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Graph Neural Network in Space: A New Gravity Explanation of Continuous Trade

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The structural gravity models of trade integrate the like of Newton's Law of universal gravitation with different economic motivations of general equilibrium models. The key advantage of these workhorse models of international trade is that they can relatively consistently fit the data on bilateral trade flows, while allowing to succinctly perform counterfactual analysis of applied policy interests. However, the role of neighboring locations of origins and destinations and its effect on bilateral trade flows are not accounted for in traditional gravity models where bilateral geographical barriers increase the size of implied trade costs hence impede trade between the same bilateral trade partners. This paper introduces graph neural network (GNN) into gravity model of trade and uses recent deep learning techniques to provide an alternative explanation of gravitational patterns of international trade flows in a geospatial framework. Unlike traditional machine learning algorithms including neural networks which typically apply to data that lie in Euclidean spaces, GNN operates on interpretable graph domain, thereby making good use of unique non-Euclidean data structure. These spatial characteristics reveal sequentially the hidden factor between country nodes and trade flows from the representation of neighborhood matrices and automatically provide a new rationale for gravity. We study interpretation approaches to interpreting model components after the model is well-learned (i.e., post-hoc interpretability analysis) and focus on the improved gradients with respect to endogenous variables (to obtain the *saliency of shocks*) in counterfactual analyses of most computable general equilibrium models. We use these interpretation methods to measure the welfare gains of trade.