EXAMINING THE EFFECTS OF FEMA-RECOGNIZED DISASTERS ON THE US ECONOMY

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ABSTRACT. This project investigates the relationships between the economies of US states and the occurence of natural disasters. In particular, it examines spatial and temporal correlations between disasters and changes in the employment rate to predict the intensity of a disaster's economic aftermath. The analysis aims to identify which states are at the most risk of damaging effects to their labor force from disasters.

1. INTRODUCTION

For economic data, I used the Bureau of Labor Statistics' Employment Status of the Civilian Noninstitutional Population dataset. Unemployment rates (**UER**) were chosen as a measure of economic strength because they are normalized to each state's population, providing a consistent basis for comparison. Additionally, the dataset's monthly granularity enables precise correlation with the timing of disaster occurrences.

For natural disaster data, I relied on OpenFEMA's Disaster Declarations Summaries - v2 and FEMA Web Disaster Summaries - v1. The Disaster Declarations Summaries dataset, which includes all official FEMA declarations since 1953, categorizes disasters into major disasters, emergencies, and fire management assistance. This dataset was particularly valuable for its detailed geographical data and precise date ranges, allowing for spatial and temporal contextualization. The Web Disaster Summaries dataset complements this information by providing financial assistance metrics such as the number of approved housing or individual assistance applications and hazard mitigation grant amounts. These financial metrics are aggregated to quantify the severity of each disaster (**DS**).

Taking an approach derived from physics, it is convenient to treat natural disasters as forces that influence the natural evolution of UERs. In this analogy, UERs are treated as positions in physics, and DS represents the strength of the force. Even without the influence of natural disasters, UERs naturally change over time due to underlying economic factors, such as market trends and technological advancements. These intrinsic dynamics are governed by what we call the *natural law of motion* for UERs. The natural law of motion describes the baseline evolution of UERs over time in the absence of external shocks. By understanding this baseline, we can separate the natural economic changes from the effects of external forces. Specifically, if we subtract the contributions of the natural law of motion from observed UER data, the remaining variation can be attributed to external forces, such as those caused by natural disasters.

Phase plots, a technique commonly used in physics, provide an approach to deriving heuristic models for the natural law of motion. In this study, we employed this heuristic model to avoid the complexity of developing a comprehensive model of the U.S. economy from first principles.

In a standard phase plot, a vector field is constructed with position on the x-axis, velocity on the y-axis, and vectors representing the first derivatives of position and velocity, respectively. In this study, the unemployment rate replaces the position, $x \mapsto \text{UER}$, while the time derivatives are replaced with discrete differences: $\frac{dx}{dt} \mapsto \Delta\text{UER}$ and $\frac{d^2x}{dt^2} \mapsto \Delta^2\text{UER}$. Since our data is discretized monthly, we use these monthly differences in place of continuous derivatives. We will abuse the language and use 'position' and UER as synonyms, ditto for 'velocity' and Δ UER and for acceleration and Δ^2 UER.

Once the acceleration predicted by the natural law of motion is removed, we obtain the residual acceleration (**RA**) and its correlation to DS.

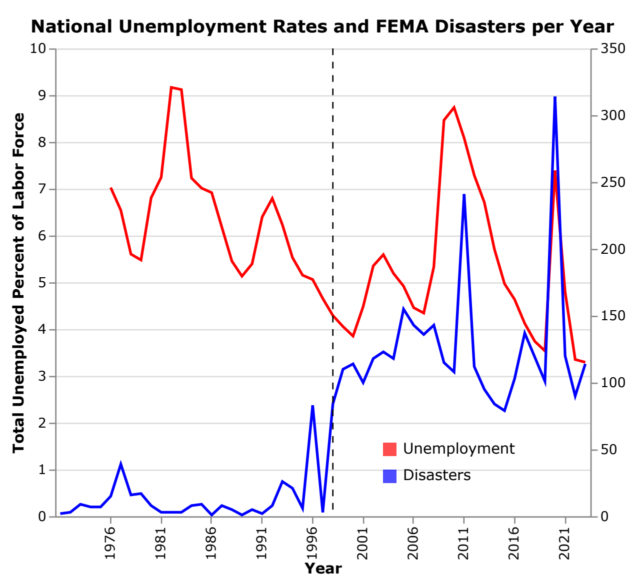

Figure 1. National UER and Total Number of Disaster Declarations Per Year. Natural disaster data appears underreported or missing before 1998.

2. Analysis

The first major choice was to exclude data prior to 1998 due to reliability concerns. As illustrated in Fig. 1, FEMA reports from earlier periods exhibit inconsistencies that could compromise the integrity of the findings.

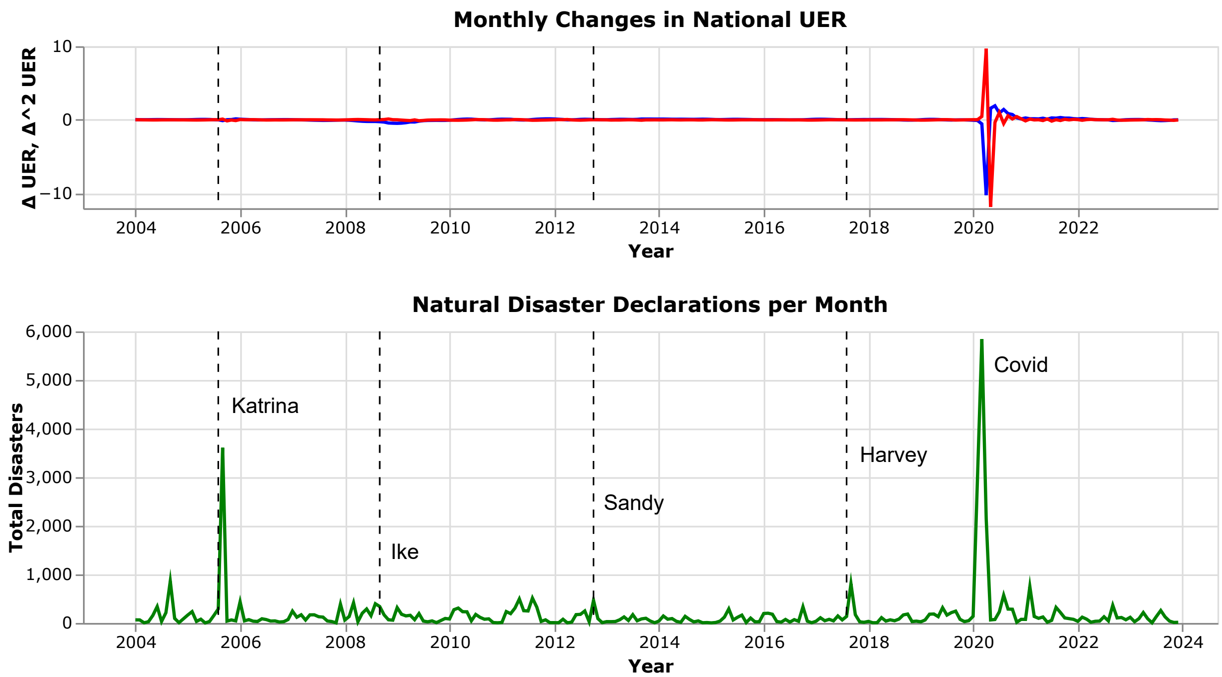

Figure 2. Changes in UER and Disaster Declarations. National UER was computed by as a weighted average of each state's UER, where a state's weight was given by its total labor force in a given month. Monthly population/labor force data was also provided in the BLC dataset.

To ensure the validity of the analysis, it is necessary to confirm that the relationship being examined actually exists. A preliminary review of nationally aggregated data might suggest that only large-scale events, such as the COVID-19 pandemic, have a significant impact on unemployment rates (UERs), see Fig. 2,. However, this observation is influenced by the vast scale and economic diversity of the United States.

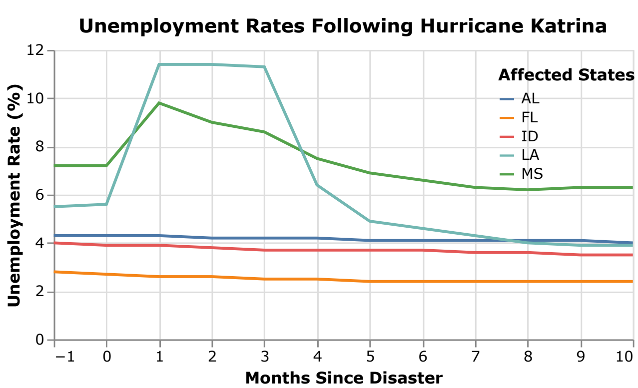

Figure 3. UERs of States Affected by Hurricane Katrina. A state is considered affected if the FEMA disasterNumber links to the state.

A closer examination of state-level data, particularly from regions affected by Hurricane Katrina, clearly demonstrates that natural disasters can have a measurable effect on UERs. For example, in Louisiana, the UER rose by more than 5% and did not return to its previous level for 4 months. Interestingly, Idaho is included in Fig. 3 because the Bush Administration designated Idaho as an evacuation destination for refugees.

Having established the existence of the phenomena we want to examine, we need to remove the effects from the economy's expected evolution. To avoid state-level/regional-level trends getting averaged out, we will concentrate on the Midwest states. Nevertheless, the code created for this study could accept any subset of U.S. states.

Continuing with our exploration of unemployment, we must separate the external effects from the economy's expected evolution. Assuming that unemployment levels, if left alone, evolve in small steps, then the largest vectors in the phase plot are caused

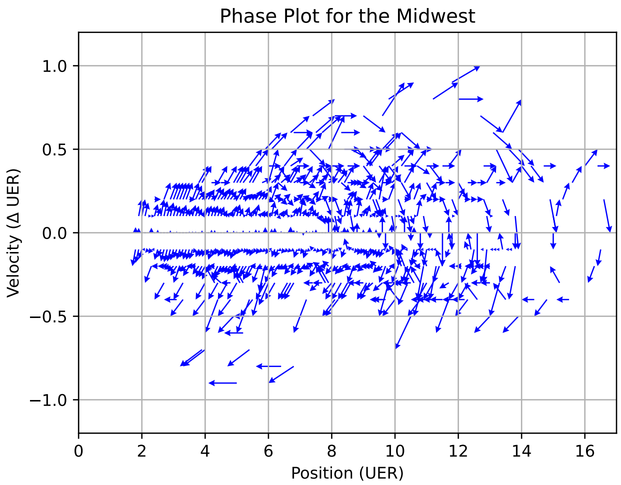

Figure 4. Phase Plot for Midwest Region. Midwest states are: IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI. The rotation around Δ UER $= 0$ implies the system prefers a constant UER. That is, changes in UER are naturally resisted.

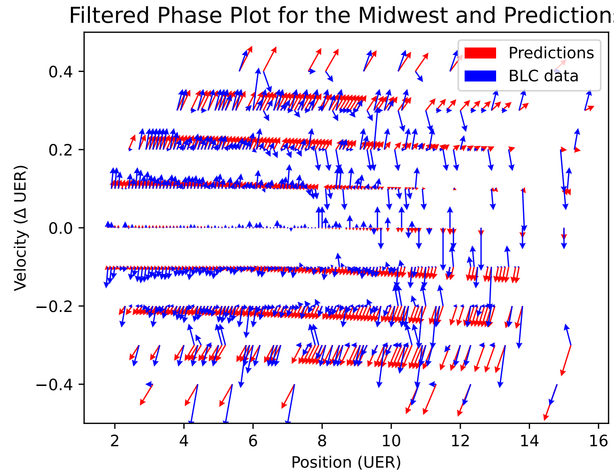

Figure 5. Filtered Phase Plot and Predicted Phase Plot. The heuristic model has a systematic failure in the region with UER $>$ 12 and Δ UER > 0.2. This is tolerated because rapidly increasing, double-digit unemployment is not *natural*: this is where we would expect government intervention.

by external factors like government intervention or natural disasters. Hence, we must impose a threshold on the largest Δ^2 UER we accept as part of our "unperturbed" model. Before filtering, we have have Fig. 4. To ensure readability, only the average accelerations were plotted; the fitting of the model uses the whole cloud of vectors. After filtering the outliers, we obtain the blue vectors in Fig. 5. The predictions are overlaid as red vectors also in Fig. 5 while the residuals are in Fig. 6.

At every point of phase space, the model for the natural law of motion defines a displacement vector. This vector field can be integrated to yield the flow lines, which are the trajectories that an unperturbed system will follow. The coefficients for the heuristic model for the Midwest states and its integration are in Figure 7. Although Figs 4-7 were created for the Midwest, they are typical for all regions and states examined; their analysis is then similar.

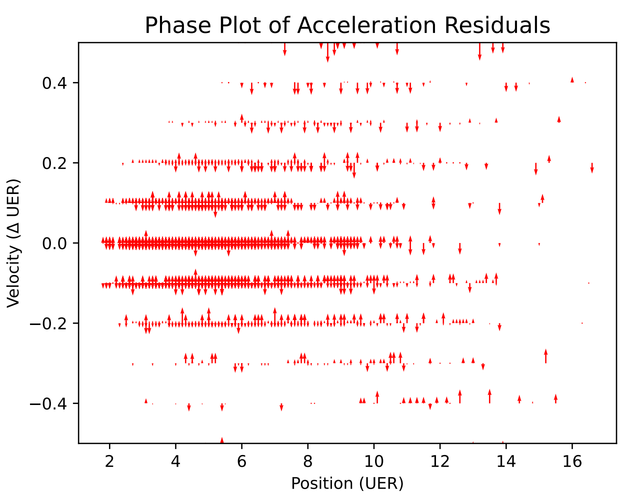

Figure 6. Phase Plot of Acceleration Residuals. Within the region of interest (UER $<$ 10, Δ UER $\in [-0.2, 0.2]$), the residuals are small, and symmetrical around 0. Hence, our model is satisfactory.

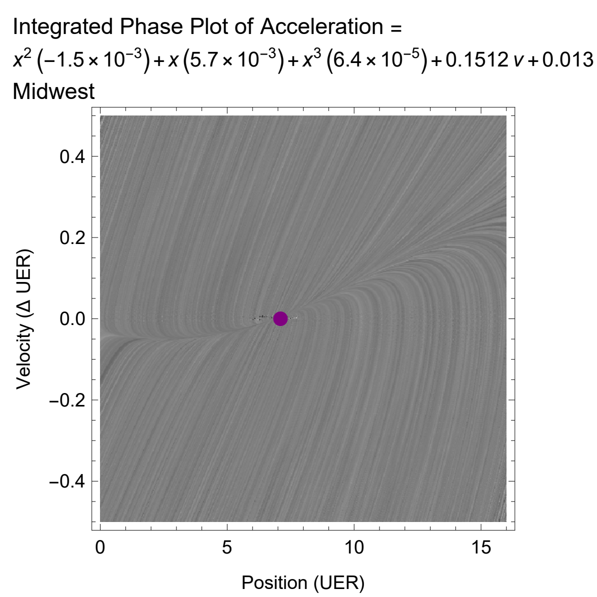

Figure 7. Integrated Phase Plot of Acceleration. The point at UER ≈ 7% and ΔUER = 0 is an unstable equilibrium point because the stream lines 'emanate' from there.

Natural disasters in the Midwest have an extremely small negative effect on unemployment rates, as indicated by the average weighted residual acceleration of -0.00019 %/month^2. This suggests that natural disasters are unlikely to cause significant job losses in the region. For insurance companies, this makes the Midwest an attractive area to operate, as they can expect policyholders to maintain their ability to pay premiums even after natural disasters, ensuring financial stability when claims need to be paid out. In contrast, Florida has one of the most negative impacts, with an average weighted residual acceleration of -0.0193 %/month^2. Accordingly, insurance companies are currently trying to leave the state.

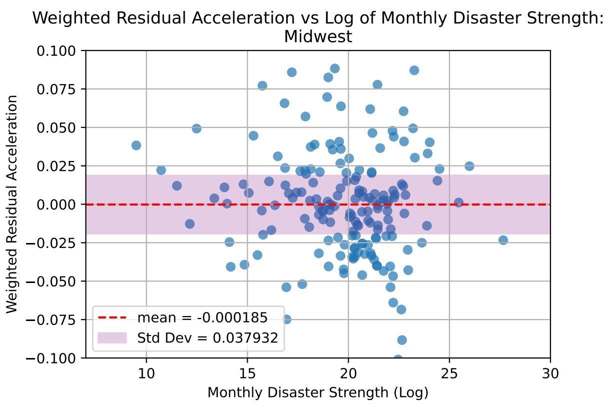

Figure 8. Acceleration Residuals vs Disaster Strength for the Midwest. Midwest states are: IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI.

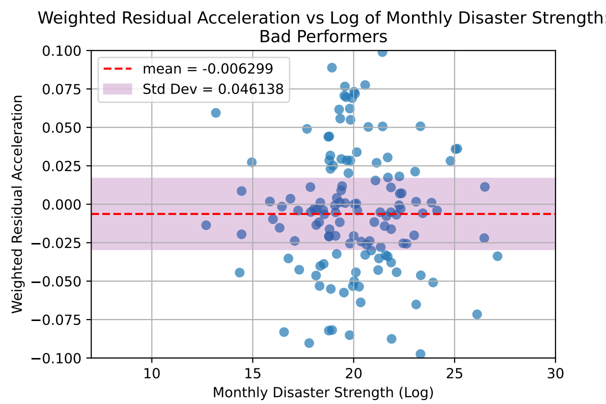

Figure 9. Acceleration Residuals vs Disaster Strength for Bad Performers. Bad performer states are states with mean residual acceleration smaller than -0.015. They are: AR, FL, MN, PA, TN.

We were not able to establish the 'mass' for the system. That is, the scatterplots in Figs. 8 and 9 do not have a discernible correlation. Of course, refining the heuristic model until we can find the inertia (correlation between the force and the acceleration) is of extreme importance (it would allow the Federal Reserve to tailor the size of the interventions), but that is beyond the scope of this paper.

3. Conclusion

It is not possible to emphasize enough the importance of phase plots. The "natural law of motion of UERs" was approximated with a cubic restoring force (polynomial up to UER^3) and a damping force (proportional to ΔUER). The insight was possible only because the overall shape of the phase plot suggested those terms.

The equilibrium point in Fig. 7 suggests that, when left to evolve naturally (no Federal Reserve and no natural disasters), the unemployment rate will diverge from the unstable equilibrium. This alone proves the necessity of the Federal Reserve to act as a restorer of balance, if only to push UER below 7%.

The choropleth in Fig. 10 highlights that some states benefit economically from natural disaster declarations. This may occur as tourists and snowbirds, who inflate UER, return home (e.g., Hawaii) or as refugee destinations experience economic boosts from FEMA funds (e.g., Idaho).

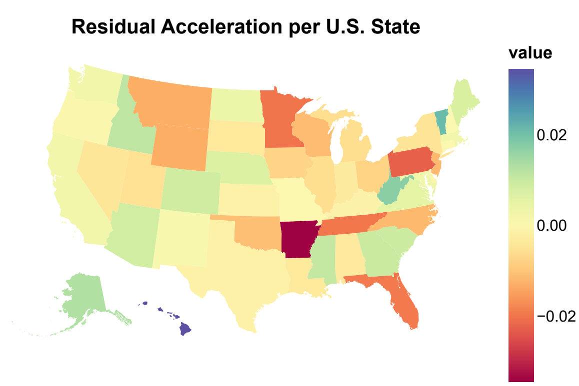

Figure 10. Residual UER Acceleration per US State. Note that even though Texas has the most disaster declarations of any state, its UER practically unaffected by natural disasters.

Interactive analysis using the cloropeth proves the following statement (which is obvious in retrospect): *the larger the area considered, the smaller the effect of the natural disasters*. The extreme is shown in Fig. 2. Even grouping the worst performing states, see Fig. 9, the weigthed average for that group is less malign than the residual acceleration of the individual states.

4. Bibliography

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