# Impact of COVID-19 Policies on Mobility and Consumer Spending

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## 1. Introduction

The COVID-19 pandemic caused widespread disruptions to both economic activity and public health, compelling U.S. states to adopt a variety of policy responses—from strict lockdowns to more relaxed guidelines. These strategies influenced consumer behavior, labor markets, and health outcomes differently across states (Chetty et al., 2020). While many policies helped reduce virus transmission, they also introduced significant trade-offs for economic resilience.

Both government restrictions and voluntary behavioral changes contributed to the initial economic decline (Goolsbee & Syverson, 2020; Toxvaerd, 2021). In some cases, fear of infection discouraged spending more than lockdowns themselves (Chetty et al., 2020). Even in states with fewer restrictions, individuals avoided high-contact sectors like restaurants and entertainment. Still, mandated policies independently reduced mobility and economic activity (Ligo et al., 2021; Dave et al., 2021). Economic relief policies partially offset these impacts. Stimulus checks spurred short-term increases in spending among low-income households (Coibion et al., 2020), while expanded unemployment benefits supported displaced workers (Gupta et al., 2020). However, when these programs ended, economic inequality widened (Crossley et al., 2021).

COVID-19's effects were uneven. Lower-income and minority communities experienced greater financial and health burdens (Courtemanche et al., 2020), while wealthier individuals shifted spending online and adapted more easily (Andersen et al., 2022). State recovery also diverged. Consumer confidence played a more important role in economic rebound than the mere lifting of restrictions (Serrano-Alarcón et al., 2021). In fact, aggressive reopenings sometimes led to virus resurgences and prolonged instability (Friedson et al., 2020).

Policy decisions were not always grounded in public health data; political and economic pressures also shaped reopening timelines (Hsiang et al., 2020; Dave et al., 2021). Countries with looser restrictions experienced spending declines similar to those with stricter rules, pointing to the importance of voluntary behavior (Andersen et al., 2020). Public communication also mattered—states with clearer messaging saw greater compliance and less disruption (Carrieri et al., 2021).

This paper contributes to the literature by examining long-term state-level economic resilience during COVID-19. Unlike previous studies, it combines mobility, health, and policy data with novel extensions: machine learning models to capture nonlinear relationships, and web-scraped petroleum consumption data to track mobility-related behavior.

The following sections present visual trends, regression models, geographic comparisons, and machine learning results to evaluate how COVID-19 policies shaped consumer spending and public health outcomes across the U.S.

## 2. Data

This study uses a combined dataset to examine how state-level COVID-19 policies influenced economic resilience. Consumer spending data comes from Opportunity Insights’ Economic Tracker. It tracks daily and weekly financial transactions to measure changes in household spending during lockdowns, stimulus payments, and reopenings (Chetty et al., 2020). Mobility data is from Ang et al. (2020), which provides human movement inflow and outflow data at different geographic levels in the U.S. This data helps analyze how mobility restrictions affected economic activity. Policy data is sourced from the Oxford COVID-19 Government Response Tracker (OxCGRT). It records daily policy changes, such as lockdowns, public health rules, and economic aid programs (Hale et al., 2021). Public health data comes from the Johns Hopkins University COVID-19 Dashboard, which tracks COVID-19 cases, hospitalizations, and deaths in real-time (Dong, Du, & Gardner, 2020).

Given the interest of this paper, the dependent variable (Y) is chosen to be consumer spending, which reflects economic resilience during the pandemic. It measures how households adjusted their spending in response to lockdowns, stimulus payments, and mobility changes. Spending is a key indicator of economic recovery, making it essential for understanding policy effectiveness. The independent variables (X) include mobility patterns, government policy indices, and COVID-19 incidence rates. Mobility data tracks movement trends, showing how restrictions and voluntary behaviors affected economic activity. Policy indices measure lockdown strictness, financial aid, and public health rules, which directly influenced consumer confidence and business operations. COVID-19 cases help separate policy effects from individual risk perception, as rising cases often lead to reduced spending even without government mandates. Together, these variables explain why spending patterns varied across states, helping to assess the trade-offs between economic recovery and public health.

## 3. Summary Statistics and Initial Visualizations

This section provides a comprehensive summary of the dataset, highlighting key descriptive statistics for both the dependent and independent variables. Initial visualizations are presented to further illustrate trends and distributions, offering insights into the relationships between the variables and their variability across different states and time periods.

Table 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Spend All | Mobility Inflow | Mobility Outflow | Stringency Index | Government Response Index | Economic Support Index | Incident Rate | Avg. Pop Stay at Home |
| Count | 61614 | 61614 | 61614 | 61614 | 61614 | 61614 | 981 |
| Mean | 0.074 | 707672.407 | 707366.741 | 39.284 | 48.21 | 38.653 | 14911.875 |
| Std | 0.107 | 673949.67 | 674129.917 | 16.487 | 10.554 | 21.433 | 11116.859 |
| Min | -0.431 | 2406.0 | 3012.0 | 16.45 | 28.01 | 0.0 | 0.0 |
| 25% | 0.018 | 212156.87 | 213959.949 | 24.35 | 39.47 | 25.0 | 4532.651 |
| 50% | 0.074 | 707672.407 | 707366.741 | 38.89 | 48.21 | 37.5 | 13170.577 |
| 75% | 0.138 | 812822.455 | 799365.062 | 51.39 | 54.69 | 50.0 | 25162.742 |
| Max | 0.54 | 4841437.0 | 4841598.0 | 93.52 | 80.21 | 100.0 | 58927.992 |

The summary statistics table (Table 1) reveals that the dependent variable, spend all, indicates consumer spending, with an average increase of 7.4%. The mobility inflow and outflow variables show high averages around 707,000, with significant variation. The Stringency Index averages 39.3, reflecting diverse policy strictness across states. The Economic Support Index averages 38.7, while the Incident Rate averages 14,912 with considerable variation. Population stay-at-home behavior varies significantly, with an average of 80,661. The next step is subgroup analysis to examine how different policy stringency levels influenced mobility, spending, and health outcomes.

A graph showing the price of a stock market

Description automatically generated

Figure 1 illustrates how consumer spending evolved in response to major COVID-19 events and policy shifts. It shows a sharp initial decline, followed by gradual recovery. Key policy moments—lockdowns, stimulus packages, and variant surges—are marked to show their potential impact. Spending dropped early in the pandemic but rebounded as restrictions eased and aid was distributed. This suggests that both government policies and public health developments shaped economic behavior.

Economically, the early decline reflects precautionary savings, as consumers reduced non-essential spending amid uncertainty. The recovery coincides with periods of lower stringency and targeted support, highlighting the role of timely interventions. This directly connects to the research question by illustrating how state-level stringency and support measures influenced spending trends over time.

A graph of a number of people

Description automatically generated with medium confidence

Figure 2 shows category-level consumer spending shifts relative to pre-pandemic levels. Essentials rose steadily, while non-essentials and services fluctuated more, reflecting elastic demand. Services declined sharply in 2020 and recovered slowly. These trends highlight how mobility restrictions and stringency policies had uneven effects across spending categories, reinforcing our main research findings.

A diagram of different colored shapes

Description automatically generated

Figure 3 displays the distribution of key COVID-19 policy indices across U.S. states. The violin plots show that while some states adopted consistently strict measures, others were more moderate or variable. Economic support levels also differed. These disparities suggest that consumer spending responses were shaped by state-specific policy combinations. The figure is also the foundation for later analysis by illustrating how policy stringency and support varied, influencing economic behavior and recovery patterns.

A graph showing a line of different colored dots

Description automatically generated with medium confidence

Figure 4 illustrates the relationship between policy stringency and consumer spending, segmented by incident rate quartiles. Across all groups, higher stringency levels are generally associated with lower consumer spending, reflecting the economic costs of stricter pandemic policies.

The negative slope of the overall trend line confirms that tighter restrictions reduced economic activity. Interestingly, the pattern varies by incident rate group. States in the “Low” and “Mid-Low” quartiles (lighter green and orange) show a wider spread in spending, suggesting that even moderate restrictions significantly influenced behavior in areas with fewer cases. In contrast, states with “High” incident rates (pink) exhibit tighter clustering at lower spending levels, likely reflecting both policy enforcement and public fear. This figure supports the research question by showing how both policy severity and pandemic intensity jointly shaped spending outcomes. It highlights that in lower-incidence states, even small changes in restrictions had visible economic effects.

## 4. Results

The results section presents key findings from visual trends, regression analysis, machine learning models, and web-scraped data. These methods reveal how policy stringency, mobility, and economic support influenced consumer spending during the pandemic, offering insight into the state-level variation in economic behavior and recovery across the United States

## 4.1 Map

This section is the visualizations of three maps in state levels, which highlights the strict policies did not necessarily result in better public health outcomes.

A map of the united states

Description automatically generated

This map 1 highlights the top five states with the highest COVID-19 incident rates while showing the average stringency index across all U.S. states. Darker shades represent states with stricter COVID-19 policies, while lighter shades indicate less restrictive measures. The five states with the highest incident rates. The map reveals that high infection rates do not always correspond with stricter policies. Some high-incident states had moderate stringency levels, suggesting that other factors, such as public compliance, health infrastructure, and economic activity, may have influenced outcomes.

A map of the united states

Description automatically generated

This map 2 shows the average stay-at-home behavior relative to COVID-19 cases by state, highlighting the top five states with the lowest incident rates. States like Vermont, Maine, and Maryland had fewer COVID-19 cases but still maintained moderate or high stay-at-home activity. This suggests that strong public compliance or early preventive behavior may have contributed to lower infection rates in these regions. This supports the idea that mobility reduction played a key role in shaping health outcomes during the pandemic. Even without strict policies, voluntary behavioral changes may influence case numbers. The variation across states highlights that not only policy stringency, but also public response, shaped the trade-off between economic activity and health outcomes.

A map of the united states

Description automatically generated

This map 3 displays the average ratio of mobility inflow to outflow by state, with the top five states having the highest ratios labeled. A higher ratio indicates more people entering than leaving, which may reflect relative economic attractiveness or less restrictive mobility policies. From a research perspective, this helps explain observed differences in consumer spending across states. In states with high inflow, the added presence of non-residents may contribute to higher local spending—even if resident activity is lower. This also aligns with regression findings in the follow sub-section, which is showing mobility outflow positively linked to spending, suggesting that economic activity can shift geographically rather than disappear.

## 4.2 Regression Analysis

In this section, the regression results provide insights into how state-level COVID-19 policies shaped consumer spending and public health outcomes.

Table 2

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Model 1 | Model 2 | Model 3 | Model 4 | Model5 | Model 6 | Model 7 | Model 8 | Model 9 | Model 10 |
| ContainmentHealth  Index  Average | 0.548\*\*\* | 0.524\*\*\* | 0.614\*\*\* | 0.614\*\*\* | 0.018\* | 0.628\*\*\* | 0.632\*\*\* | 0.479\*\*\* | 0.550\*\*\* |  |
| Economic  Support  Index | 0.076\*\*\* | 0.073\*\*\* | 0.086\*\*\* | 0.086\*\*\* |  | 0.089\*\*\* | 0.089\*\*\* | 0.066\*\*\* | 0.076\*\*\* |  |
| Government Response Index  Average | -0.615\*\*\* | -0.587\*\*\* | -0.691\*\*\* | -0.690\*\*\* | -0.009\*\*\* | -0.719\*\*\* | -0.716\*\*\* | -0.534\*\*\* | -0.617\*\*\* |  |
| High Stringency |  |  |  |  |  |  |  | -0.054\*\* |  |  |
| Log Economic  Support |  |  |  |  | 0.010\*\*\* |  |  |  |  |  |
| Mobility  Stringency  Interaction |  |  |  |  |  |  |  |  | -0.000\*\*\* |  |
| Stringency Index  Average | -0.009\*\*\* | -0.009\*\*\* | -0.008\*\*\* | -0.007\*\*\* | -0.009\*\*\* |  | -0.005\*\*\* | -0.010\*\*\* | -0.009\*\*\* |  |
| Stringency  Economic  Interaction |  |  | -0.000\*\*\* |  |  |  |  |  |  |  |
| Stringency  Squared |  |  |  | -0.000\*\*\* |  |  |  |  |  |  |
| Constant | -0.050\*\*\* | -0.056\*\*\* | -0.071\*\*\* | -0.077\*\*\* | 0.075\*\*\* | -0.067\*\*\* | 0.213\*\*\* | 0.040\*\*\* | -0.094\*\*\* | -0.053\*\*\* |
| Mobility  inflow | -0.000\*\*\* | -0.000\*\*\* | -0.000\*\*\* | -0.000\*\*\* |  | -0.000\*\*\* | -0.000\*\*\* | -0.000\*\*\* | -0.000\*\*\* |  |
| Mobility  outflow | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* |  | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* | 0.000\*\*\* |  |
| Observa-tions | 61614 | 61614 | 61614 | 61614 | 61614 | 61614 | 30807 | 30807 | 61614 |  |
| R² | 0.464 | 0.463 | 0.468 | 0.467 | 0.002 | 0.467 | 0.295 | 0.069 | 0.544 | 0.464 |
| Adjusted R² | 0.464 | 0.463 | 0.468 | 0.467 | 0.002 | 0.467 | 0.295 | 0.069 | 0.544 | 0.464 |
| Residual Std. Error | 0.078 | 0.078 | 0.078 | 0.078 | 0.106 | 0.078 | 0.089 | 0.082 | 0.073 | 0.078 |
| F Statistic | 8890.771\*\*\* | 13289.592\*\*\* | 7747.965\*\*\* | 7718.818\*\*\* | 66.289\*\*\* | 9010.719\*\*\* | 4297.233\*\*\* | 382.933\*\*\* | 6125.211\*\*\* | 7626.025\*\*\* |

Model 1 serves as a baseline, incorporating mobility, government response measures, containment policies, and economic support. The results confirm that higher policy stringency reduced consumer spending, but economic support measures helped offset part of this decline. For example, a one-unit increase in the Stringency Index is associated with a 0.009 decrease in average spending, holding other factors constant, which is both statistically and economically meaningful. Economic SupportIndex shows a positive and significant coefficient (0.076), meaning stronger support programs are associated with higher spending. The mobility effects are mixed. Mobility outflow is positively associated with spending, indicating that economic activity shifted elsewhere, while mobility inflow negatively impacts spending, possibly due to economic uncertainty or restrictions limiting business operations.

Model 2 removes mobility variables to focus only on policy effects. The results remain stable, reinforcing the idea that restrictions alone significantly influenced consumer behavior, independent of movement patterns. This finding is consistent with Goolsbee & Syverson (2020), who found that consumer spending declined primarily due to restrictions rather than voluntary behavioral changes. However, it also suggests that consumer confidence and enforcement of policies may have varied across states, influencing the effectiveness of restrictions.

Model 3 introduces an interaction between stringency and economic support. The negative interaction term indicates that financial aid does not fully offset the economic costs of strict restrictions. This aligns with Chetty et al. (2020), who found that stimulus payments boosted short-term spending but were less effective in states with prolonged lockdowns. The magnitude may seem small, but it compounds when both components are large, suggesting important diminishing returns. The results suggest that broad economic relief measures may be less effective in heavily restricted areas unless paired with policies that encourage safe economic activity.

Model 4 tests for non-linear effects by adding a squared term for the Stringency Index. The results indicate diminishing returns to restrictions: early policies sharply reduce spending, but additional restrictions beyond a certain point have smaller incremental effects. This is reflected in the negative and significant coefficient on the squared term. This reflects the adaptive behavior of consumers and businesses, where prolonged restrictions lead to alternative ways of operating rather than further economic decline. This finding supports Crossley et al. (2021), who observed that the strongest economic shocks occurred at the beginning of the pandemic, with later restrictions having less impact.

Model 5 isolates the effect of mobility on spending, confirming that mobility outflow increases spending, while mobility inflow reduces it. This suggests that some economic activity was displaced rather than eliminated, meaning that inter-state spillovers played a role in shaping state-level spending trends. The magnitudes, though small, are statistically significant and consistent with the idea that where people go matters for economic outcomes.

Model 6 applies a log transformation to the Economic Support Index. The results show that government aid remains effective but has diminishing returns, supporting the theory of diminishing marginal propensity to consume—additional aid leads to smaller spending increases. The log specification confirms that the largest effects come at the lower end of aid levels.

Model 7 introduces a dummy variable for high-stringency states, confirming that states with above-median restrictions had lower consumer spending. This supports the idea that even moderate levels of restrictions created significant economic disruptions, reinforcing Toxvaerd (2021), who argued that voluntary behavioral changes can sometimes achieve similar health outcomes without the same economic costs. The coefficient of -0.054 shows a meaningful average gap in spending between high and low stringency environments.

Models 8 and 9 conduct a subgroup analysis, splitting the sample into high-incident and low-incident states. The results show that restrictions had a stronger economic impact in high-incident states, suggesting that both policy enforcement and public fear played a role in reducing spending. In contrast, low-incident states experienced a weaker spending decline, indicating that consumer behavior was more resilient when public health risks were lower. This split helps clarify how the same policies may produce different effects depending on context, which future research could extend with fixed effects to control for unobserved state characteristics.

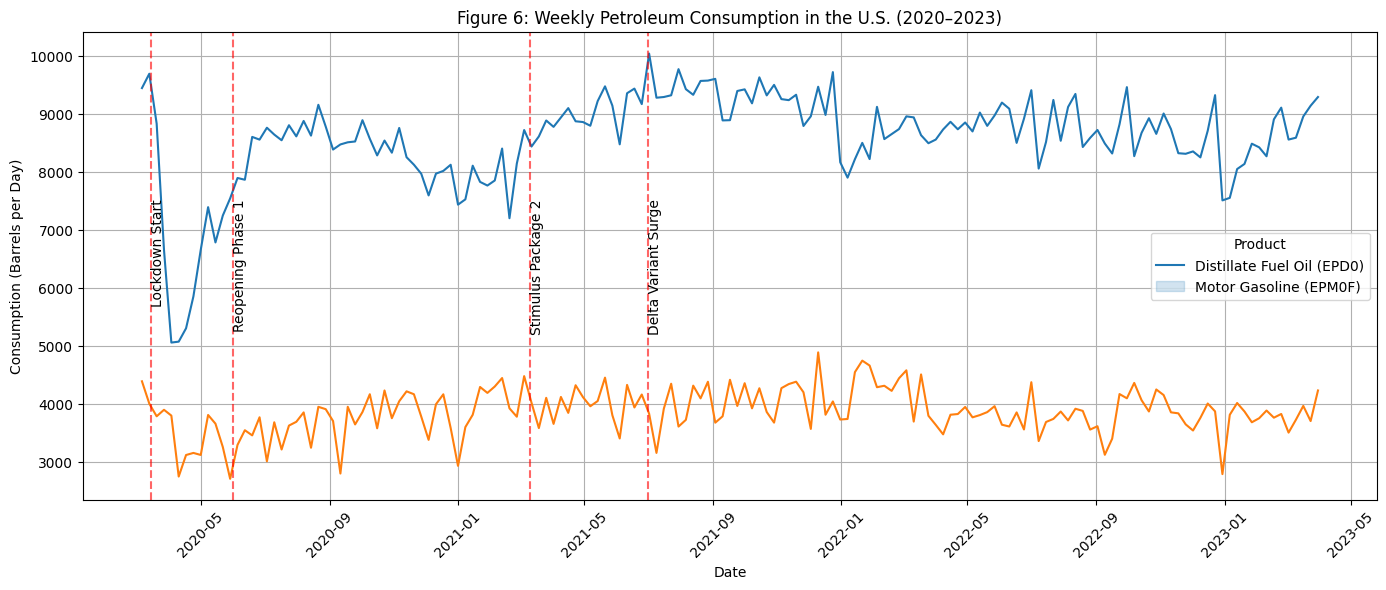
Model 10 introduces an interaction between mobility and policy stringency. The negative coefficient suggests that in states with strict restrictions, mobility increases did not lead to higher spending. This implies that even if people were moving, they were not engaging in economic activity at normal levels due to uncertainty and continued restrictions.

Across all models, Model 4 is the preferred specification as it accounts for both the direct and diminishing effects of policy restrictions. The results confirm that policy stringency significantly reduced consumer spending, but with diminishing effects at extreme levels. Economic support played a stabilizing role, though its effectiveness was weaker in states with strict restrictions.

The findings suggest several important policy insights. First, while lockdowns effectively limited mobility and public health risks, their economic costs were high, and additional restrictions showed diminishing economic effects. This suggests that policies should focus on balancing economic stability with health outcomes, using targeted restrictions rather than broad lockdowns. Second, economic support measures helped sustain consumption, but their effectiveness depended on broader restrictions. This highlights the need for flexible stimulus policies—when restrictions are high, direct aid alone is not sufficient to restore normal economic activity. Instead, aid should be paired with policies that facilitate safe consumer engagement, such as support for remote services, local business adjustments, and phased reopening plans. Third, mobility patterns suggest that economic activity was displaced rather than eliminated, indicating that regional economic spillovers played a key role in shaping state-level recoveries. Future regressions with fixed effects or instrumental variables could help isolate these dynamics more precisely. Future crisis policies should consider cross-state economic interactions, particularly in highly mobile regions where state policies may indirectly influence neighboring economies.

## 4.3 Web Scraping Extension

This project incorporates web-scraped weekly fuel consumption data from the U.S. EIA API, focusing on distillate fuel oil and motor gasoline. These variables reflect mobility-related activity (U.S. Energy Information Administration, 2023).



This plot in Figure 6 shows weekly U.S. consumption of motor gasoline and distillate fuel oil from March 2020 to April 2023. Both fuel types experienced a sharp drop at the start of the pandemic, in March 2020. As reopening began in mid-2020, consumption gradually recovered. Gasoline use increased more steadily, while diesel (distillate) showed a quicker rebound. The second stimulus package in March 2021 appears to support a small increase in gasoline demand. However, consumption remained below pre-pandemic highs for much of the period. A small dip is visible around the Delta variant surge in mid-2021, indicating renewed uncertainty or mobility restrictions.

## 4.4 Machine Learning Models

A regression tree was used to predict total consumer spending by identifying variable thresholds that minimize prediction error. To ensure interpretability and reduce overfitting, the model was limited to four levels with a minimum of ten observations per final group. The Stringency Index shows as the most influential variable, with lower values associated with higher spending. Additional key predictors included mobility outflow and the Containment Health Index. The tree explained approximately 47.7% of the variation in spending. A random forest model produced slightly lower explanatory power, indicating that simple policy and mobility-based splits captured most of the behavioral variation.

## 5. Conclusion

This study examines how states COVID-19 policies shaped consumer spending and public health outcomes by analyzing mobility trends, policy indices, and economic support measures in the U.S. The findings from the regression analysis show that stricter containment measures led to lower consumer spending. Economic support policies helped reduce some of that impact. Mobility had a mixed effect. Mobility outflow was positively related to spending, possibly reflecting people moving away from strict areas to spend elsewhere. In contrast, mobility inflow did not consistently increase spending. This may reflect uncertainty, fear, or local policy differences.

Trend analysis and visualizations show that spending dropped sharply early in the pandemic. It recovered gradually as states reopened and stimulus payments reached households. Spending on essentials remained steady, while services and non-essential items were more sensitive to lockdowns. The maps provide further insight. States with high COVID-19 rates did not always have stricter rules. This suggests that public compliance, health system capacity, or political choices also mattered. One map shows that financial support per COVID-19 case varied widely across states. Some states provided much more help than others. These uneven patterns raise questions about how well resources were targeted and whether support was aligned with actual need.

The machine learning results confirm and extend these findings. The regression tree shows that when the stringency index was low and mobility outflow was high, spending was higher. But when restrictions were strict and mobility dropped, predicted spending fell sharply. These breakpoints reflect real-world behavior. The random forest model finds that policy variables were the most important predictors of spending. In fact, the stringency index alone explained nearly 80 percent of the model’s power. This matches the regression findings and shows that government policy had the strongest effect on economic behavior during COVID. Mobility played a smaller role once policy was accounted for. The regression tree and forest performed similarly to the OLS model in terms of accuracy, but they provided clearer rules and captured nonlinear effects more naturally.

Additionally, the project also contains web-scraped data from the U.S. EIA, which adds an energy consumption dimension to the analysis. Patterns in fuel use, especially during lockdowns and reopenings periods, reinforce the central role of mobility in mediating the policy-spending relationship. These extensions enhance the analytical depth and policy relevance of the study, offering practical insights for future crisis response strategies.

Despite these insights, the study has several limitations. First, the analysis uses state-level data and cannot reflect differences within states. Second, the policy indices do not measure how strongly policies were enforced or how well the public followed them. These real-world behaviors may have had a large effect on spending patterns.

Future research could address these gaps by using data at the city or county level, studying how people responded to policies in practice, and exploring long-term changes in consumer behavior. It would also be useful to combine survey data or real-time mobility apps with policy data to understand how people made decisions during the pandemic. Learning from this period can help governments balance health and economic goals more effectively in the future.

## 6. References

[Include all references cited in proper format.]