1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Data size** | **Configuration** | **Training error** | **Validation error** | **Time of execution** |
| 1000 | 1 hidden layer 4 nodes | 0.2490 | 0.2583 | 1679.13 |
| 10000 | 1 hidden layer 4 nodes | 0.0042 | 0.0055 | 1499.21 |
| 100000 | 1 hidden layer 4 nodes | 0.0014 | 0.0019 | 1463.70 |
| 1000 | 2 hidden layers of 4 nodes each | 0.2160 | 0.2386 | 1561.62 |
| 10000 | 2 hidden layers of 4 nodes each | 0.0061 | 0.0081 | 1382.20 |
| 100000 | 2 hidden layers of 4 nodes each | 0.0017 | 0.0023 | 1310.42 |

2.

The model with 100,000 data points and one hidden layer with four nodes demonstrates superior performance by reaching the lowest training error of 0.0014 and validation error of 0.0019. The one-hidden-layer configuration performs better as a simpler model because it produces better validation error scores while being more parsimonious by using less resources while reducing the risk of overfitting the data. When compared to the 2-hidden-layer structure with 100,000 training points (0.0017 training error, 0.0023 validation error).

3.

| **Method used** | **Dataset size** | **Testing-set predictive performance** | **Time taken for the model to be fit** |
| --- | --- | --- | --- |
| XGBoost in Python via scikit-learn and 5-fold CV | 100 | 0.90 | 0.08 |
| 1000 | 0.94 | 0.0464 |
| 10000 | 0.98 | 0.142963 |
| 100000 | 0.9886 | 0.753442 |

The XGBoost model shows better performance than deep learning models when evaluating all dataset sizes. XGBoost delivers exceptional predictive results starting from low data quantities (0.90 with 100 observations) and continues to achieve 0.9886 with 100,000 observations. XGBoost demonstrates exceptional computational speed because it needs only 0.753442 time units to process 100,000 observations even though deep learning models require over 1,300 time units for the same dataset.

The evaluation of XGBoost superiority relies on its dual performance and efficiency capabilities. The best deep learning model using one hidden layer and 100,000 observations achieved low errors at 0.0014 training and 0.0019 validation yet XGBoost provided equivalent or superior predictive accuracy at 1,900 times faster processing speed for 100,000 observations. The exceptional performance of XGBoost through its high accuracy and computational efficiency makes it the best solution for this modeling task particularly in situations where resources or time limits apply.