Early warning systems

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Abstract

Complex systems can undergo sudden, irreversible changes when critical thresholds—known as tipping points—are crossed. While statistical indicators can serve as early warning signals (EWS) of such transitions, their integration into decision-making frameworks remains limited. This paper develops a theoretical framework connecting early warning signals to optimal management of systems prone to tipping. We translate early warning indicators into the formal language of management science, introduce an analytically tractable approximation of tipping indicators, and derive practical insights about the optimal design and value of early warning systems. Our analysis reveals how the optimal design and value of these systems depend on both the magnitude of potential damages and decision-maker risk preferences, providing a foundation for incorporating early warning signals into management decisions.

Keywords: Early warning signals; Tipping points; Critical transitions; Decision theory; Risk management; Uncertainty; Learning.

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