City-Level Growth Potential Prediction

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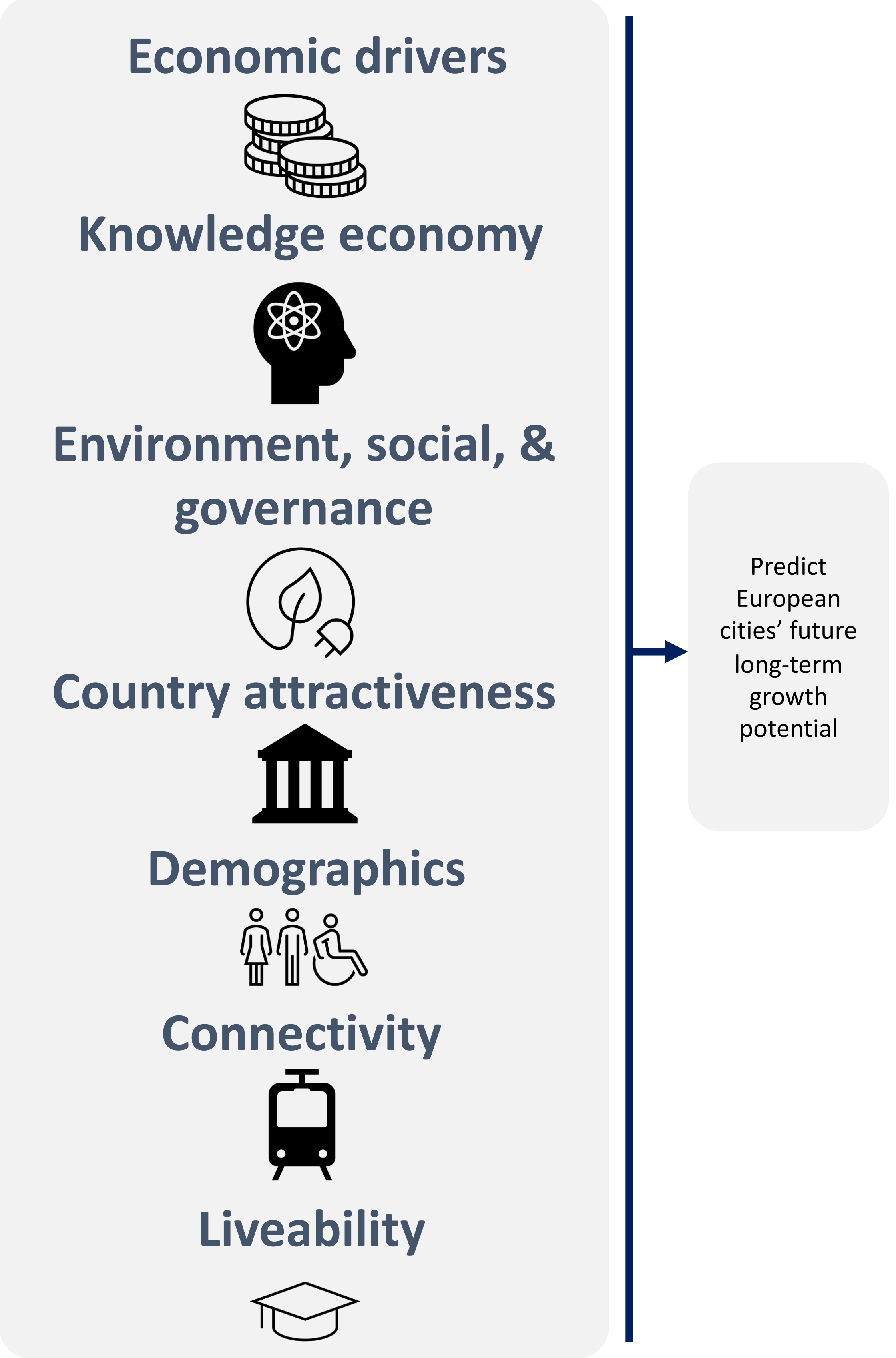
Project Context and Overview

Problem Statement

CTI Real Estate Research wishes to develop a Machine-Learning driven tool to identify European cities with top long-term future growth potential. This could help in facilitating the team's investment decisions. Utilize analytics to gain insights on factors impacting city growth potential, and determine:

- Cities with top growth potential across 8 European countries
- Most important indicators that impact future long-term potential

Dataset Description


Economic drivers

Knowledge economy

Environment, social, & governance

Country attractiveness

Demographics

Connectivity

Liveability

Predict European cities' future long-term growth potential

Project Objectives

Develop analytical approaches to predict long-term future growth potential for 600+ European cities:

- Problem framing with Real Estate Research team
- Select independent variables from existing dataset
- Predictive Modeling
- Enhance interpretability of results

- Assist Real Estate Research team in making investment decisions with rank of top growth potential cities
- Interpret the impact of each modeling input factor on prediction outcome

Project Timeline

March-April: conduct initial exploratory analysis on the dataset of independent variables

May: Identify long-term growth potential indicators, establish baseline criteria, build first version of Linear Regression models

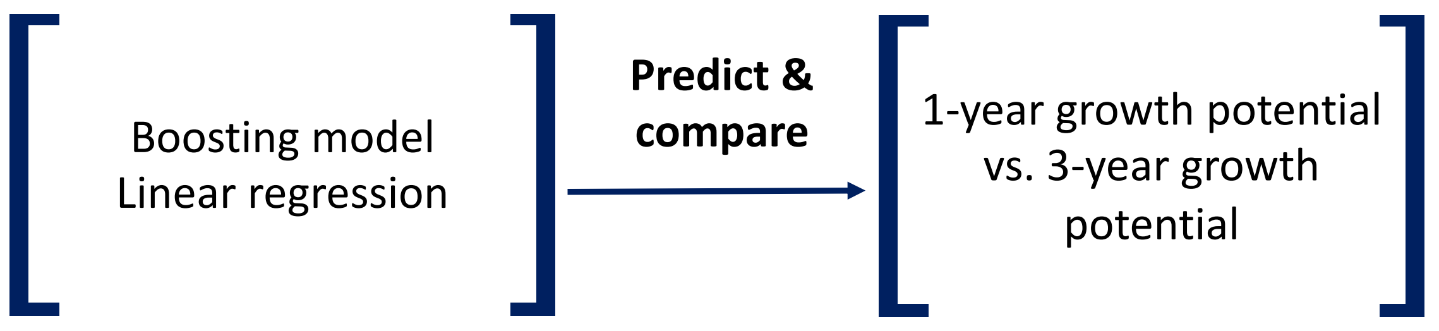
June-July: Build and evaluate first version of boosting models, select desired training & test time frames

July-August: Refine modeling approaches to include new independent variables, explore additional modeling approaches & extract insights

Methods

Direct growth potential prediction approach

We want to predict **future** growth potential with data collected from the **past** and deliver our results in an **interpretable** manner. One method to do so would be using Linear Regression models that display the weight of each factor in making predictions. To leverage the **extensive** data sources and **extract the most insights**, we also used boosting models as an additional method.


Boosting model
Linear regression

Predict & compare

1-year growth potential vs. 3-year growth potential

Two-step implied growth potential prediction approach

To gain an additional perspective, we experimented with a two-step modeling approach. In step one, we used boosting models to predict the level values of growth potential indicators. In step two, we derived the implied rate of increase from the corresponding level values.

Selection of Performance Metrics

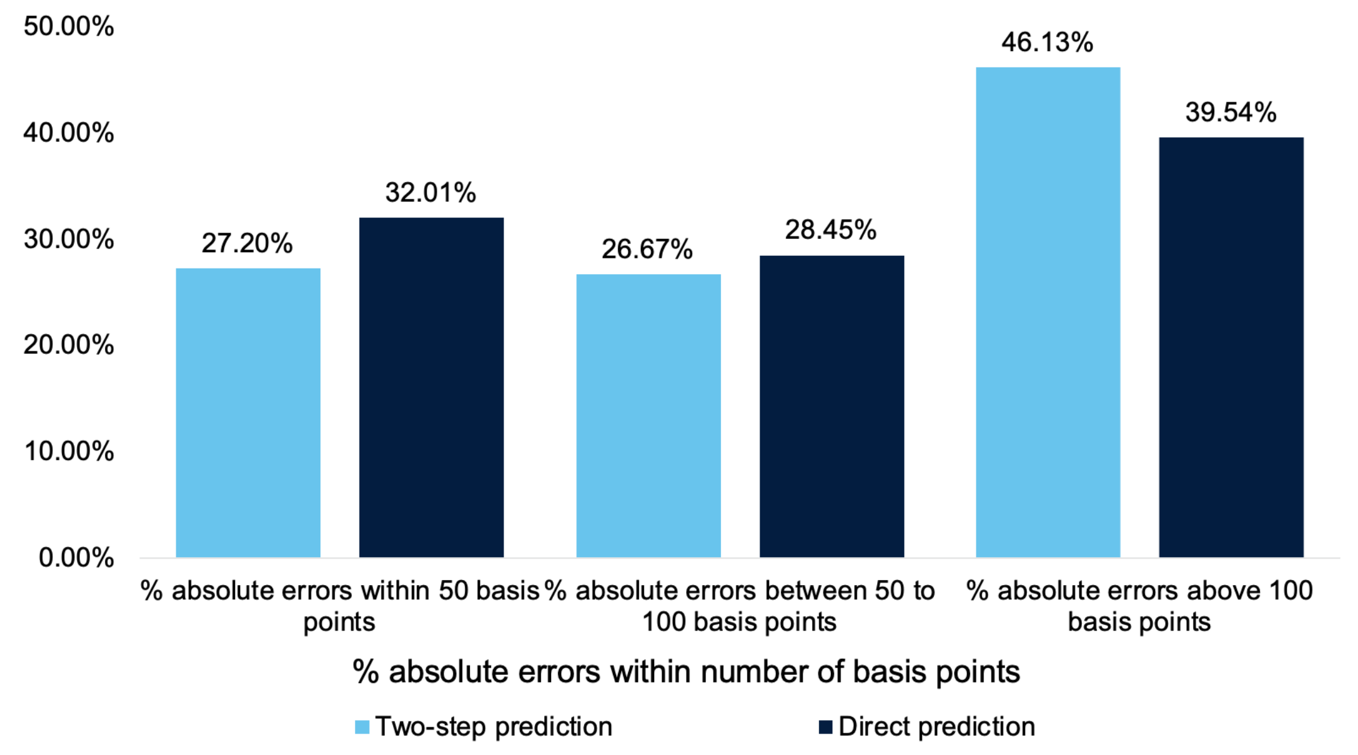
To gain a comprehensive perspective on our models' performance, we assessed the prediction outputs with a variety of performance metrics:

- **Accuracy in ranking of cities' growth potential:** Mean Absolute Errors for top n ranked cities, Spearman's Rank Correlation
- **Comparison of predictions relatively to set criteria:** Binned Absolute Errors within 50 to 250 basis points, % predictions with opposite signs from true values
- **Comparison of performance against baseline model:** Training R^2 and Test R^2 values

Evaluation of Modeling

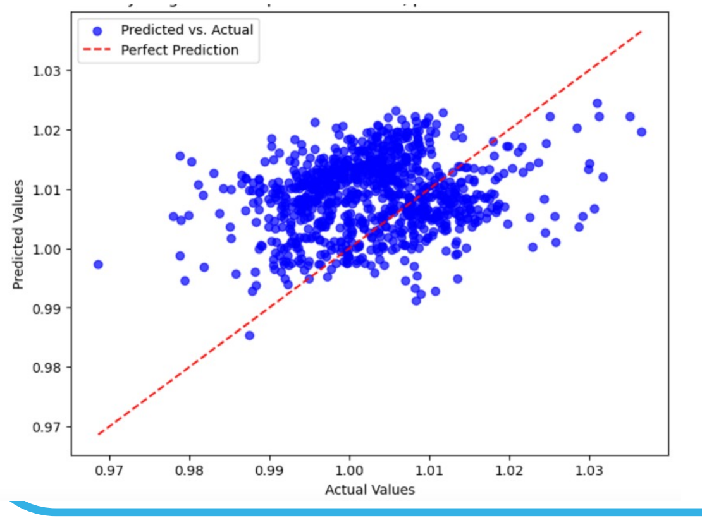
Comparison of performance between direct vs. two-step growth potential prediction models:
Different performance evaluation metrics help us gain insights from different perspectives on our models. For instance, the Binned Absolute Errors plot shown below demonstrates that the direct model outperforms the two-step model through capturing more % absolute errors within 50 and 100 basis points.

Comparison of binned absolute errors between two-step vs. direct growth rate prediction model

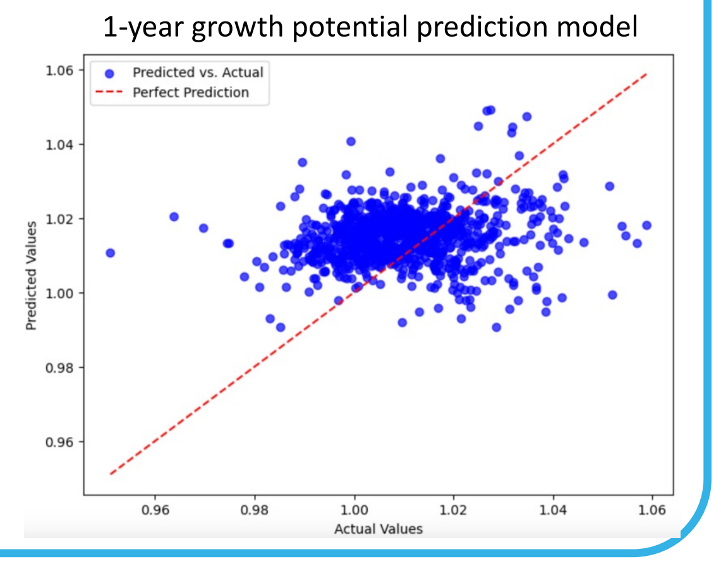


Predicted vs. actual value plots show the distribution of outputs from 1-year growth potential prediction model and 3-year growth potential prediction model

3-year growth potential prediction model



1-year growth potential prediction model



Conclusions and recommendations

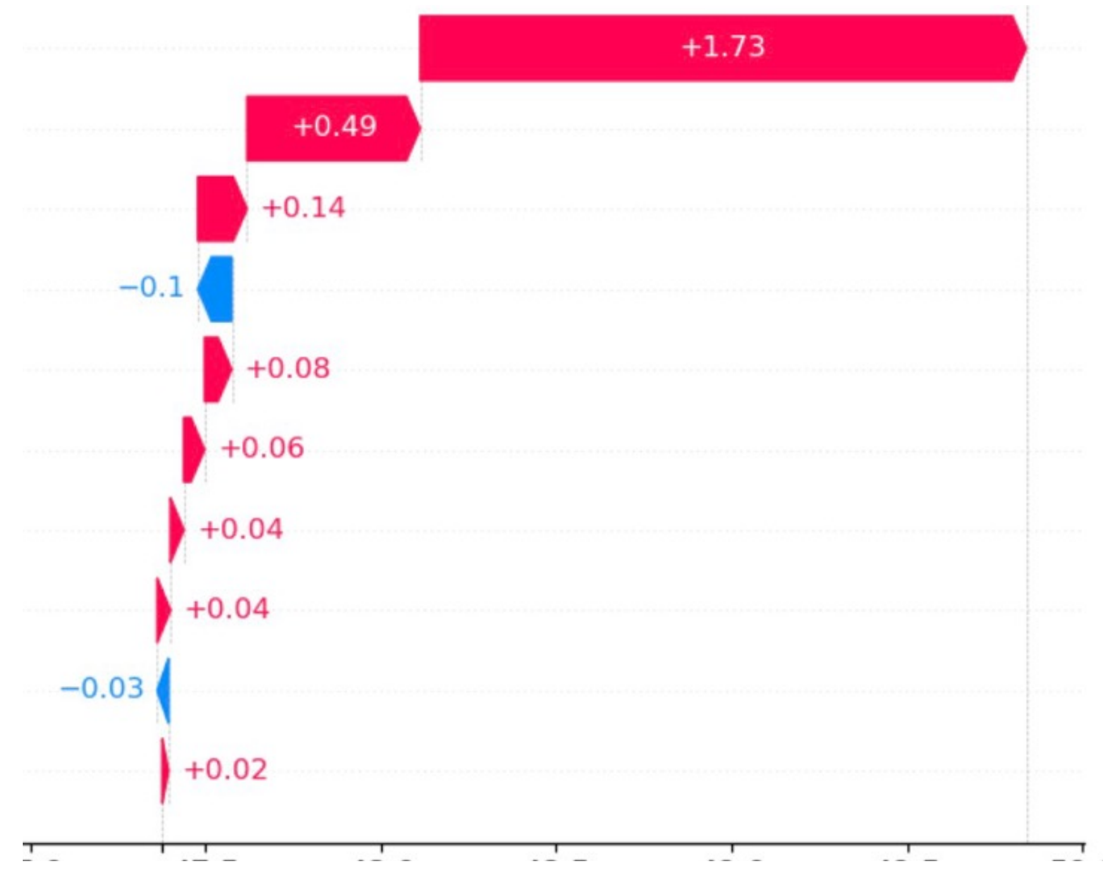
Top important factors impacting growth potential

From boosting model and linear model outputs, we identified top important factors that impact city-level growth potential predictions and the common themes these factors belong to.

Themes of top important factors: The distribution of top important factors among the 7 themes of data helps CTI Real Estate Research team identify data sources that effectively predict cities with high growth potential

Additionally, SHAP value analysis enhances interpretability of model outputs by demonstrating how each factor positively/negatively impact prediction results.

SHAP Waterfall plot for two-step prediction model (variable names and key values removed for data privacy)



Recommendations for next steps

Explore with country-level prediction models for potential improvements in accuracy

Continue the current fruitful journey of collecting data and leverage state-of-the-art boosting models. Further gains in predictive ability are likely to come from enhanced data rather than from more powerful models

Include predictions from other independent sources into the dataset to elevate boosting model's predictive power.

Explore if integrating predicted output of the 1-year and 3-year models can provide additional insight

Our contribution

Built a **comprehensive** model pipeline, from feature engineering to evaluating output

Provided **diverse** perspectives in **prediction time frames** and **growth potential estimation techniques** through a variety of modeling approaches and performance metrics analysis.

Enhanced interpretability of model outputs with analytical techniques such as SHAP analysis, communicate direct insights to all stakeholders

Provide **recommendations** on future data **enhancements**, that can get seamlessly folded into the modeling process

Handed out model that **can be "cloned" and adapted** to address other prediction targets of interests at CTI