Modeling and Forecasting Real GDP of HK using Vector Autoregression

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Contents

1 Introduction

In the dynamic realm of economic forecasting, the accurate prediction of a nation's Gross Domestic Product (GDP) stands as a critical endeavor with far-reaching implications for policy formulation and strategic decision-making. This paper embarks on a journey into the intricacies of Hong Kong's economic landscape, aiming to develop a robust forecasting model for its real GDP through the application of Vector Autoregression (VAR).

Hong Kong, renowned for its resilience and economic openness, presents a compelling case for a meticulous examination of the factors shaping its economic trajectory. As the global economic landscape undergoes constant evolution, the ability to anticipate changes in Hong Kong's real GDP becomes an invaluable tool for policymakers, economists, and businesses alike. The utilization of Vector Autoregression, a potent method in time series analysis, allows us to capture the dynamic interactions among multiple economic variables, providing a foundation for accurate and insightful forecasts.

The primary objective of this paper is to construct a forecasting model that enhances our ability to predict the real GDP of Hong Kong. By exploring the interdependencies among key economic indicators, we seek to not only unravel the underlying dynamics of Hong Kong's economy but also to contribute to the development of a practical tool for anticipating future economic trends. The outcomes of this study hold substantial value for policymakers crafting strategies in a rapidly changing global environment and for businesses navigating the complexities of the Hong Kong market.

2 Data

This study utilizes quarterly economic data spanning the period from 1990 to 2020, sourced from the CEIC data bank. The dataset encompasses a comprehensive array of economic indicators that encapsulate the multifaceted nature of Hong Kong's economic landscape. The endogenous variables under scrutiny include the Real GDP, Consumer Price Index (CPI), and Gross Fixed Capital Formation—a vital measure reflecting investment activities. Complementing these, the study incorporates several exogenous variables, namely World GDP, Unit Value Imports, and the Best Lending Rate. Notably, a crucial addition to the model is a dummy variable denoting the occurrence of the Severe Acute Respiratory Syndrome (SARS) pandemic, which impacted Hong Kong from 2002 to 2004. This inclusion is motivated by the anticipation that the health crisis may have exerted a discernible influence on the GDP growth during that specific time period. The meticulous selection of variables aims to capture the nuanced dynamics of Hong Kong's economy and enhance the forecasting capabilities of the Vector Autoregression model.

2.1 Transformations to Data

In the pursuit of modeling a stationary time series, a crucial step in the analysis involves the application of transformations to the data. Notably, all variables, with the exception of the Best Lending Rate, exhibited non-stationary behavior. To rectify this, a log difference was implemented for each variable. This transformation aims to stabilize the variance and induce stationarity, a prerequisite for effective time series analysis. By logarithmically differencing the Real GDP, Consumer Price Index (CPI), Gross Fixed Capital Formation, World GDP, and Unit Value Imports, we mitigate the inherent non-stationarity, facilitating a more robust exploration of the dynamic relationships within the Vector Autoregression framework. This meticulous preprocessing ensures that the data conforms to the necessary assumptions for reliable and meaningful forecasting.

3 Method

The pivotal choice of employing Vector Autoregression (VAR) with a lag order of three is intricately tied to the quarterly nature of the dataset. With economic data recorded on a quarterly basis spanning from 1990 to 2020, each lag in the model corresponds to a quarter, allowing us to effectively account for changes within a year. This quarterly structure aligns with the inherent periodicity of economic phenomena, capturing the short-term dynamics and ensuring that the model adequately incorporates the temporal relationships among the variables. By selecting three lags, we strike a balance between capturing meaningful historical context and avoiding an overwhelming increase in model complexity. This methodological approach serves as a robust foundation, facilitating a nuanced exploration of how past quarterly values influence the current state and future trajectory of Hong Kong's real GDP.

Subsequently, the years 2017 to 2019 emerge as the testing ground—a critical evaluation phase where the model's predictive prowess is put to the test against actual data. This dichotomy between training and testing periods not only ensures the robustness of our Vector Autoregression model but also provides a practical assessment of its accuracy in forecasting the Real GDP of Hong Kong. By adopting this temporal segregation, we aim to contribute not only to the theoretical understanding of economic dynamics but also to the development of a reliable forecasting tool with practical applications for policymakers and stakeholders alike.

$$Y_t = \delta + \Theta_1 Y_{t-1} + \Theta_2 Y_{t-2} + \Theta_3 Y_{t-3}$$
$$+\Theta_4 Z_{t-1} + \Theta_5 Z_{t-2} + \Theta_6 Z_{t-3}$$
$$+\theta_7 SARS_{t-1} + \theta_8 SARS_{t-2} + \theta_9 SARS_{t-3} + \epsilon_T$$

The equation presented above encapsulates the fundamental model underpinning our study. In this representation, Y denotes a matrix encompassing the data for the endogenous variables, Z captures the information pertaining to the exogenous variables, and $SARS$ serves as the binary dummy variable designed to account for the impact of the Severe Acute Respiratory Syndrome (SARS) pandemic. This modeling framework forms the crux of our analysis, providing a structured and comprehensive approach to understanding the dynamic interplay between the endogenous and exogenous factors influencing Hong Kong's Real GDP.

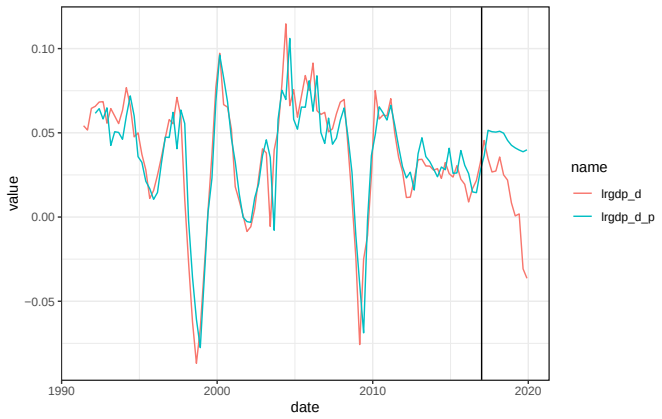
4 Results

The performance of our forecasting model is encapsulated by the adjusted R-squared value, which stands at an impressive 0.744. This statistic serves as a measure of the proportion of the variance in the dependent variable, namely the Real GDP of Hong Kong, that is explained by our Vector Autoregression model. An adjusted R-squared of 0.744 indicates that approximately 74.4% of the variability in the observed Real GDP can be accounted for by the combined influence of the endogenous and exogenous variables included in our model. This substantial explanatory power suggests that our Vector Autoregression framework effectively captures the underlying dynamics of Hong Kong's economic landscape, making it a robust tool for forecasting and understanding the factors shaping the trajectory of the Real GDP.

Table 1:

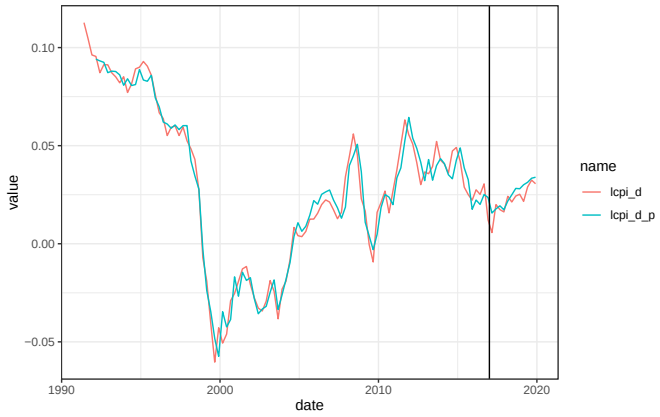
Observations	100
R^2	0.806
Adjusted R^2	0.744
Residual Std. Error	0.018 (df = 75)
F Statistic	12.961^{***} (df = 24; 75)

The following graph detailing the actual and predicted values of Real GDP presents a compelling narrative of the model's precision. Notably, during the modeling period with an RMSE of 0.0196, the model excels in accuracy, closely aligning predictions with observed values. Transitioning to the forecasting or post-modeling period, marked by an RMSE of 0.0384, a discernible increase in prediction error is evident. This represents a percentage increase of approximately 95.93% from the pre-modeling to the post-modeling phase. While the model remains a powerful tool for capturing historical trends, the nuanced understanding of the increased prediction error in the forecasting period is crucial for contextualizing and refining future predictions.



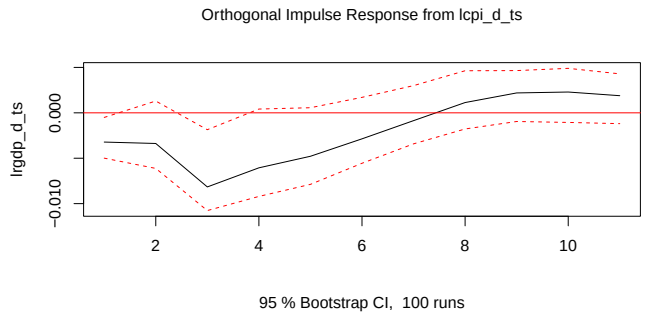
The following graph illustrating the actual and predicted values of the Consumer Price Index (CPI) highlights the model's accuracy. During the modeling period, characterized by an RMSE of 0.006492855, the model excels in closely aligning its predictions with observed CPI values. Transitioning to the forecasting or post-modeling period, marked by an RMSE of 0.00448016, the model continues to exhibit high precision. Interestingly, the post-RMSE reflects a decrease, suggesting an improvement in accuracy for CPI predictions. This signifies a reduction in prediction errors by approximately 31.02% from the pre-modeling to the post-modeling phase.

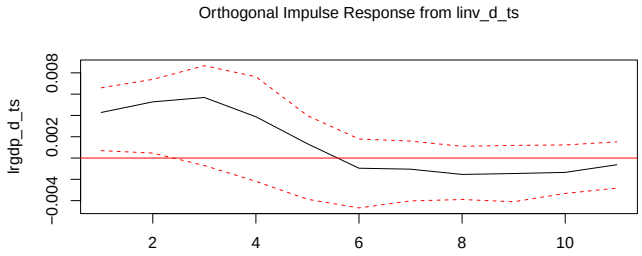
Examining the alterations in RMSE values throughout and after the modeling phase, it becomes intriguingly evident that the VAR model exhibits superior forecasting capabilities for the Consumer Price Index than the Real GDP.

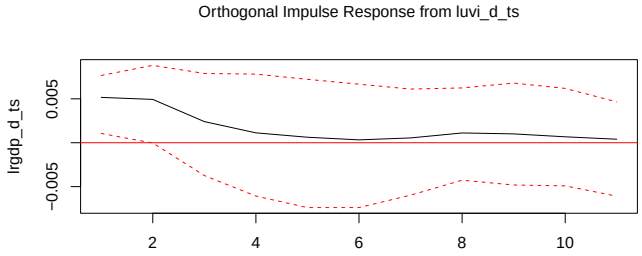


4.1 Impulse Response Functions

In this section, we delve into the dynamic interactions within our Vector Autoregression model by employing Impulse Response Functions.




Orthogonal Impulse Response from linv_d_ts
lrgdp_d_ts
−0.004
0.002
0.008
2
4
6
8
10
95 % Bootstrap CI, 100 runs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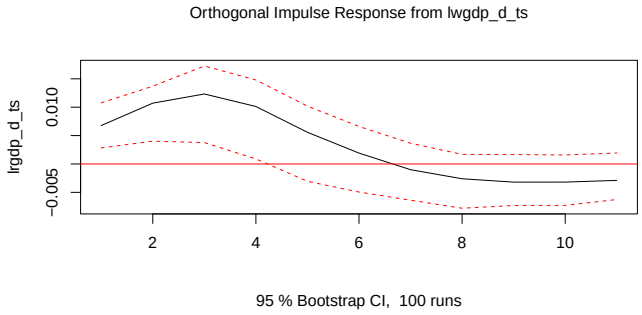
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from lwgdp_d_ts
lrgdp_d_ts
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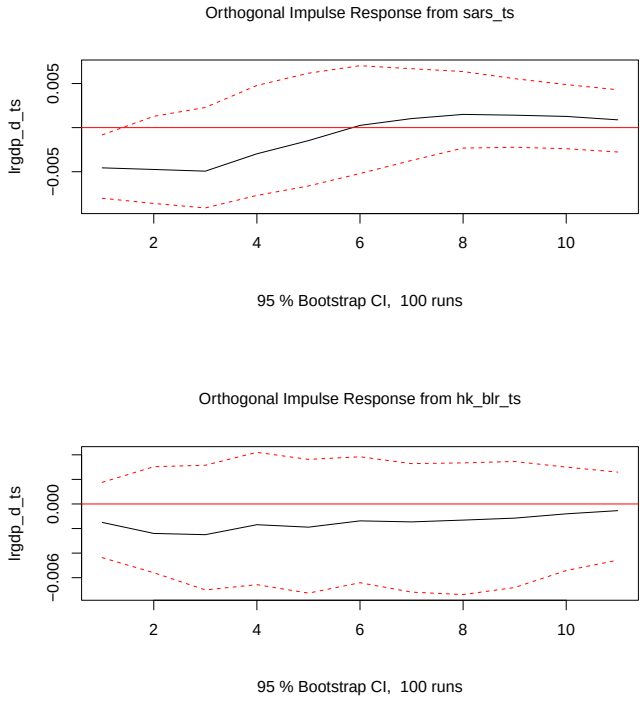
0.010
2
4
6
8
10
95 % Bootstrap CI, 100 runs



The analysis of the Impulse Response Functions yields intriguing insights into the dynamic relationships within the economic variables under consideration. The IRF reveals a noteworthy short-term trend: an increase in the unit value of imports coincides with an elevation in Real GDP. This unexpected positive relationship suggests a nuanced interplay between import values and overall economic output, possibly indicating a scenario where heightened import activities contribute positively to short-term economic growth.

Furthermore, the IRF analysis indicates a somewhat surprising result concerning the Best Lending Rate. In both the short and term, the Best Lending Rate appears to exhibit no significant effect on Real GDP. This observation challenges conventional expectations, as changes in lending rates are often associated with shifts in borrowing and investment behaviors that in turn influence economic activity. The apparent lack of immediate impact prompts a deeper exploration into the intricate dynamics governing the relationship between lending rates and Real GDP.

5 Conclusion

In the pursuit of unraveling the intricate dynamics of Hong Kong's economic landscape, our Vector Autoregression model has proven to be a valuable tool, offering insights into the forecasting capabilities and interdependencies among key variables. While the model exhibits a limited extent of accuracy in forecasting Real GDP, it surprisingly outperforms expectations in predicting the Consumer Price Index. This discrepancy underscores the importance of tailoring forecasting methodologies to the unique characteristics of each economic indicator, challenging conventional assumptions and enriching our understanding of economic dynamics.

Acknowledging the limited forecasting ability observed for Real GDP, it is crucial to recognize the complex and multifaceted nature of economic dynamics. The possibility of omitted variables looms large, as our model captures a subset of the myriad factors influencing Real GDP. Hong Kong's economic landscape is inherently intricate, with numerous variables at play, such as global economic trends, geopolitical shifts, and other unaccounted-for elements. The observed limitations in forecasting may, in part, be attributed to these omitted variables that contribute to the overall complexity of the economic system. Future research endeavors could benefit from a more comprehensive inclusion of additional factors, allowing for a more nuanced and accurate representation of the intricate web of variables shaping Hong Kong's economic trajectory. This recognition highlights the ongoing need for refinement and expansion in our modeling approaches as we strive for a more holistic understanding of economic dynamics.

The Impulse Response Functions provide a captivating lens through which we observe the immediate and delayed effects of various shocks. Notably, our analysis reveals that pandemics, exemplified by the SARS outbreak, exert a significant negative immediate impact on Real GDP, persisting for up to six quarters. The unexpected resilience and surprisingly good forecasting performance for CPI suggest that inflation, as depicted in the CPI, does not exhibit an immediate response to shocks. Instead, the negative effects become discernible after a lag of three quarters, underscoring the importance of considering temporal dynamics in the assessment of economic phenomena.

6 References

Genberg, Hans, and Jian Chang. "A VAR Framework for Forecasting Hong Kong's Output and Inflation." Hong Kong Monetary Authority, 2007