of 0 and standard deviation of 1. By standardizing all variables in this way, the controls with the largest estimated coefficients are the most important in explaining the variation in the outcome variable. One implication worth noting in this transformation is that the coefficients no longer have a standard interpretation as an elasticity. It is immediately apparent that climate variables are, as a group, the most important as annual temperature spread has the largest coefficient, followed by annual rainfall. The next most important is cost of living. The smallest, as a category, is terrain ruggedness. It is also important to note that importance in the overall regression does not imply importance to each location. Some locations such as New York City may see much larger cost-of-living effects than climate effects. Other areas may see large climate effects and no effect from the cost of living.

Another way of capturing the importance of each set of control variables is to partition the variation explained by each set of controls using a method inspired by Figure 5. This method seeks to partition the 23.1% of variation explained by Model 1 (according the r-squared). This calculation first predicts TFP (y-hat) using the coefficients from Model 1 (omitting the constant). Because these location-level predictions will, by the nature of OLS regression, roughly sum to zero, the absolute values of these predictions are then summed for a 'total absolute variation' explained by the model. Next a prediction is made using only the coefficients pertaining to weather as estimated in Model 1. The absolute values of these weather-only predictions are then summed for the variation explained by weather. The ratio of the weather-only variation to the total absolute variation is the contribution from weather. The procedure is then repeated using cost-of-living and finally using ruggedness. Specifically, of the absolute variation explained by Model 1, 59% is explained by weather, 23% by cost-of-living, and 18% by ruggedness.[48] Scaled to the r-squared of Model 1, these values are 14%, 5%, and 4% respectively.[49] This method confirms the general picture presented by the standardized regression that weather controls are the most important, followed by cost-of-living, and finally ruggedness.

48 For purposes of rounding to 100 percent, we rounded these results to the nearest digit.
49 For purposes of rounding to 23 percent, we rounded these results to the nearest digit.

Table A2.2: Spatial Autocorrelation Models

	(1)	(2)
Dependand Variable: ln(TFP)	Contiguity Weights	Inverse Distance Weights
ln(CCER COLI)	-0.138**	-0.165**
	(0.054)	(0.066)
ln(Yr. Tot. Rain)	-0.092**	-0.118**
	(0.021)	(0.031)
ln(Yr. Tot. Snow)	0.002	0.003**
	(0.009)	(0.011)
ln(Ave. Yr. Temp.)	-0.000	0.025
	(0.154)	(0.184)
ln(Annual Max - Min)	-0.314**	-0.342**
	(0.120)	(0.149)
ln(Ruggedness Index)	-0.011	-0.014**
	(0.009)	(0.009)
Constant	2.633**	2.940**
	(1.127)	(1.452)
Observations	180	180

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2.2 presents a series of models that account for spatial autocorrelation, using only 2017 but otherwise following our primary specification. The concern addressed by these models is that neighboring units are not truly independent observations but often are part of the same labor market, introducing more correlation between the outcome and control variables than would otherwise exist. The GSLA regression also addresses this concern in a different way.

These models require the specification of a weighting matrix. We present a model that uses contiguity weights where units (ODIS areas) that physically touch each other are assumed to be correlated. The second uses the inverse distance as the weight matrix. Both models suggest that higher cost of living is associated with lower productivity.

Table A2.3: Further Alternative Dependent Variables

Dependant Variable:	Pieces / Processing Hour	ln(Area TFP)
Climate		
ln(Max temp. - Min temp.)	-0.078	-0.264**
standard error	(0.774)	(0.129)
ln(Mean temp.)	0.101	0.055
standard error	(0.754)	(0.152)
ln(Annual Rainfall)	-0.119	-0.106***
standard error	(0.085)	(0.024)
ln(Annual Snowfall)	-0.044	0.005
standard error	(0.034)	(0.009)
Cost of Living		
ln(Cost of Living Index)	-0.997**	-0.019**
standard error	(0.409)	(0.009)
Ruggedness		
ln(Ruggedness Index)	0.029	-0.014*
standard error	(0.051)	(0.008)
I(Multiple Floors)		-0.028
standard error		(0.030)
Additional Controls		
Weighted Mail Volume	**Dep. Var.**	**Implicit**
Delivery Points	**No**	**Implicit**
Square Miles of Area	**No**	**Implicit**
Year Fixed Effect?	**Yes**	**Yes**
Observations	313	310
R-squared	0.134	0.241

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A2.3 tests one final alternative productivity measure examining processing of mail and one additional control variable (the presence of multiple floors in processing plants) using the TFP measure of productivity. In the first regression the dependent variable is pieces per processing-hour, but pieces are defined to capture counts of mail reflective of processing. To develop this measure, we use MODS data at the finance number level and take the first non-zero value, in order, of total pieces fed, total pieces handled, or non-add total pieces handled. Thus, if there is no volume recorded for a finance number for total pieces fed, total pieces handled will be used. Where there is no volume for total pieces handled, non-add total pieces handled will be used.

The point estimates are qualitatively similar to those in Model 1, but statistical precision is reduced. No climate effects are statistically significant. A region with a cost of living 10 percentage points above the average, pieces per processing hour will be 10 percentage points below average. The effect of ruggedness is not statistically significant. This measure of productivity, while informative of this particular mail processing function, is narrow in the sense that it omits all carrier functions. The other drawbacks of this measure are similar to those for other alternative measures in that the difficulty of processing different classes of mail is ignored, and all processing labor hours are treated equally regardless of craft or employee experience level.

The second regression examines processing locations and includes an indicator (0/1 variable) for locations with multiple floors. Locations where the processing plant has multiple floors will have a 1, while those with all processing on a single floor will have a 0. Where an ODIS contains multiple plants, the indicator is for any plant having multiple floors. The control of interest, multiple floors, is negative but statistically insignificant and small. While this coefficient does not rule out a productivity reduction from the presence of multiple floors for plants, the effects of this must be limited in size. We can rule out reductions in productivity more negative than -0.1. Other covariates are qualitatively the same as in our main regression, Model 1, but many point estimates shift because the limitation to locations with processing plants shifts the sample.

Appendix B: Management's Comments

UNITED STATES POSTAL SERVICE

August 9, 2019

FREDY DIAZ
Acting Manager
Operations Central, Research and Insights Solution Center

SUBJECT: White Paper - Geographic Variation in Productivity

Thank you for the opportunity to provide comments in reference to the subject white paper. We appreciate that your study offers potential reasons for the geographic variation in productivity. As stated, your model explains 23 percent of the variance which leaves the majority of the variation to other local differences such as volume mix, route types, delivery mode, automation equipment, management approach, etc.

It is critical to point out that our internal operational measures and robust safety programs do attempt to offset these external factors. We will continue to look for ways to improve efficiency and counteract the negative impact of severe weather and rugged terrain, while keeping employee and customer safety as our top priority.

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Vice President, Finance & Planning

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