An Intelligent System for Automated Share Evaluation using Graph Neural Networks and Semantic Bayesian Networks

OVERVIEW

Portfolio management is a decision-making process that aims to maximise return through the proportional allocation of capital into identified shares. The initial **share evaluation** phase involves identifying shares with suitable characteristics for investment.
Stock markets are dynamic systems, and share evaluation ordinarily requires expert domain knowledge.

PROBLEM

Existing AI techniques are black-box and provide minimal decision support. INVEST is a **semantic Bayesian network**-based intelligent system framework but has yet to be implemented.
Stock market prediction using **spatial-temporal graph neural networks** is untested, for which the forecasts can proxy share evaluation.

OBJECTIVES

Our aims were to design and implement the INVEST system in Python and evaluate its performance for share evaluation and decision support.

We extended the system and investigated:

- Different Bayesian network topologies
- The stability and robustness of the intelligent system
- The integration of a GNN predictive component
- The application of ST-GNNs to JSE-listed share price forecasting
- The capability of a correlation matrix to encode stock market structural information

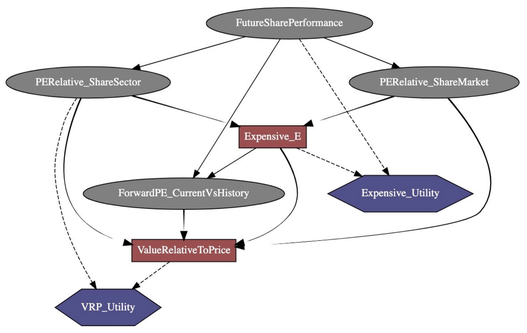
SEMANTIC BAYESIAN NETWORKS

The INVEST system incorporates **ontologies** and **Bayesian networks** to support decision-making for share evaluation, using three decision networks.

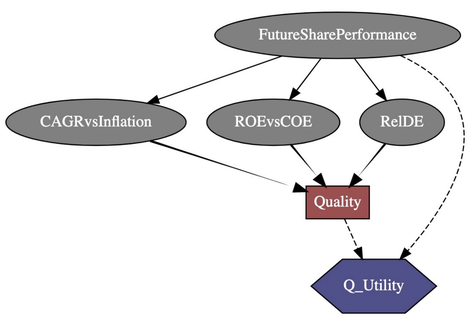
We tested INVEST with varying conditions and extensions:

- Systematic risk-extended Bayesian network
- ST-GNN model integration
- Ablated Bayesian network topologies

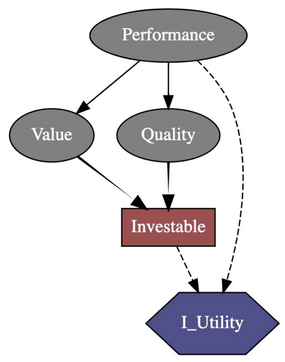
We used price and fundamental data for 36 JSE-listed stocks with one-year and one-month holding periods.



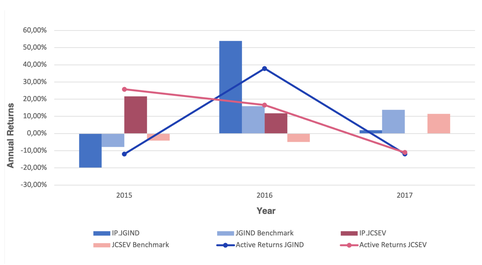
Value Evaluation Bayesian Network



Quality Evaluation Bayesian Network

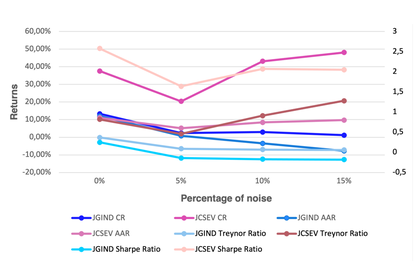


Investment Recommendation Bayesian Network



Annual Returns of INVEST vs Benchmark (β = 0.2)

Annual Returns of INVEST vs Value Network (β = 0.2)



Noise Simulation (β = 0.2)

INVEST demonstrates consistent ***excess returns***.
However, the base system is ***unstable*** and susceptible to noise.
The results provide evidence to support the ***inclusion*** of ***systematic risk***.

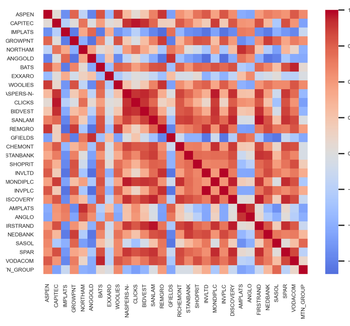
The ablation study showed the relative importance of the ***Value Evaluation*** network in the overall framework.
We concluded that the ST-GNN ***predictions improve performance*** for short-term holding periods.

GRAPH NEURAL NETWORKS

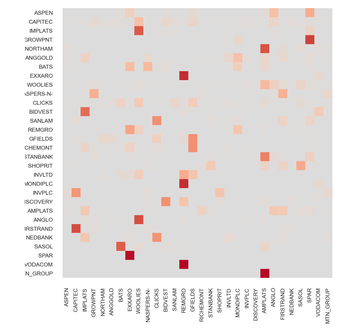
We tested **Graph WaveNet (GWN), MTGNN, StemGNN** and baseline LSTM on single-step and multi-step forecasting tasks.
We used the daily closing prices of 30 stocks in the JSE Top 40 Index.

The results show that ***MTGNN*** outperforms on a single-step forecasting task, and ***GWN*** is best for multi-step forecasts.

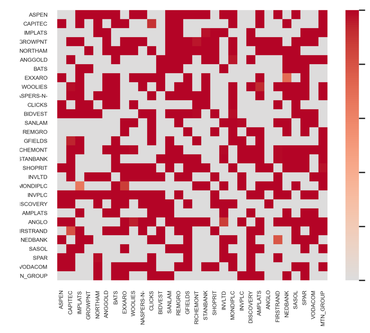
We concluded that ST-GNNs can be successfully applied to the ***price prediction*** problem.



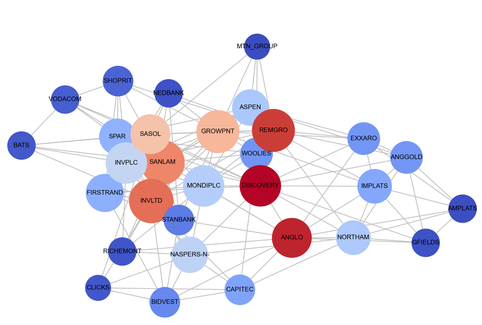
JSE Top 40 Index Correlation Matrix



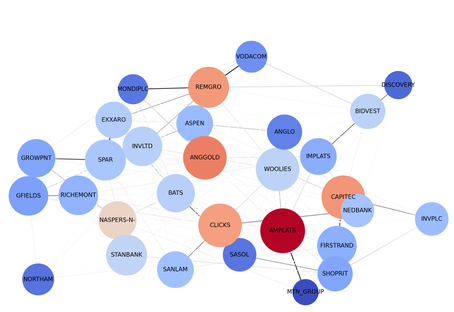
GWN Adaptive Adjacency Matrix



MTGNN Adaptive Adjacency Matrix



Simple Correlation Network



Graph WaveNet Adaptive Graph

We selected a **correlation matrix** to capture inter-share dependencies and seed the ST-GNN graphs.
We found that including linear correlations ***negligibly impacts performance***, evidenced by the disparate correlation and adaptive adjacency matrices.

While our results suggest that a correlation matrix is an ***unsuitable proxy*** for ***structural information***, network analysis revealed potential alternative dependency encodings.

University of Cape Town
Department of Computer Science

www.cs.uct.ac.za
dept@cs.uct.ac.za

+27 21 650 2663

PROJECT TEAM

Insaaf Dhansay
dhnins001@myuct.ac.za

Kialan Pillay
pllkia010@myuct.ac.za

Supervised by **A/Prof Deshendran Moodley**

This research is partly funded by the National Research Foundation (Grant Number MND200411512622)