

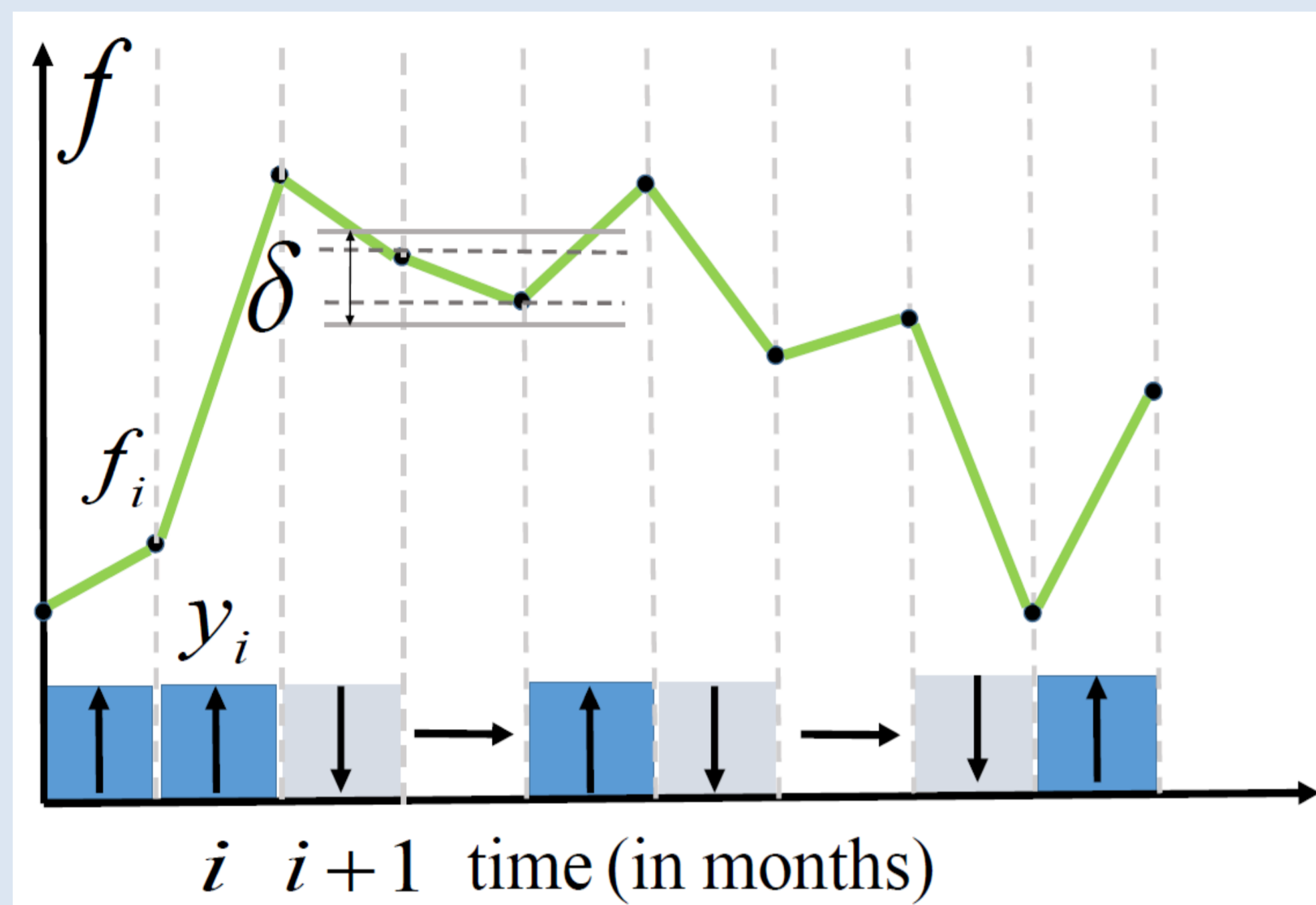
## Abstract

Recessions are economic downturns that can be recognized from macro-indicators such as the Dow Jones Industrial Average (DJIA) and the Federal Reserve Interest Rate (FRIR). To provide early-warning signals of recessions and similar systemic transitions, here we propose a new approach based on pattern recognition, called inclination analysis [1, 2]. For this purpose, we develop a stochastic model based on time-series analysis to assess the probability of a recession to occur at a given moment in the past, present, or future. Calibrating our model to data proceeds in three steps, involving the coarse-graining of the available input time series, the identification of short series motifs that foreshadow recessions, and the optimization of key model parameters according to the model's desired forecasting horizon.

## Methodology

Key steps:

- Time series mapped onto sequence of **inclination signals**:  $\{\rightarrow \uparrow \downarrow\} f_i \mapsto y_i$

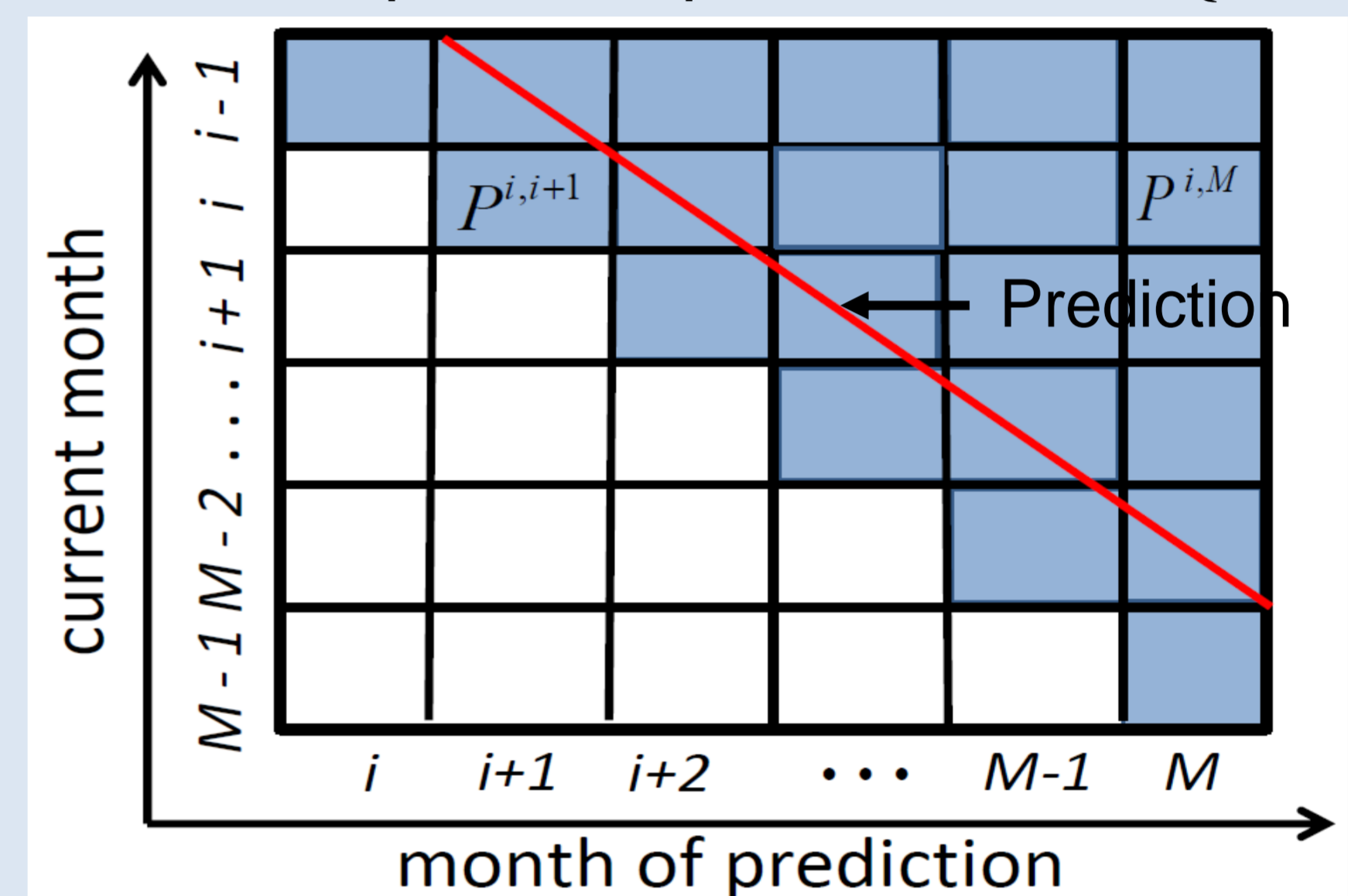


- A set of **binary coding** of time series is assigned:  
 $y \mapsto s, s \in \Omega, \Omega = \{\sigma_i : \sigma_i - \text{binary code}\}$
- Based on frequency in historical path of  $s$  **transition probabilities** are defined:  
 $\rho_{\sigma_i}^{\sigma_{i+1}} = \rho\langle \sigma_i | \sigma_{i+1} \rangle, i = 1, \dots, N$

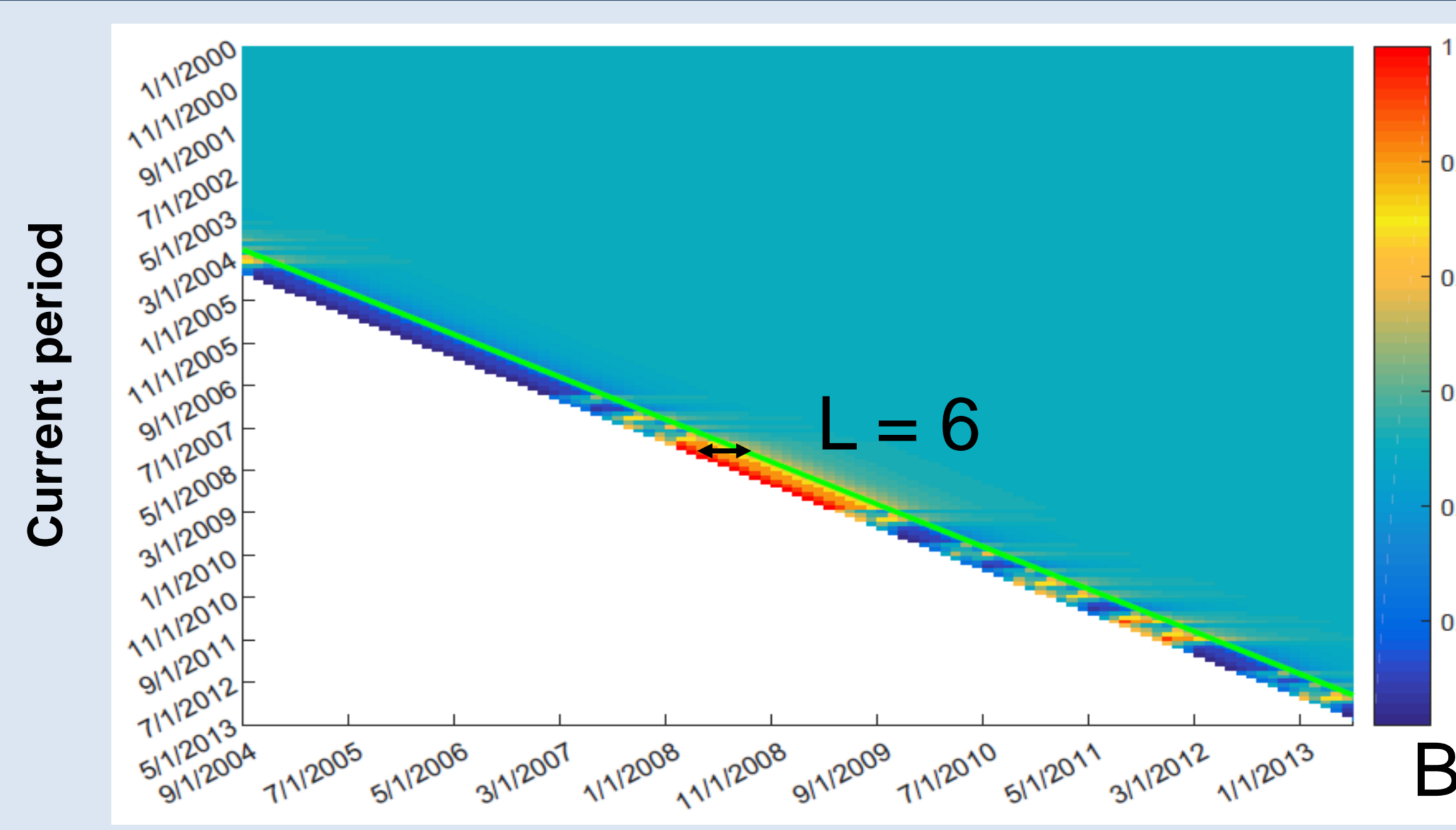
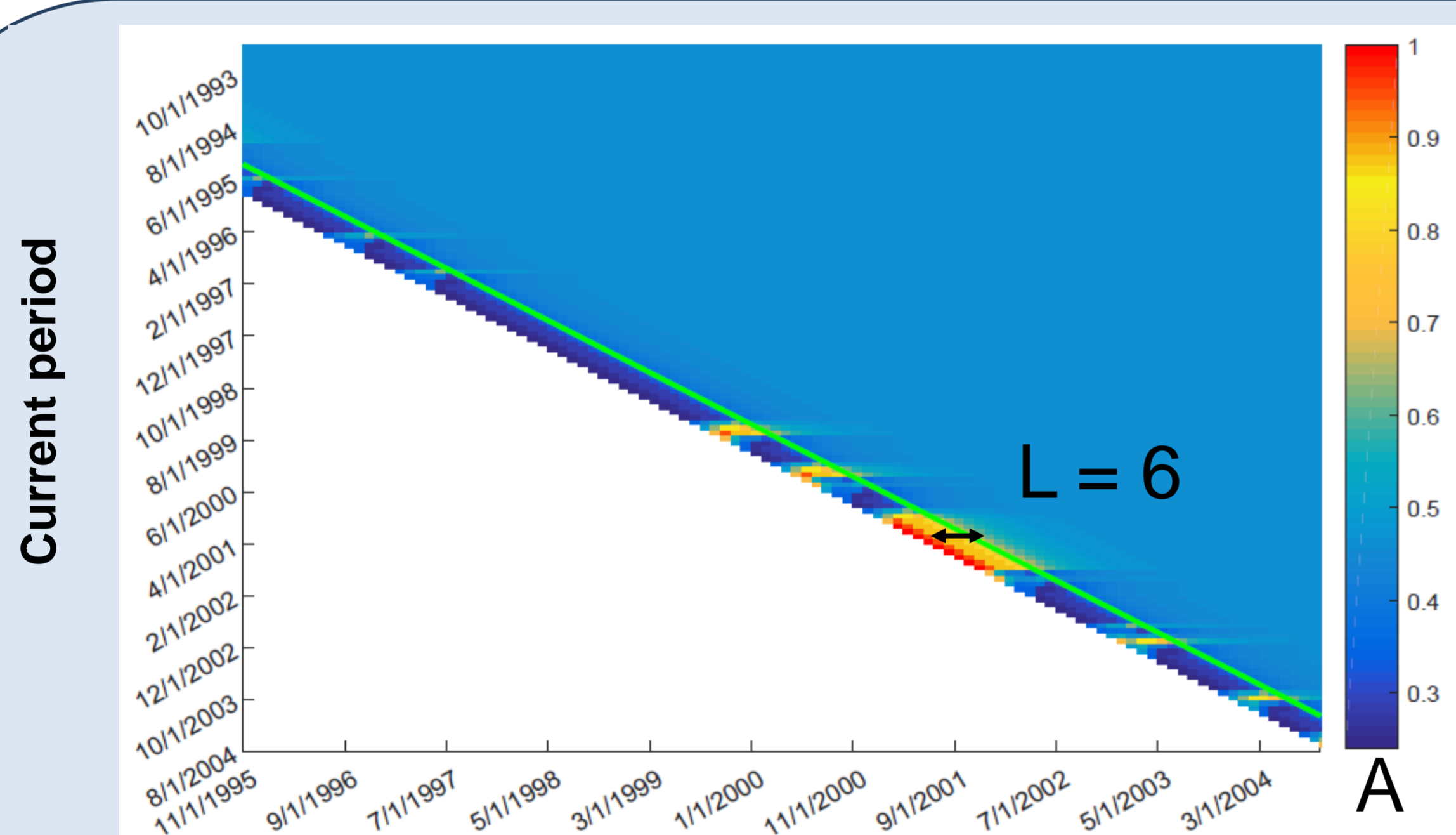
	11	10	01	00	
$\rho_{11}^{11}$	0	$\rho_{11}^{01}$	0	11	
$\rho_{10}^{11}$	0	$\rho_{10}^{01}$	0	10	
0	$\rho_{01}^{10}$	0	$\rho_{01}^{00}$	01	
0	$\rho_{00}^{10}$	0	$\rho_{00}^{00}$	00	

Model parameters are optimized so that to maximize prediction power for the past recessions

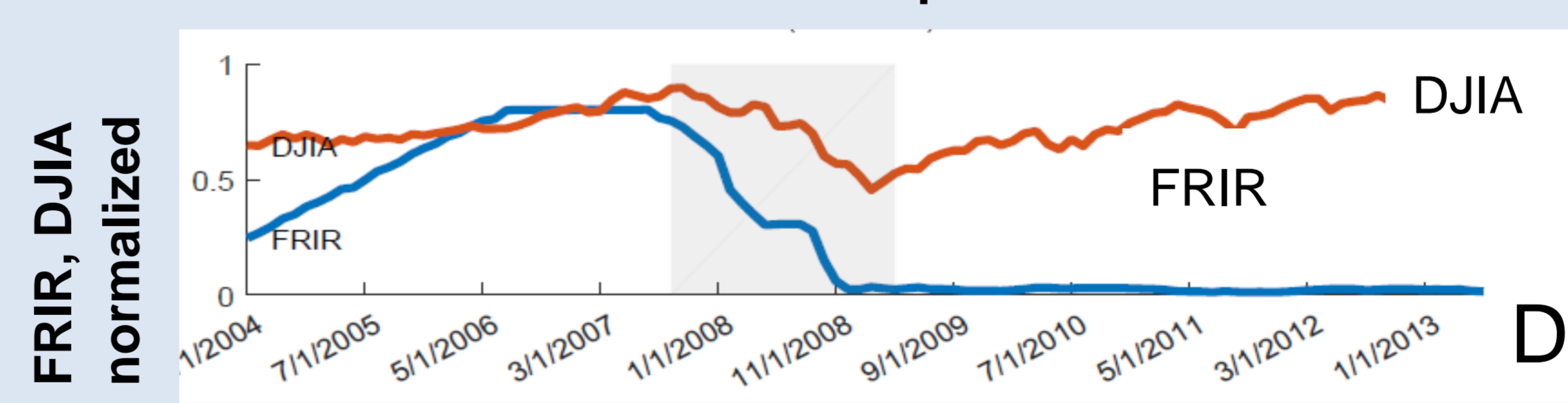
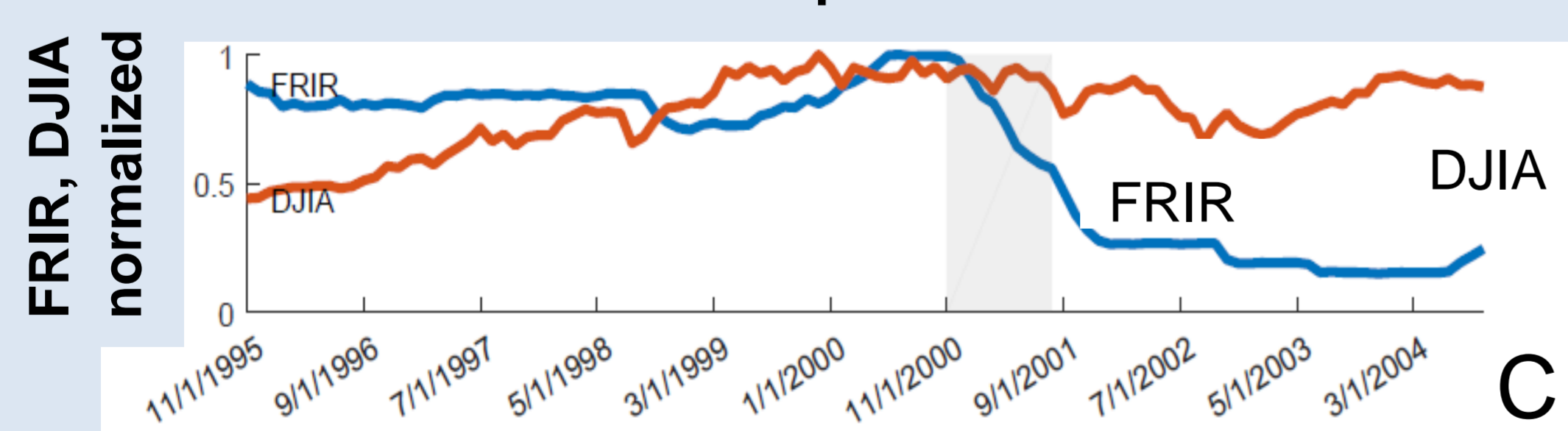
- The **recession probability** is evaluated for the optimized parameters:  $\{P^{i,j}\}_{i=1, \dots, M, j=i, \dots, M}$



## Preliminary Results



**Fig. (A)(B) Recession matrix.** High values indicate the likely commencement of recession.



**(C)(D) FRIR and DJIA time series** with recession periods indicated by shading.

## Conclusions

- The method provides an assessment of **recession probability** through a new kind of **pattern-recognition algorithm**: using the economic time series, it provides an early warning signal.
- The applicability of our method is shown for a set of  $n = 2$  **economic macro-indices (DJIA, FRIR)**; in general, more macro-indices can be used

## References

- [ 1 ] A. Puchkova, A. V. Kryazhimskiy, U. Dieckmann. *Inclination Analysis Can Yield Early-Warning Signals of Economic Recessions*, Internal Report, IIASA  
 [ 2 ] A. Puchkova, A. V. Kryazhimskiy. *Towards detection of early warning signals on financial crises*. IIASA, IR-12-001, 2012

## Acknowledgments

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