THE RESILIENCE OF FIRMS TO DEMAND SHOCKS: AN EXAMPLE OF THE TOILET PAPER INDUSTRY IN 2020

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As thesis advisor for Andrew Davila, I have read this paper and find it satisfactory.

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Précis

In early 2020 the average consumer could not find toilet paper in stores. The COVID-19 pandemic caused an immense demand shock leaving shelves empty. After the United States issued a stay-at-home mandate, uncertainty arose as to how long the people would stay in their homes. In a state of panic, people began stockpiling toilet paper to secure their share of the essential good. The public also had a legitimate reason to need more toilet paper (TP). As non-essential jobs began working from home, more consumer toilet paper would be needed. Consumer toilet paper is the soft, marketable brand you see in stores, whereas its counterpart, commercial toilet paper, is a rougher version found in offices, restaurants, or public areas. Toilet paper manufacturers in the United States and beyond operate around a constant demand curve. Their production structure does not have the flexibility for strong fluctuations in demand. In the face of this serious problem, an interesting question arises. How did TP manufacturers respond to the demand shock? And more importantly, what characteristics of a firm exert resilience to demand shocks?

In this paper, we attempt to answer these questions by analyzing the financial data of toilet paper manufacturers during the COVID-19 pandemic. Revenue, liabilities, and other financial information of 7 toilet paper manufacturers were collected from their financial statements. Data was collected before and after the demand shock period, 2018 and 2020 respectively. To answer our research questions, a quantifiable measure of resilience needs to be defined. We examine the existing literature and find that the definition of resilience and its applications vary greatly across academic fields. Economic resilience generally refers to a firm's ability to operate under stress. Akin to its definition, resilience does own a common estimation method. In our analysis, we propose two metrics for measuring economic resilience and use regression analysis to determine causal effects. Our first model defines resilience as the change in sales. Intuitively, in the face of a demand shock, the opportunity for an increase in sales is present, and thus a successful firm will show an increase of change in sales. Our results display significance under a 10% confidence level. They imply a positive relationship between the cost of goods sold and the change in revenue. Additionally, model one finds an inverse relationship between fixed assets and change in sales. Our paper discusses that the estimate of the fixed assets coefficient most likely refers to a firm's size rather than their long-term investment decisions. In model two we define resilience as the inventory turnover ratio. This ratio represents how quickly a company sells and replenishes its inventory. A firm successful in combatting the demand shock will show high levels of inventory turnover. The results of model two imply decreasing cash equivalents, or spending money, and increasing short-term liabilities can contribute to a firm's ability to replenish inventory.

Although our analysis is particular to the demand shock during the COVID-19 pandemic and the TP industry, our paper fills a gap in the literature on measuring economic resilience using real-world data. Our results also provide a bridge to existing literature revolving around ideas such as *financial slack*, and using cash as a buffer. Future work on measuring the resilience to a demand shock can analyze two different industries where one acts as a control. The COVID-19 pandemic humbled the entire world; it is difficult to find a market completely unaffected where public data is also available. Further analysis could also use estimation methods other than ordinary least squares. Models such as difference-in-difference, fixed effects, or subset-selection models such as Ridge or LASSO can work given a dataset with more observations. Identifying characteristics of a firm can potentially be achieved through stress tests, rather than analyzing the consequences of a natural event. Overall, analysis on how to build resilience can help firms make informed choices to prepare for future shocks.

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I. Introduction

The COVID-19 pandemic has highlighted the vulnerability of industries to demand and supply shocks. It has resulted in unprecedented changes in the way consumers and firms interact with one another. In April of 2020, nearly half of all grocery stores in the United States were in some capacity, out of stock of toilet paper. The sudden surge in demand for toilet paper and other household essentials, followed by the scarcity of baby formula in 2022 (Jung, 2022), has demonstrated the importance of understanding the resilience of industries to such shocks caused by global events. This paper will attempt to measure the success of the toilet paper industry's response to the demand shock in 2020 and identify financial characteristics of a firm that significantly contribute to economic resilience.

Demand vs Supply Shock

When a firm suddenly cannot reach the demand for their product or service, two events are likely to be behind this change: a demand shock, or a supply shock. A demand shock is when the demand for a product or service suddenly changes (Barone, 2020). Global events, breaking news, or misconceptions from the public can cause the demand for a product or service to change. If news breaks out that apples contain a chemical that slows down aging within humans, the demand for apples will likely spike because to avoiding aging is a common desire. However, demand is not always objective: the demand for a product or service can spike in the absence of a true, rational cause; largely in part because humans are driven by fear and exhibit a herd mentality (Raafat, 2009). Humans will act without verifying that apples contain anti-aging properties.

A supply shock occurs when the supply of a product or service changes quickly (Tarver, 2022). Unlike demand, supply shocks usually happen behind the scenes. Any disruptions in the supply chain of a product or even a decrease in human labor can lead to a supply shock. Following the same vein of thought with apples, imagine a new species of pests emerge that take a liking to the fruit. The pests will destroy the apple stock, thus farmers will have fewer apples to sell to grocery stores. The COVID-19 pandemic has created a similar result. The virus was nationally acknowledged in early 2020, distinct for its contagious and fatal behavior (CDC, 2021). The serious nature of the virus caused industry shutdowns across the world and shocks rippled through capitalist countries such as the United States (*2020 Results of the Business Response Survey: U.S. Bureau of Labor Statistics*). But what exactly caused consumers to find empty shelves of toilet paper in 2020?

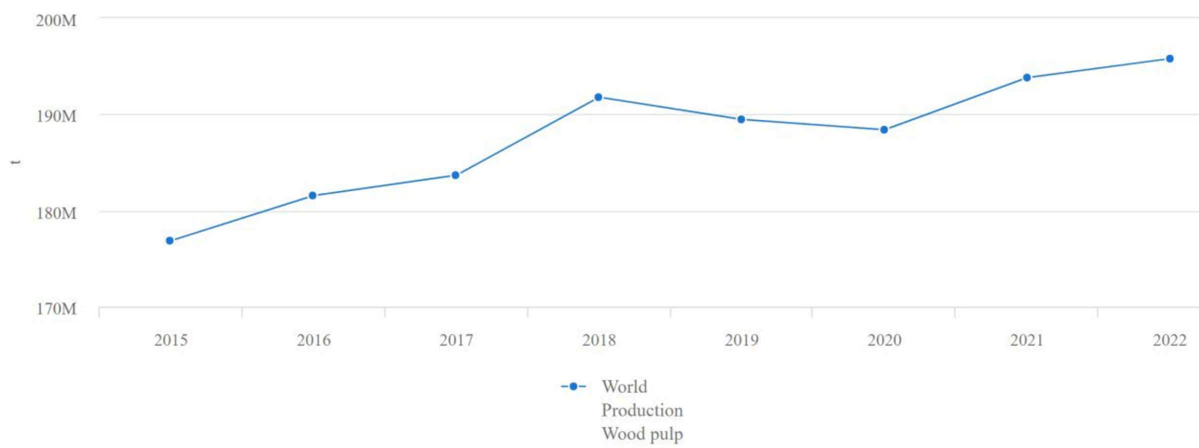
Commercial vs Consumer Toilet Paper

It is important to note that not all toilet paper is made equal. Most manufacturers produce two types of toilet paper: commercial and consumer. Commercial toilet paper is larger roll found in offices, schools, and public areas. Consumer toilet paper is made for the home that is found in retail stores. The difference is that consumer toilet paper prioritizes comfort, and appeals to the buyer through advertising while commercial toilet paper is scratchy and cheap, enough to get the job done (Moore, 2020).

Toilet Paper Shortage in 2020

There are many reasons to believe that the toilet paper shortage was not caused by supply shock issues. Generally, toilet paper is produced from three ingredients: wood pulp, water, and bleach. Any strong disruptions to these ingredients would constitute a supply shock. Figure I show the total world wood pulp production from 2016 to 2022 (FAO, 2022). The global supply of wood pulp in 2020 only decreased by 0.5% tons compared to 2019. However, as the figure shows, the decline began in 2018 and was not likely caused by COVID-19 disruptions.

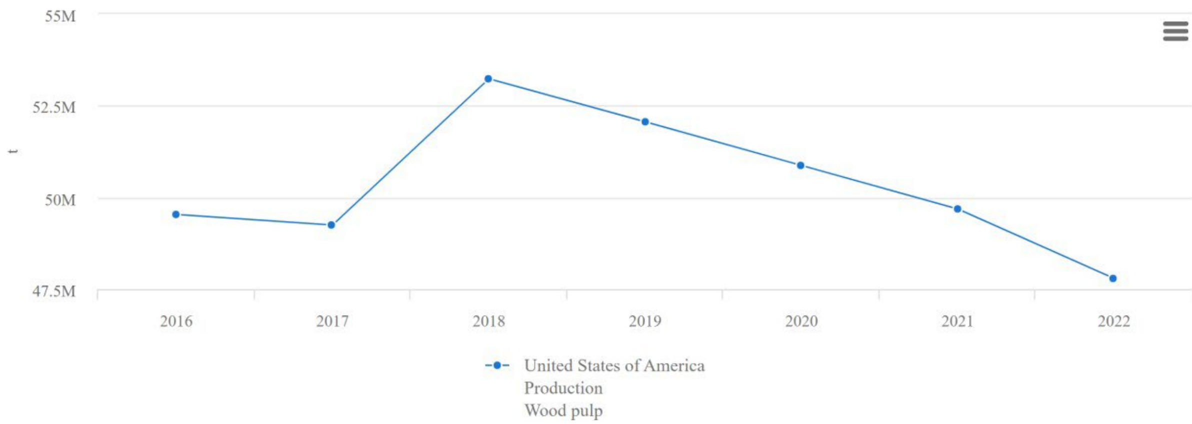
Figure I: Production of Wood Pulp in the World (Tons)



Source: FAOSTAT (Dec, 5th, 2023)

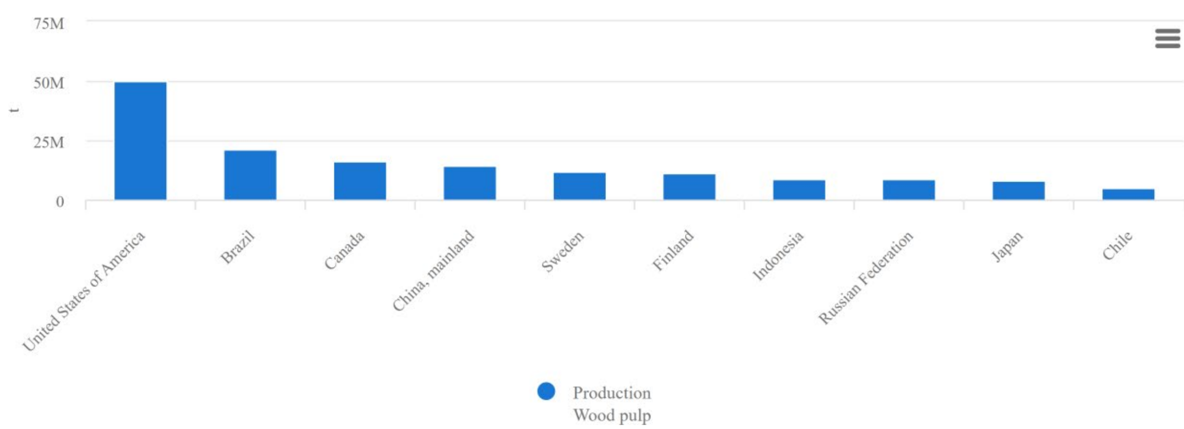
It would be beneficial to view the wood pulp production in the United States. Figures II and III shows the total wood pulp production in the United States (U.S.) between 2016 and 2022 (FAO, 2022). Similar to the global supply graph in Figure I, the U.S. maintains a slight decrease of production of 2.28% tons from 2019 to 2020. Figure III highlights the important fact that the U.S. is the leading producer of wood pulp, allowing issues of trade and foreign supply chain disruptions to be less likely.

Figure II: Total Production of Wood Pulp in the United States (Tons)



Source: FAOSTAT (Dec, 5th, 2023)

Figure III: Production of Wood Pulp by Country (Tons)



Source: FAOSTAT (Dec, 5th, 2023)

Although the supply of wood pulp decreased, the magnitude of change is likely not enough to constitute a supply shock. In addition, imports of global wood pulp increased in 2020 by 7.5% which contradicts the idea that wood pulp was in low supply, and supports that ingredient scarcity was never an issue.

Furthermore, the toilet paper industry in the U.S. did not experience massive factory shutdowns either. The United States Department of Homeland Security considered toilet paper plants as an “essential business,” allowing factories to stay open (Terlep 2020a). Toilet paper manufacturers were able to increase production by implementing innovative strategies. Kimberly-Clark, a strong competitor in the toilet paper industry, attempted a strategy to meet demand by converting commercial TP factories to produce consumer TP (Helper, 2021). Georgia-Pacific, another giant in the toilet paper industry, was also able to increase production while utilizing its excess inventory.

The shortage of toilet paper in 2020 was not caused by a supply shock but rather by an immense shift in demand. Hospitals were full, restaurants were closing, and public events were halted. 72,000 food and drink establishments were closed by the second quarter of 2020. As the pandemic spread across the United States, thousands of people were getting sick and deaths were steadily increasing (Murphy, 2021). In response to the deaths, the U.S. government decided to issue a stay-at-home order. A level of uncertainty spread as the public could not expect how long they would be forced to stay in their homes. The public began stocking up on essentials such as canned food, hand sanitizer, and hygiene products such as toilet paper.

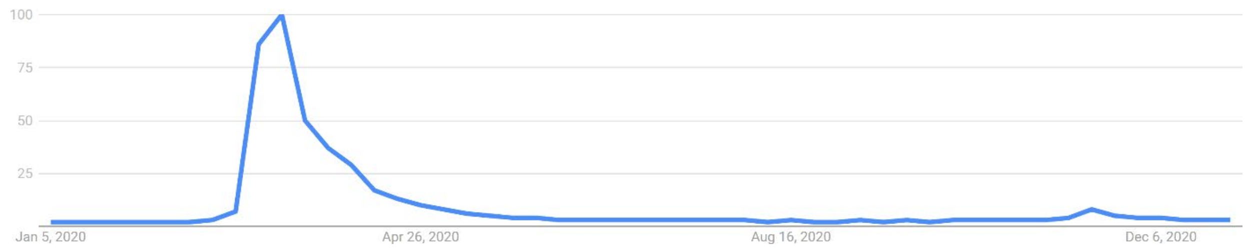
A formal term for this behavior is called hoarding. Distinct from compulsive hoarding, hoarding behavior is defined by the Oxford English Dictionary as the “amass[ing] and put[ing] away (anything valuable) for presentation, security, or future use.” (n.d). It is a behavior that is motivated by fear; particularly the threat of not having a possession when needed. (Frost & Gross, 1993). A threat to a possession's availability is experienced as a loss of freedom along with an “unpleasant motivational arousal” that encourages the consumer to reclaim the possession’s availability (Steindl et al., 2015). Thus, the response in early 2020 was to excessively stock up on toilet paper, along with other essential goods, to reestablish the sense of control and security that was lost when the reality of not having these essential goods became a possibility. (Frost and Hartl, 1996). The obsessive need to feel in control ultimately led to empty shelves within stores. A study by Hyunjoo Im (et al. 2022) uses survey data to show that respondents bought essential items in panic during the COVID-19 pandemic as a coping mechanism to deal with anxiety and loneliness. The researchers concluded that panic buying is a consumer response to levels of uncertainty and product scarcity.

In addition, as supply lowers and demand rises, many common goods fall victim to scalpers: people who buy in bulk and take advantage of the short-term high demand to make a quick profit. An interesting new article tells the story of a man in Australia who attempted to return around $10,000 of toilet paper and hand sanitizer to a grocery store. The man's eBay account, a website marketplace, was closed. The man had no medium of re-selling the essential goods and attempted to return them but was denied by the store (Impelli, 2020).

The spike in demand was not solely caused by compulsive shopping or scalpers. Consumers had a legitimate reason to buy more toilet paper in that a stay-at-home order meant that people had to work from home. The U.S. Census Bureau says the number of people working at home tripled from 2019 to 2021 to reach 27 million people (U.S. Census Bureau, 2022). Now working from home, their bathrooms were being used way more than they had been before. The bathrooms in workplaces, restaurants, and public areas were, in turn, deserted.

Although the demand for toilet paper is not perfectly observable, a simple proxy for its demand can be done through search popularity. Google collects data on search trends and can map a keyword's popularity over time. Below is a figure that shows how popular "toilet paper" as a Google search has changed over time.

Figure IV: Popularity of "Toilet Paper" as a Google Search

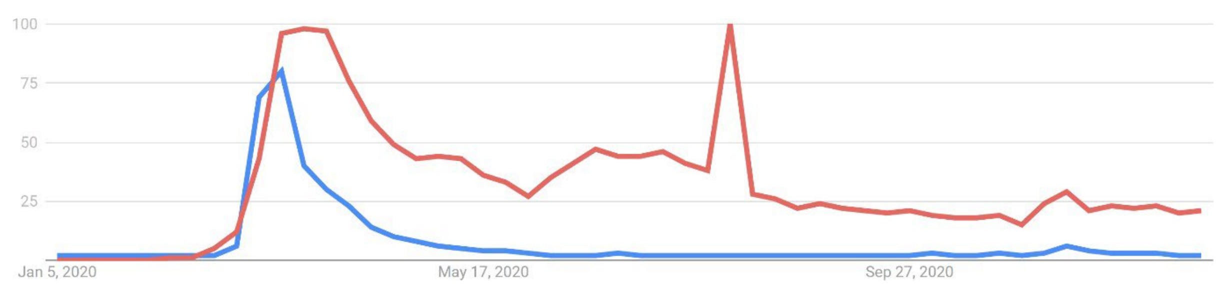


Source: Google Trends

"Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term."

We can see that the Google search for toilet paper has been constant throughout time besides the large spike around March 2020. It may be redundant to show but below is a figure that maps the spike of "toilet paper" popularity to "COVID-19" popularity.

Figure V: Popularity of "Toilet Paper" Compared to "COVID-19"



Source: Google Trends Note: Blue: Toilet Paper; Red: Covid-19

We can see that both events align. In an article by the White House titled, "Why the Pandemic Has Disrupted Supply Chains," the United States government states that demand for retail toilet paper suddenly rose by 40% (Helper, 2021).

To conclude, this spike in demand can be attributed to the worry caused by the unavailability of toilet paper and the shift of demand from commercial to consumer toilet paper. The toilet paper industry has a steady demand, and companies optimize their capital, output, and shipments of toilet paper based on standard benchmarks. Facing the demand shock, toilet paper manufacturers did not have the machinery or production capacity to keep up with demand, and shortages of toilet paper spread.

II. Literature Review

Economic Resilience

The general definition of resilience varies across studies. In the ecological field, resilience refers to the ability of a system to absorb change whilst the structural integrity of population relationships remains (Holling, 1973). C.S. Holling was the first to define the concept of resilience and researchers have modified this definition to complement their respective fields. Enterprise resilience is another form, defined as the preparation a firm has established to face disruptions (Sanchis and Poler, 2013). The variations of these definitions lie in the focus on which stage of change the system, firm, or individual, has merit. As with enterprise resilience, merit is placed in the pre-period of a disaster, while Holling’s definition contains a post-period goal of maintaining relationships. Economic resilience is distinct in that it defines two types: static and dynamic (Rose, 2004). Static economic resilience reflects an entity’s ability to function under the stress of a shock. Adam Rose finds “static” to be apt in that a firm can achieve this resilience without altering the foundation of production. Dynamic economic resilience refers to “the speed at which an entity or system recovers from a severe shock to achieve a desired state” (Rose, 2004). The severity of a disaster is already defined in dynamic resilience. The definition implies that a shock must be severe enough to disrupt a firm physically or metaphorically to a point where significant reconstruction is needed. It is important to note that this discussion firmly surrounds firm resilience rather than a macroeconomic perspective. The latter carries a goal of minimizing aggregated consumption loss given a loss of capital (see Hallegatte, 2014).

The toilet paper industry's response to the 2020 demand shock cannot be classified under these two definitions as the classification is firm-dependent. Responses to a shock depend heavily on firm goals, resources, and the portion of the demand shock that a company faces. Kimberly-Clark for example, perceived the TP demand shock as severe, reflected in its actions to commit to a reconstructive strategy. In a Mobile, Alabama factory, the company converted commercial TP lines to consumer TP lines (Terlep, 2020b). In a Wall Street Journal article, the CEO of Kimberly-Clark, Mike Hsu noted that the conversion would be costly, as the technology and ingredients are different for both products. On the other hand, Georgia-Pacific's challenge can be classified as static resilience. Fernando Gonzalez, the president of Georgia-Pacific's consumer business sector stated in March 2020, that the company has been able to meet demand through increasing production and excess inventory (Feldman, 2020). The company's extensive storage of TP, intentional or not, reflects its ability to handle stress under a shock.

Measuring Resilience and Examples

Generally, the existing research surrounding measuring economic resilience fails to adopt a standardized approach. The quantitative definition for resilience will likely vary from the external or internal event that causes a shock. One example of an offered approach is *direct static economic resilience* (Rose, 2009), where "direct" refers to a micro or meso-level entity, and "static" in the same manner as defined above. Below is a figure of Rose's proposed metric:

Figure VI: Direct Static Economic Resilience Equation

$$DSER = \frac{\%\Delta DY^m - \%\Delta DY}{\%\Delta DY^m} ,$$

where

$\%\Delta DY^m$ is the maximum percent change in direct output and
$\%\Delta DY$ is the actual percent change in direct output.

In simple words, DSER reflects how well a firm performed against a maximum expectation outcome. Provided a shock, a firm can calculate a limit to how their output will be affected. In a supply shock, the output of a firm is likely to decrease in the absence of raw materials. After a maximum expectation of change in output is calculated, the firm compares its actual output level to the worst outcome. A DSER level of 1 implies that the actual percent change in output is 0, signifying that a supply shock did not affect the firm. A level of 0 implies that the actual percent change in output is equal to the maximum expectation of change in output. It is important to note that Rose's metric cannot be standardized across all scenarios. The meaning of DSER's value changes according to the expectation of a change in output. In our context of a demand shock, a firm can expect its maximum change in output to be some positive value. A DSER level of 0 then implies that a firm was able to perfectly meet demand, whereas a 0 under a supply shock means a firm faces maximum losses.

Another analysis using theoretical models exists. Employing the toilet paper industry during the COVID-19 pandemic, authors Sanjoy Paul & Priyabrata Chowdhury created a theoretical demand model that includes number of manufacturers, product quality, product size, and available raw materials (Paul and Chowdhury, 2020). The authors defined measured resilience using the service level: the percentage of demand satisfied. They then established four resilience strategies and manipulated their model to reflect them:

1. Resource share among all manufacturers
2. Use of collective emergency sourcing
3. Produce a lower quality product
4. Reduce product to minimum package size

After implementing these strategies on hypothetical data meant to reflect the toilet paper industry during the COVID-19 pandemic, they found that the service level rose from 27% to 86% (Paul and Chowdhury, 2020). All manufacturers in a market are unlikely to share resources in the face of a shock, however producing a lower-quality product is a reasonable option. In a Wall Street Journal news article, the CEO of Kimberly-Clark acknowledged that selling commercial toilet paper was an option during the pandemic but refused (Terlep, 2020b).

In a paper titled *Economic resilience of the firm: A production theory approach*, researchers applied resilience strategies to a constant elasticity of substitution (CES) production function (Dormandy et al., 2019). To perform analysis of all inputs, they nest CES functions into a larger CES function to capture inputs such as labor, capital, raw materials, and infrastructure. Unlike the hypothetical demand model mentioned above (see Paul and Chowdhury, 2020), the authors apply shock outcomes to the model to observe how input costs and productivity change.

Ultimately few empirical studies are measuring economic resilience using real-world examples. One study analyzes the effect of COVID-19 on the tourism industry in the Visegrad group countries: Czech Republic, Hungary, Poland, and Slovakia (Wieczorek-Kosmala, 2020). The author defines resilience through the lens of organizational slack: potential resources that allow an organization to adapt to changes in *external* policies or environments (Bourgeois, 1981). In the context of an operating business, this definition becomes f*inancial slack* where "potential resources" converge to liquid monetary resources, primarily cash (Natividad, 2012).

Adopting this approach, Kosmala classifies 4396 tourism businesses into four resilience categories established by their level of cash holdings relative to other assets. She employs a weighted-least squares model to measure cash holdings as a function of profitability ratios such as return of assets (ROA) and operating profit margin (OPM). Rather than defining resilience to be measured, the author uses pre-existing literature to represent resilience as cash-holdings, a given metric.

The beta coefficient for ROA is positive, suggesting that profitable tourism firms hold more cash (Wieczorek-Kosmala, 2020). The beta coefficient for OPM is negative, in which the author suggests that firms that operate close to the break-even point hold more cash as a hedge against operational risk. However, the dynamics between financial ratios are often not a one-way relationship. In a resilience setting, the level of cash holdings can affect revenue and thus operating profit margin, potentially producing biased and inconsistent beta estimates. This point was not addressed in Kosmala's paper.

III. Data and Methodology

This project uses financial data from the Bloomberg database. Quarterly data was collected from seven consumer toilet paper manufacturers in a pre-period and post-period. 2018 is chosen as the pre-period to represent a pandemic-free environment. 2020 is chosen as the post-period to capture the demand shock of COVID-19. All 56 observations were collected using income statements standardized through the Generally Accepted Accounting Principles (GAAP).

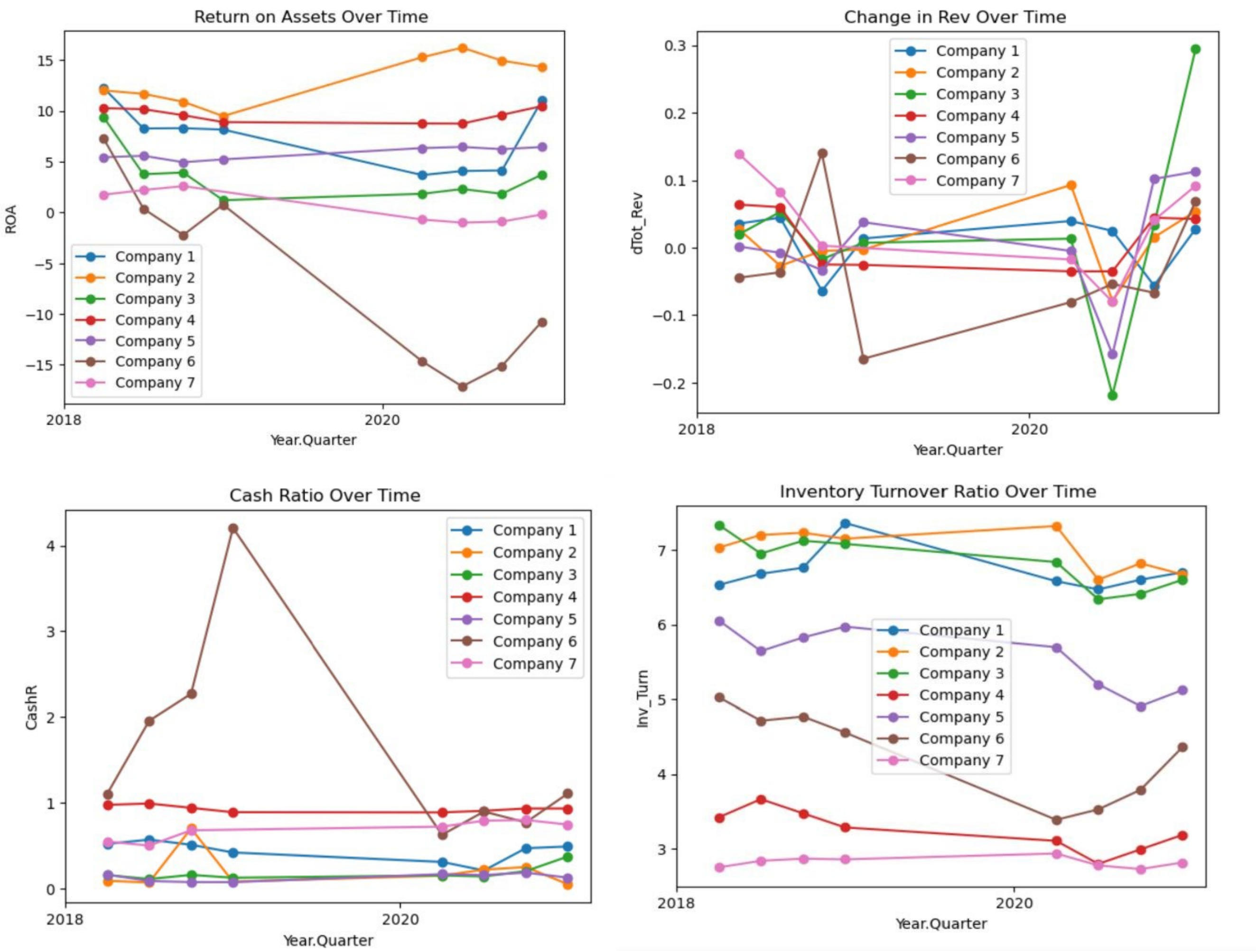
Table I: Variable Definition and Units

Variable	Definition	Unit
CASHR	Total cash plus cash equivalents divided by current liabilities	--
COGS	Cost of goods sold	USD
DTOT_SALES	Change in total sales from previous quarter	%
FA	Fixed assets	USD
INV_TURN	COGS divided by average inventory value	--
ROA	Net income divided by total assets	--
ST_LIAB	Liabilities expected to be paid within a year	USD
COVID	Value of 1 if in 2020; 0 otherwise	--
Employ	Number of employees	--

Minimal data cleaning is done. Data from a manufacturer in China had only semi-annual values within the Bloomberg database. A simple linear interpolation method was used to calculate Q1 and Q3, where Q2 and Q4 datapoints were given.

For an intuition to see how these variables change over time given our data, examples of line plots are provided:

Figure VII: Variable Time Series Plots



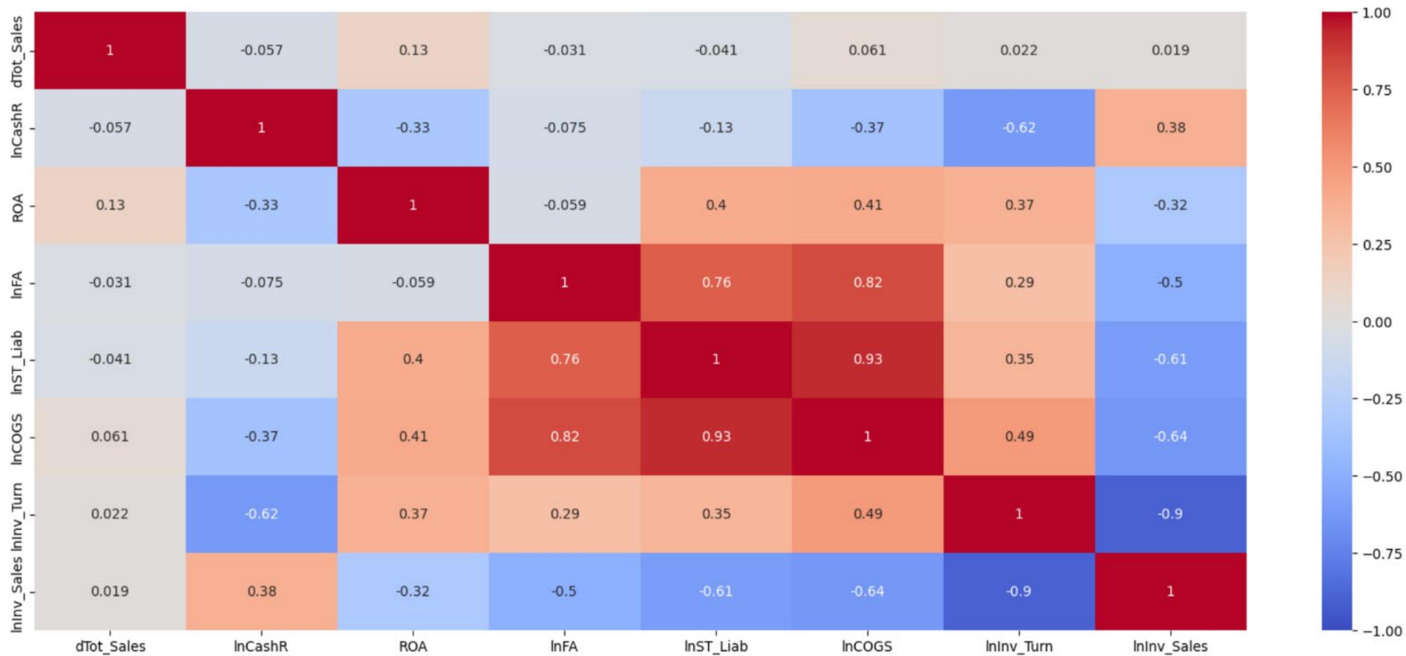
Note: Data points for 2019 are not included in dataset or plots.

Table II: Descriptive Statistics

	count	mean	std	min	25%	50%	75%	max
ROA	56.0	4.86	7.03	-17.13	1.85	5.52	9.52	16.24
CashR	56.0	0.60	0.67	0.05	0.16	0.50	0.82	4.21
FA	56.0	20560.76	30515.87	1934.00	2856.12	11037.75	12968.15	96409.00
COGS	56.0	2500.18	2645.84	444.07	886.62	1119.40	3005.25	8827.00
Inv_Turn	56.0	5.20	1.68	2.73	3.41	5.67	6.68	7.36
dTot_Sales	56.0	0.01	0.08	-0.22	-0.04	0.01	0.04	0.30
ST_Liab	56.0	7116.12	10098.90	668.70	1393.80	3452.95	6453.00	33107.00

It is important to understand how these financial ratios are connected. To view the correlation between these financial measures, Figure VIII displays a correlation heat map where a darker shade of red represents a strong positive correlation, and dark blue represents a strong negative correlation.

Figure VIII: Correlation Heat Map for all Log Transformed Variables



We can see that ln (COGS) and logged short-term liabilities have an almost +1 correlation, as well as ln (COGs) and logged fixed assets with a value of +0.83. The presence of strongly correlated independent variables is called multicollinearity. Multicollinearity causes the variance of the correlated variable to increase, leading to inaccurate coefficient estimates and p-values (Kim, 2019). Additionally, the confidence intervals become wide. However, if we determine that the cost of goods sold, fixed assets, or short-term liabilities is a relevant determinant to the dependent variable, then dropping the variables from the model can cause omitted variable bias, leading to biased beta coefficients (Wooldridge, 2016). Faced with this problem, we will determine the validity of our results by the Variance Inflation Factor (VIF). The VIF is a common test to assess the severity of multicollinearity. There is extensive discussion on what VIF value reflects unreliably beta estimates. A common cutoff value is under 10, while others suggest 5 is more appropriate (O'Brien, 2007). However, Jeffery Wooldridge in his textbook *Introductory Econometrics: A Modern Approach*, argues that VIF values over 10 cannot solely prove variable coefficients to be useless (Wooldridge, 2016).

As mentioned before, the definition and measurement of economic resilience varies across papers and studies. In any case, a shock is proposed to have some effect on the performance of a firm. This paper will propose two performance metrics and analyze their change relative to the pre-post period using a shock-period dummy variable. Like the hypothetical demand model by Paul and Chowdhury, our first dependent variable takes an approach of estimating service level (Paul and Chowdhury, 2020). The change in total revenue is chosen to capture a firm's ability to produce sales during a shock. The more sales a TP manufacturer make, the closer that firm satisfies demand. We will use an ordinary least square regression with change in revenue as the dependent variable, and various financial information as our explanatory variables. Our goal is to identify which characteristics lead to an increase in our defined resilience metric. Thus, **model one** is as follows:

$$\Delta TR_{it} = \beta_0 + \beta_1 \mathrm{ROA}_{it} + \sum_{j=2}^{5} \beta_j \log(X_{ijt}) + \beta_6 \mathrm{COVID}_{it} + \sum_{j=2}^{5} \beta_{5+j} \log(X_{ijt}) \times \mathrm{COVID}_{it} + \beta_{11} \mathrm{ROA}_{it} \times \mathrm{COVID}_{it} + \varepsilon_{it}$$

Where:

ΔTR_{it} is the change in total revenue for firm i in time period t (dependent variable).
ROA_{it} is the return on assets for firm i in time period t (independent variable).
X_{ijt} represents the jth independent variable for firm i in time period t, where j ranges from 2 to 5.

X_{2jt} representing short-term liabilities ($\mathrm{ST\_Liab}$),
X_{3jt} representing cash ratio (CashR),
X_{4jt} representing (COGS),
X_{5jt} representing fixed assets (FA).

$$H_1 : \beta_6 = 0, \quad H_2 : \beta_7 = 0, \quad H_3 : \beta_8 = 0, \quad H_4 : \beta_9 = 0, \quad H_5 : \beta_{10} = 0, \quad H_6 : \beta_{11} = 0$$

For each null hypothesis H_j where $j = 1, 2, \ldots, 6$, the alternative hypothesis asserts that the corresponding coefficient β_i is not equal to zero:

$$H_1 : \beta_6 \neq 0, \quad H_2 : \beta_7 \neq 0, \quad H_3 : \beta_8 \neq 0, \quad H_4 : \beta_9 \neq 0, \quad H_5 : \beta_{10} \neq 0, \quad H_6 : \beta_{11} \neq 0$$

To answer our research question in discovering characteristics of a firm that affect resilience, we need to assert an alternative hypothesis that the demand shock had an overall non-zero effect on performance. We particularly focus on the interaction terms of the financial ratios and the COVID dummy variable because they represent the effect of financial ratios on the resilience metric during the demand-shock period. Our hypothesis setup allows us to individually assess each estimate's significance, rather than a joint-test.

All variables undergo a log transformation to reduce variance between firm ratios and to normalize their distributions. It should be noted that although our model is primarily a linear-log model, our dependent variable is in the form of a percentage, thus beta coefficients of logged independent variables can represent the elasticity of total revenue.

Our second model uses a different approach to measuring economic resilience. For our second performance metric, we define resilience as a measure of inventory. A firm that is resilient to the demand shock would experience no significant change in inventory relative to the pre-shock period. The inventory turnover ratio then provides an estimation of a firm's resiliency. Defined as the cost of goods sold divided by average inventory value, this ratio represents how often a firm sells and replaces its inventory in one year (Fernando, 2023). Firms with higher inventory turnover values are more resilient as they re-stocked inventory more often. **Model two** becomes:

$$\ln(\text{Inv\_Turn}_{it}) = \beta_0 + \beta_1 \text{ROA}_{it} + \beta_2 \text{COVID}_{it} + \beta_3 \text{ROA}_{it} \times \text{COVID}_{it} + \sum_{j=2}^{4} \beta_j \log(X_{ijt}) + \sum_{j=2}^{4} \beta_{j+3} \log(X_{ijt}) \times \text{COVID}_{it} + \varepsilon_{it}$$

Where:

X_{i1t} represents FA_{it}, fixed assets for firm i in time period t.
X_{i2t} represents ST_Liab_{it}, short-term liabilities for firm i in time period t.
X_{i3t} represents CashR_{it}, the cash ratio for firm i in time period t.

Null hypotheses:

$$H_1 : \beta_3 = 0, \quad H_2 : \beta_5 = 0, \quad H_3 : \beta_6 = 0, \quad H_4 : \beta_7 = 0$$

Corresponding alternative hypotheses:

$$H_1 : \beta_3 \neq 0, \quad H_2 : \beta_5 \neq 0, \quad H_3 : \beta_6 \neq 0, \quad H_4 : \beta_7 \neq 0$$

Our dependent variable is log-transformed to maintain elasticity interpretation. The alternative hypotheses set also assumes a non-zero effect of any beta estimate during the shock period.

IV. Results

Model One

The table below displays our results for model one. The results for our first model show no significance of estimates at the 5% confidence level. As mentioned above, the correlation between independent variables can affect our estimates. The variance inflation factors are above 5 for all variables meaning that multicollinearity is an issue.

Table III: Results of Model One

Model One

						Dependent variable: dTot_Sales
Intercept	0.001	0.059	0.058	-0.107	-0.185*	-0.104
	(0.013)	(0.089)	(0.089)	(0.090)	(0.111)	(0.106)
ROA	0.001	0.002*	0.002	0.002**	-0.001	-0.005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.005)
lnST_Liab		-0.007	-0.007	-0.078**	-0.103**	-0.057
		(0.010)	(0.010)	(0.033)	(0.040)	(0.052)
lnCashR			-0.001	0.022	0.040**	0.021
			(0.011)	(0.014)	(0.020)	(0.013)
lnCOGS				0.103**	0.212**	0.129*
				(0.042)	(0.091)	(0.079)
lnFA					-0.054*	-0.036*
					(0.030)	(0.019)
COVID						-0.455*
						(0.273)
COVID:lnST_Liab						-0.108
						(0.076)
COVID:lnCashR						0.047
						(0.038)
COVID:lnCOGS						0.389*
						(0.213)
COVID:lnFA						-0.161*
						(0.088)
Observations	56	56	56	56	56	56
R^2	0.016	0.026	0.026	0.126	0.184	0.282
Adjusted R^2	-0.002	-0.011	-0.030	0.057	0.102	0.103
Residual Std. Error	0.080 (df=54)	0.080 (df=53)	0.081 (df=52)	0.077 (df=51)	0.076 (df=50)	0.076 (df=44)
F Statistic	1.583 (df=1; 54)	1.415 (df=2; 53)	0.973 (df=3; 52)	2.296* (df=4; 51)	1.945 (df=5; 50)	2.030** (df=11; 44)
Note:						*p<0.1; **p<0.05; ***p<0.01

Although multicollinearity does not affect predictive power and goodness of fit, it affects the standard errors of our estimates leading to biased p-values. Our model attempts to determine causal effects towards our resilience metric, however, the true significance becomes dubious due to increased variance (Kim, 2019).

There is the significance of the estimates of the cost of goods sold (lnCOGS:COVID) and fixed assets (lnFA:COVID) under a 10% confidence level. Our results say that during the COVID-19 period, if COGS increase by 1%, the change in sales increases by 0.39%.

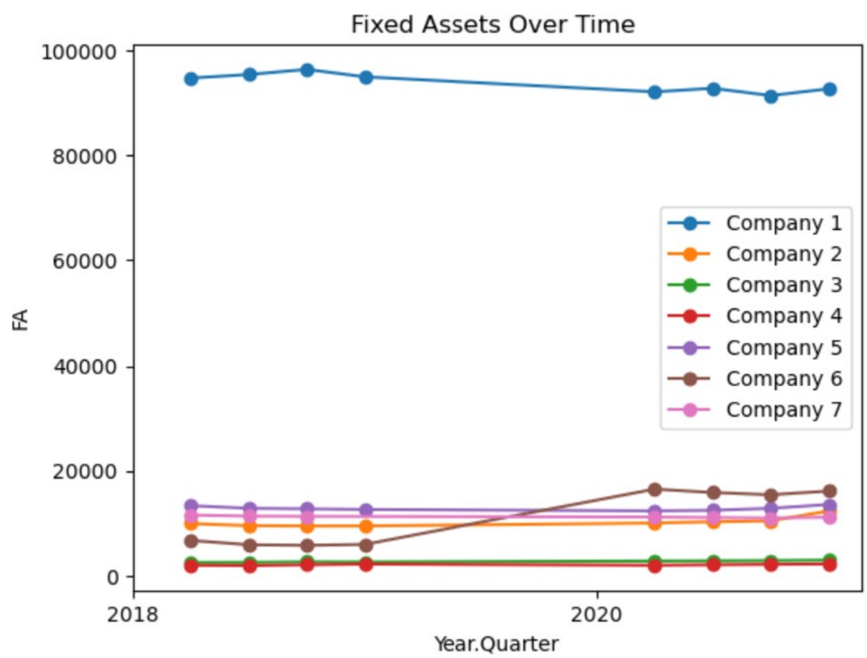
Table IV: Variance Inflation Factors for ΔTR_t as Dependent Variable

Variable	VIF
Intercept	217.87
lnFA	167.09
lnCashR	6.04
ROA	7.37
lnCOGS	77.67
lnST_Liab	19.29
COVID	167.09
COVID:lnFA	1495.04
COVID:ROA	30.09
COVIDLlnCOGS	4806.09
COVIDLlnST_Liab	910.58

This is a reasonable result. COGS simply represents the cost of production and therefore includes costs such as labor, materials, and other variable costs. To manage the demand shock, toilet paper manufacturers incurred more costs to achieve resilience strategies. As noted in news articles, these strategies included working overtime, converting factory TP lines, and even sending a private jet to transport engineers across state lines (Terlep, 2020a and 2020b). Additionally, both Kimberly-Clark and Proctor and Gamble have acknowledged increased production costs in their annual reports (*Kimberly-Clark - Annual Reports, 2021 and; Proctor and Gamble - Annual Report, 2021*). Assuming change in sales is a proxy for economic resilience, we would expect that increasing COGS leads a firm to be more resilient against a demand shock.

Fixed assets and the change in sales have an inverse relationship. Model one reports that during the COVID-19 period, a 1% increase in fixed assets caused a decrease of change in sales by 0.16%. Intuitively one can expect that an increase in fixed assets would allow a firm to produce more and face the demand shock. However multiple sources have made it clear that toilet paper manufactures operate around a fixed capacity; adding capacity by investment in equipment was not an option (Kavilanz 2020; Narishkin, 2020). Our dataset is congruent with this suggestion. Figure IX shows that fixed assets of the toilet paper manufacturers were constant over time.

Figure IX: Fixed Assets over Time

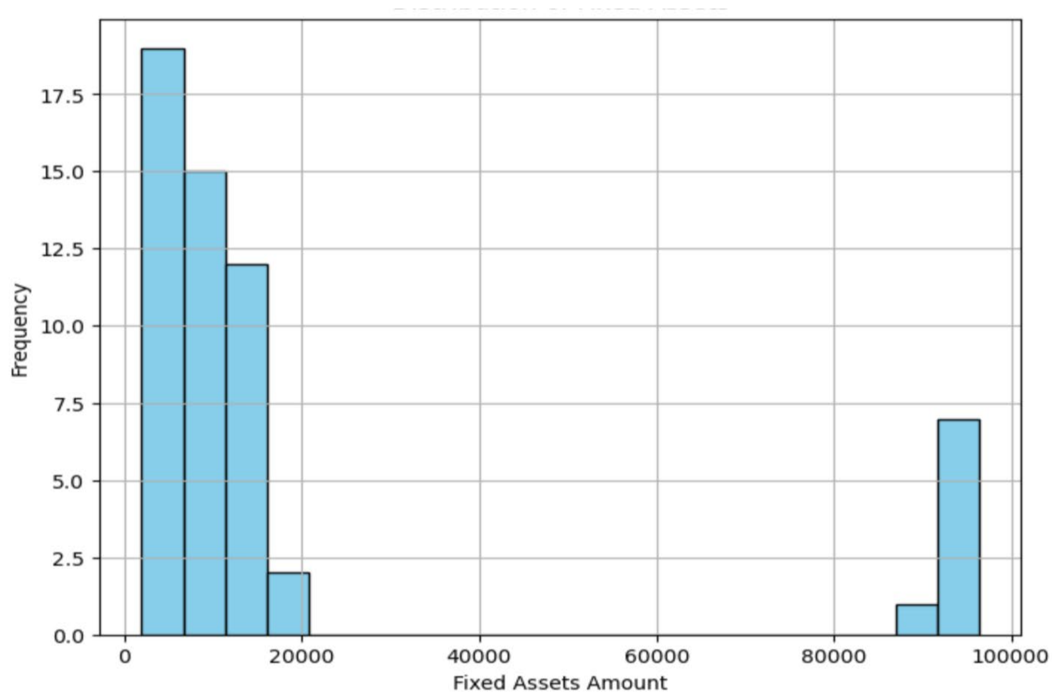


Proctor and Gamble and Kimberly-Clark are both examples of companies that used long-term equipment to increase production. But, since both companies utilized idle factory lines rather than investing in new equipment, their resilience strategy would not be reflected in our fixed assets data (Terlep, 2020a: and Terlep, 2020b).

Another way to interpret fixed assets is through company size. Since fixed assets is defined as the value of long-term equipment, it is reasonable to say that fixed assets can define the size of a firm in terms of production capacity. The interpretation of the fixed assets and COVID-19 period interaction estimate then changes to: “The larger a firm, the less ability they had to increase change of sales during the demand shock.” Smaller firms can have an advantage due to their agility in implementing resilience strategies. Operational changes such as increasing employees, enforcing COVID-19 regulations, and allocating resources may have been harder for a large firm. This proposed size effect can also be caused by a disproportionate share of the demand shock. If the larger TP manufacturers faced a stronger portion of demand, then the small firms would appear resilient in our results.

We can formally test this idea using our data. Figure X shows the distribution of fixed assets among all firms. Based on this, we create a cutoff that defines a small firm as FA < 15 billion, and a large firm as FA > 15 billion. Then we can add two binary variables that separate our firms by size and interact them with our COVID time variable to test significance during the demand shock period.

Figure X: Distribution of Fixed Assets



"Big_Firm_FA" is equal to 1 if a firm has 15 billion or more of fixed assets, and 0 otherwise. The estimate for our size variable and its interaction with the COVID time dummy coincides with this idea. The negative sign of the estimate suggests that the impact of being a "large" firm on the change in sales during the COVID period is negative relative to smaller firms. It is also important to note that the "Big_Firm_FA" estimate is positive in the pre-shock period. This suggests that in a shockless economy, larger firms have a greater ability to increase sales; an expected result due to an economics of scale advantage (Sritharan, 2015).

Table V: Results of Model One Including Firm Size Binary Variable

Model One

							Dependent variable: dTot_Sales
Intercept	0.001	0.059	0.058	-0.107	-0.185*	-0.104	-0.062
	(0.013)	(0.089)	(0.089)	(0.090)	(0.111)	(0.106)	(0.141)
ROA	0.001	0.002*	0.002	0.002**	-0.001	-0.005	-0.005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.005)	(0.005)
lnST_Liab		-0.007	-0.007	-0.078**	-0.103**	-0.057	-0.057
		(0.010)	(0.010)	(0.033)	(0.040)	(0.052)	(0.052)
lnCashR			-0.001	0.022	0.040**	0.021	0.019
			(0.011)	(0.014)	(0.020)	(0.013)	(0.014)
lnCOGS				0.103**	0.212**	0.129*	0.126
				(0.042)	(0.091)	(0.079)	(0.078)
lnFA					-0.054*	-0.036*	-0.038*
					(0.030)	(0.019)	(0.021)
COVID						-0.455*	-0.473
						(0.273)	(0.447)
COVID:lnST_Liab						-0.108	-0.110
						(0.076)	(0.081)
COVID:lnCashR						0.047	0.049
						(0.038)	(0.038)
COVID:lnCOGS						0.389*	0.389*
						(0.213)	(0.216)
COVID:lnFA						-0.161*	-0.158*
						(0.088)	(0.090)
Big_Firm_FA							0.018
							(0.049)
Big_Firm_FA:COVID							-0.009
							(0.118)
Observations	56	56	56	56	56	56	56
R^2	0.016	0.026	0.026	0.126	0.184	0.282	0.283
Adjusted R^2	-0.002	-0.011	-0.030	0.057	0.102	0.103	0.061
Residual Std. Error	0.080 (df=54)	0.080 (df=53)	0.081 (df=52)	0.077 (df=51)	0.076 (df=50)	0.076 (df=44)	0.077 (df=42)
F Statistic	1.583 (df=1; 54)	1.415 (df=2; 53)	0.973 (df=3; 52)	2.296* (df=4; 51)	1.945 (df=5; 50)	2.030** (df=11; 44)	1.753* (df=13; 42)
Note:							*p<0.1; **p<0.05; ***p<0.01

Although interesting, no true effect can be claimed as both Big_Firm_FA and its interaction with COVID carry no statical significance.

ΔTR as a Resilience Metric

Regarding the lack of significance, it is also possible that the change in revenue as a measurement of economic resilience may not be the best approach. This model assumes that the production needed to satisfy demand was unreachable.

For example, assume a firm is facing a demand shock in the COVID-19 period:

$$D_t = quantaity\ demanded\ from\ firm\ in\ period_t$$

$$D_{t+1} = quantaity\ demanded\ from\ firm\ in\ period_{t+1}$$

If a firm can satisfy demand in $period_t$ we can assume that the change in total revenue is positive → $\Delta TR_t > 0$. However, if $D_{t+1} < D_t$, regardless of if the firm can satisfy demand, the change in total revenue might decrease assuming other factors affecting sales remain constant → $\Delta TR_{t+1} < 0$. According to our model, this firm demonstrated strong resiliency in $period_t$ but did not in $period_{t+1}$ when we know that this firm's performance overall is positive.

Model Two

Our results for model two show significance for cash ratio and its interaction with the COVID time dummy: p-value < 0.05. We can reject the hypothesis that our independent variables have a zero effect since $\beta_2 < 0, and\ \beta_5 < 0$. In the pre-shock period,

Table VI: Model Two Results

Model Two

	Dependent variable: lnInv_Turn				
Intercept	1.497***	0.928***	0.781***	0.625***	0.741**
	(0.046)	(0.316)	(0.264)	(0.232)	(0.322)
ROA	0.019***	0.014***	0.005	0.012**	0.005
	(0.004)	(0.004)	(0.004)	(0.005)	(0.020)
lnST_Liab		0.073**	0.072**	-0.009	0.065
		(0.036)	(0.030)	(0.072)	(0.127)
lnCashR			-0.199***	-0.189***	-0.149***
			(0.040)	(0.039)	(0.038)
lnFA				0.087	0.021
				(0.060)	(0.100)
COVID					-0.299
					(0.457)
COVID:lnST_Liab					-0.057
					(0.152)
COVID:lnCashR					-0.156**
					(0.078)
COVID:lnFA					0.056
					(0.122)
Observations	56	56	56	56	56
R^2	0.139	0.186	0.467	0.488	0.542
Adjusted R^2	0.123	0.155	0.436	0.448	0.452
Residual Std. Error	0.337 (df=54)	0.331 (df=53)	0.270 (df=52)	0.267 (df=51)	0.266 (df=46)
F Statistic	20.977*** (df=1; 54)	12.639*** (df=2; 53)	16.484*** (df=3; 52)	19.048*** (df=4; 51)	20.555*** (df=9; 46)

Note: *p<0.1; **p<0.05; ***p<0.01

a 10% increase in the cash ratio causes inventory turnover to decrease by 1.49%. For each 10% increase in the cash ratio, inventory turnover increases by 1.59 % during the demand shock period compared to the non-demand shock period.

In other words, the effect of the cash ratio during the COVID period is more pronounced. Although there are still multicollinearity concerns with FA and ST_LIAB, the variance inflation factors for both of our significant variables remain under 5. The variance inflation factors of other coefficients can be ignored as they do not affect our interpretation of the cash ratio's significance (Wooldridge, 2016).

The cash ratio reflects a company's capacity to meet its immediate financial obligations, while inventory turnover indicates how frequently a company sells and replenishes its inventory. Our results have established that an inverse relationship exists between these two ratios. By looking at their formulas we can identify potential strategies that firms may have used.

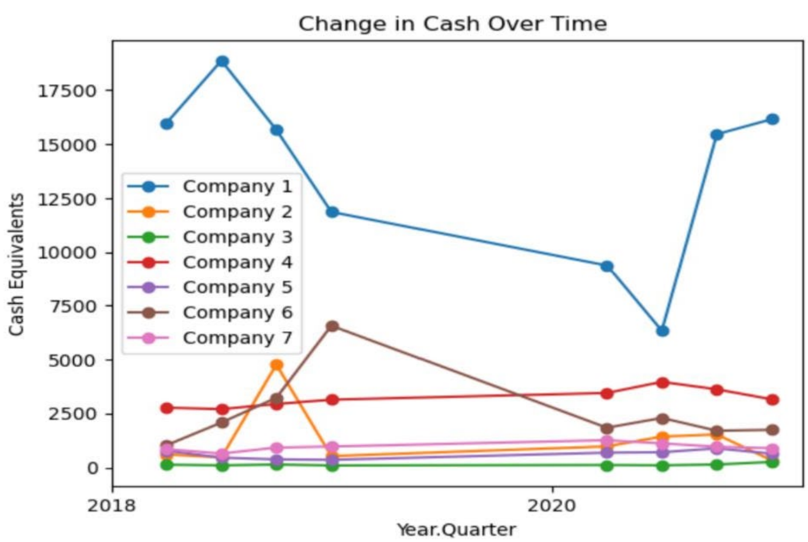
Inventory Turnover	Cash Ratio
$\frac{COGS}{Average\ Inventory\ Value}$	$\frac{Cash\ Equivalents}{Short\_Term\ Liabilities}$

Adhering to the inverse relationship determined, there are two cases in which altering the cash ratio leads to an increase in inventory turnover. These two cases can be classified as resilience strategies since they both lead to an increase in our resilience metric.

Case 1: Cash Equivalents Decrease

A firm that invests more is expected to have a higher inventory turnover ratio according to our results. This conclusion aligns closely with results of the tourism study in the Visegrad countries that determined having more cash allowed firms to be more resilient (Wieczorek-Kosmala, 2020). There is no doubt that most firms had to invest money to survive the demandshock in 2020. Annual reports mentioned previously provide evidence that the demand shock incurred extra production costs. Below is a time series of cash equivalents for all firms in our dataset:

Figure XI: Cash Equivalents over Time



Most firms during the demand shock had decreased levels in cash by Q4 of 2020. The only company that shows an increase in cash equivalents is P&G. In Q3, the company reported an increase of $2.8 billion in short-term debt. These two facts are likely connected.

Case 2: Short-Term Liabilities Increase

Our results suggest that increasing short-term liabilities helped TP manufacturers re-stock their products. In addition to obtaining funds from banks or private lenders, firms can incur debt obligations through other means. A likely source of increased financial obligations is the procurement of large quantities of raw materials or TP ingredients. Given the uncertainty of the demand shock, firms may find a sense of security by ordering more essential supplies than is needed. The paper industry faced a similar demand shock to supply TP manufacturers, as noted by the American Forest and Paper Association in 2020 (Kavilanz, 2020).

V. Conclusion

This work uses financial information from the Bloomberg Terminal Database to determine which characteristics of TP firms contribute to economic resilience during the COVID-19 pandemic. Due to a shift in consumer demand, panic buying, and scalpers, toilet paper could not be found on shelves in early 2020. TP manufacturers around the globe had to face a massive demand spike and work hard to keep up with consumers. The definition of resilience varies from study and context while a standardized method of measuring economic resilience fails to be established. Existing literature uses hypothetical models and production functions to simulate how a firm can stay resilient. This paper helps fill a gap in the literature by applying resilience concepts to real-world data. We employ ordinary least squares to analyze two models using two different resilience metrics. Under the change in total revenue as the dependent variable, we find that COGS have a positive relationship with the change in revenue and that fixed assets have an inverse relationship. As inventory turnover as our second resilience metric, our results conclude that decreasing cash equivalents and/or increasing short-term liabilities can help regulate the stock of inventory.

VI. Limitations

This paper's methodology is largely specific to the toilet paper industry. The TP industry is a highly concentrated market with little available public data. Due to the small number of observations in our dataset, methods that are efficient in dealing with multicollinearity could not be used. Principal component analysis or variable selection methods such as using LASSO or Ridge models would be preferable in our study given a larger dataset. In a natural experiment where data of before-and-after periods are collected, difference-in-difference or mixed effects models are common for panel data estimation (Wooldridge, 2016). These types of estimation methods also account for entity-specific effects, something the model proposed in this paper lacks. In an ideal scenario, our dataset would contain firms that only produce consumer toilet paper. However, the financial data used in our analysis is not perfectly segmented. Companies that primarily produce consumer toilet paper were chosen for analysis.

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