AN ECONOPHYSICS FRAMEWORK TO FOREIGN VOLATILITY TRANSMISSION

ABSTRACT:

This study explores the use of an econophysical framework based on differential geometry (Gauge Theory) to track and measure the cross-border transmission of volatility between financial markets. By modeling markets as interconnected systems in a global coordinate frame, the approach aims to identify unidirectional and multidirectional pathways through which foreign volatility propagates across countries.

Existing methodologies have sought to explain volatility and risk transmission beyond domestic effects, in the context of globalized “travelling risk,” where countries increasingly import volatility originating abroad. This study proposes applying econophysical theory - specifically gauge theory from differential geometry - to capture both the direction and magnitude of volatility transmission, highlighting deep structural parallels between economic and physical systems.

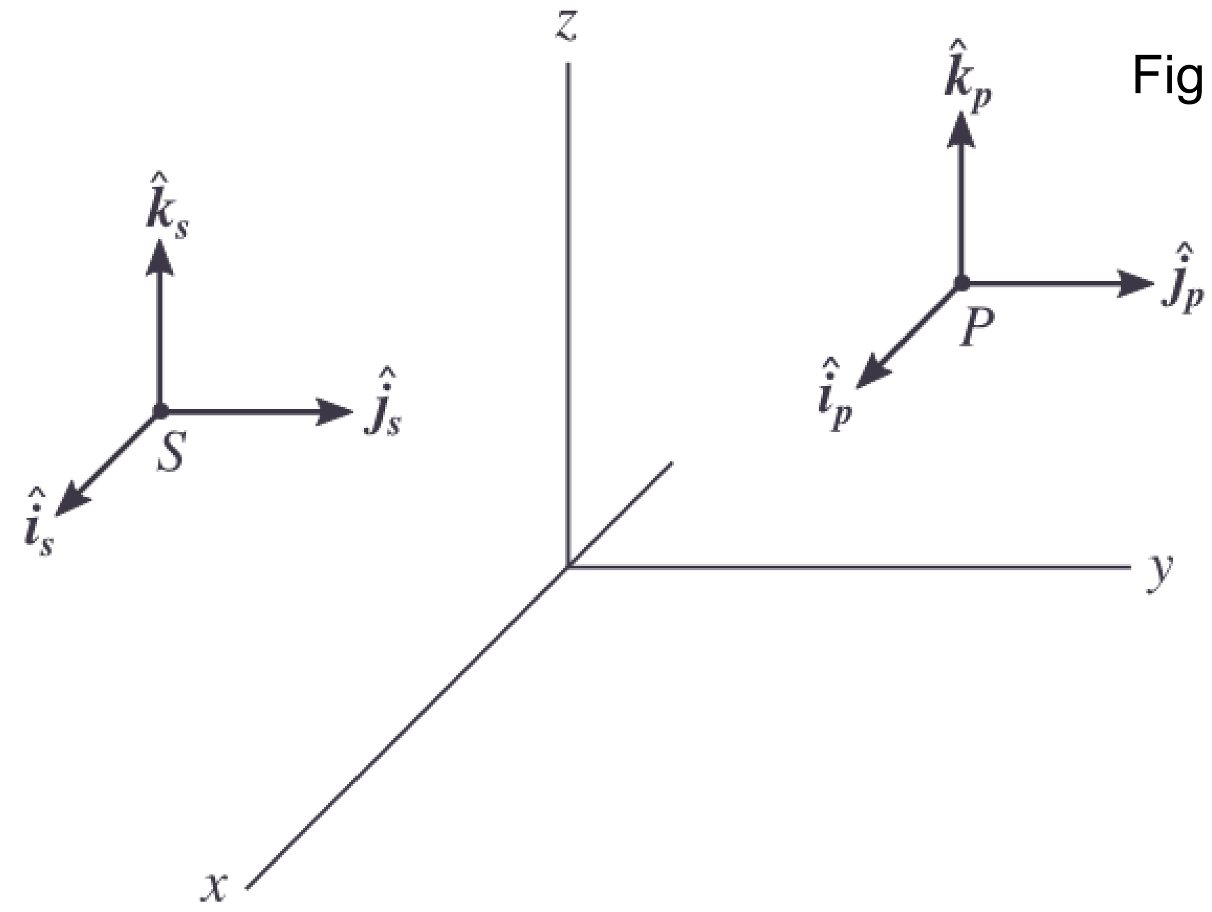

Fig 1

INTRODUCTION:

The similarity between economics and physics is not surprising. Much of the world is filled with complex patterns & interacting units, whose aggregate behaviour is often stable and predictable. Black-Scholes Model uses Brownian motion for instance. Another example is stochastic learning for optimal meals in the Kolkata Paise Restaurant problem being a typical resource allocation issue.Thermodynamics, Shrodinger’s Uncertainty Principle etc. are also widely seen as potential concepts for financial systems. A popular application of econophyics has been in percolation theory of networks in understanding how local interactions between individual agents lead to larger systemic events - much like in 2008 (see Fig 2).

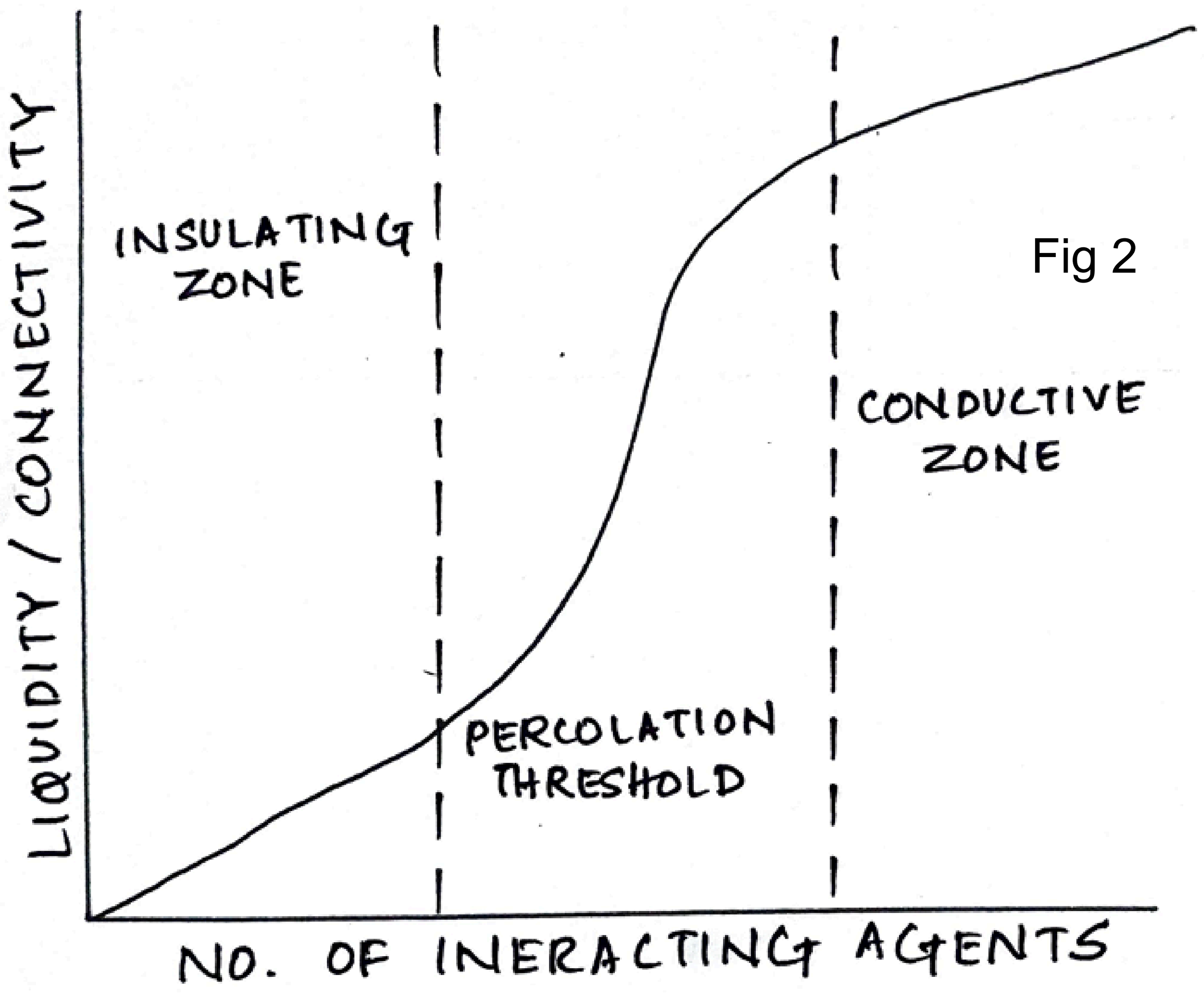

Fig 2

CONCEPT:

Think of the global financial system as a geometric space, and each market index (foreign and domestic) lives on its own local coordinate chart, governed by its domestic drivers (inflation, interest rates, news, crises), and volatility acts as the coupling field that transports information, stress, and risk across markets in a global system (see Fig 1).

In physics, a charged electron in an EM field moves along a deflected path because the surrounding field alters the geometry of the space it travels through. Its motion follows this geometry rather than an explicit force. The volatility transmitted from abroad is the part of the deformation caused to domestic volatility by foreign field. Differential geometry provides a framework to distinguish the extent of distortion of the path due to the force - here, being the foreign volatility transmitted. (see Fig 3).

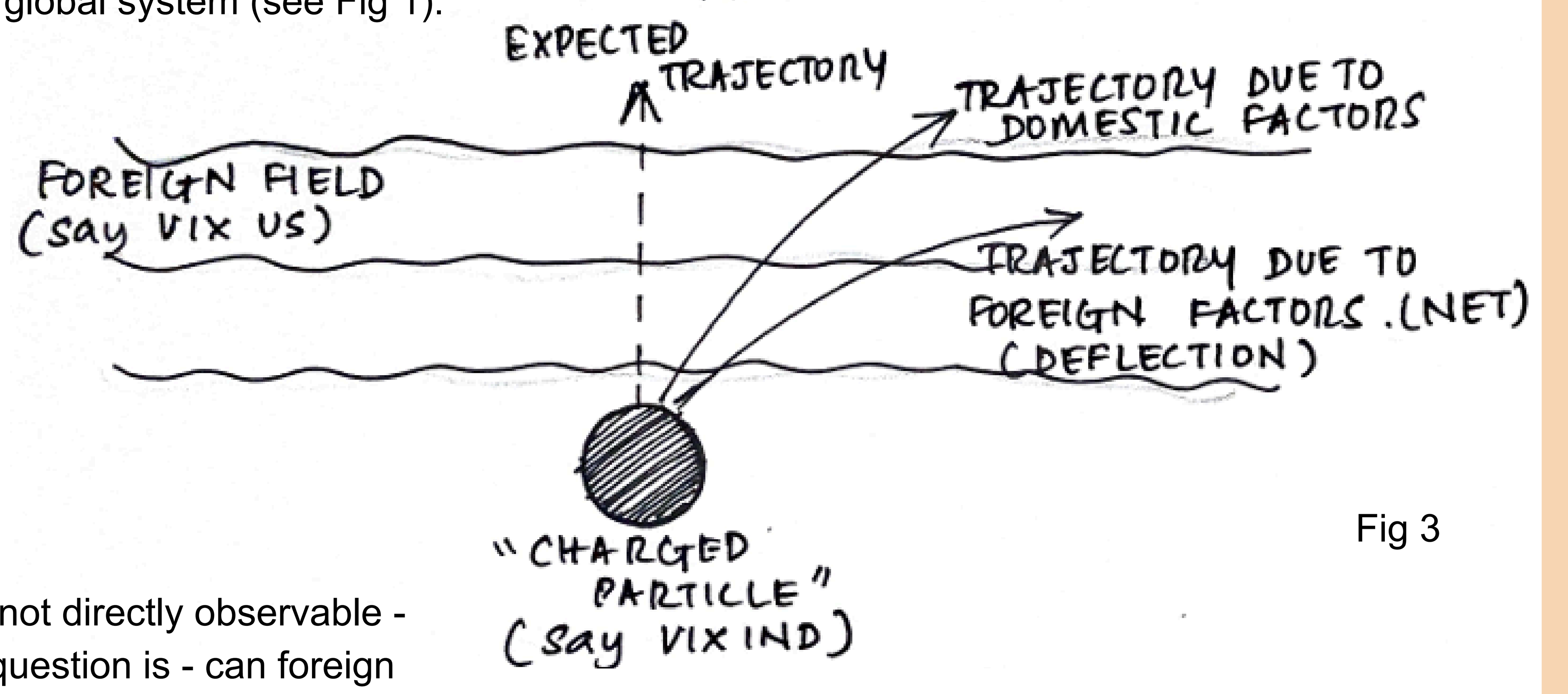

Fig 3

METHOD/PROCESS PROPOSAL:

Gauge theories are essential for quantizing forces that are not directly observable - especially helpful in our case, since volatility is latent. Our question is - can foreign voltatlity transmission channels be accurately represented through a gauge theory model?
Each is affected by their own parameters of interest rates and inflation rates between them, but connected by a volatility tranmission channel.
The simplest representation of the framework would look like this:

$$\Delta\sigma_t^{dom} = \frac{\delta\sigma^{dom}}{\delta t} + A_t\sigma_t^{dom}$$

The unique introduction here is A (for → dom), a guage field of the volatility transmission channel. It measures by how much the path of domestic volatility is distorted due to force of foreign volatility changing its curvature.
The model requires further research on expanding to include lagged effects of the dependent and independent variables, since past news, and news that takes time to reach both affect volatility state at time t. However, volatility is no longer a “noise” measured, but fully integrated into the market systems and their interaction. Using data from Bloomberg terminals to caputure time variant values and run this equation, to compare with established volatility models like BEKK-GARCH and VAR models is proposed to observe feasibility and effeciency of such econophysical models.

SPECIAL FEATURES:

Standard models such as AR, VAR, and GARCH treat volatility transmission as shocks or lagged spillovers, with foreign volatility enterin as an exogenous variable while domestic market structure remains fixed. This view cannot fully capture directionality, asymmetry, path dependence, or structural changes in domestic volatility dynamics. Gauge theory shifts the representation by modeling each market as a local system with its own internal drivers, embedded in a global financial space. Volatility transmission is not an additive shock but a geometric modification of how the system evolves. The gauge field represents the transmission channel, allowing a clear separation between intrinsic domestic volatility and extrinsic, imported volatility, while naturally capturing directional, asymmetric, and path-dependent contagion effects. A latent variable is visualized!

More on this proposal: https://www.diyd2.in/assets/files/Harshini_Eco.pdf

References: https://docs.google.com/document/d/1CruIKwhhQioTTR2DdpAozEdALl4wdV-9yknOrAWNMSU/edit?usp=sharing

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