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Theoretical and Conceptual Framework**

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**Keywords:** Nowcasting, Economic indicators, Co-movement, Gross Gaming Revenue, Gross Domestic Product

# Nowcasting Gross Domestic Product and Gross Gaming Revenue of Macau: a Theoretical Framework

## Introduction

As the world's largest casino hub, Macau's gross gaming revenue (GGR) contributes significantly to its economy. As shown in Fig. 1, GGR has reached over 50% of Macau's gross domestic product (GDP) since 2004, making the highest contribution of 84% in 2010 and taking up as much as 60% in 2019 (Statistics and Census Service [DSEC], 2021). Future performance of the gaming industry is not only a concern of casino operators and their investors, but it is also an interest of government policy makers and the general public. Therefore, the objective of this paper is to propose a theoretical and conceptual framework for forecasting Macau's GGR and GDP, so that future research can put it into practice empirically. Forecasts of GGR and GDP are also important signals for local businesses to better strategize themselves as they adjust to the post-COVID-19 new normal.

Numerous previous studies searched for predictors of GDP. Burns and Mitchell (1946) identified co-movements of various economic indicators with the business cycle. The co-movement was described as "pro-cyclical" or "counter-cyclical" depending on whether it moved in the same or opposite direction of GDP, and as "leading," "coincidental," or "lagging," depending on whether it moved before, at the same time or after GDP. Owing to their properties, economic indicators have been widely used to create composite leading, coincident and lagging indexes to explain GDP movements (Moore and Shiskin, 1967).

In the GDP forecasting literature, Lucas (1973) hypothesized that a few aggregate shocks drove most co-movements between macroeconomic series, allowing for extraction of information in many series to predict business cycle conditions. Subsequent studies such as Geweke and Singleton (1981) developed the dynamic factor model (DFM) to capture the co-movements. More recently, Giannone et al. (2008) suggested to forecast GDP based on the

latest released data to increase precision. This technique was coined, “nowcasting” (Browning, 1981). In Giannone et al. (2008), nowcasting of quarterly GDP could be updated every time monthly data were announced. The DFM has been adopted by many central banks and econometricians to perform GDP nowcasts, including France (Barhoumi et al. (2009)), Germany (Kuzin et al. (2009)), the US (Liebermann (2011)), Norway (Aastveit and Trovik (2012)), Czech Republic (Rusnák (2013)), Argentina (Camacho et al. (2015)), Brazil (Bragoli et al. (2015)), Indonesia (Luciani et al. (2015)), Russia (Porshakov et al. (2016)), Japan (Bragoli (2017)), and India (Bragoli and Fosten (2018)).

Due to the availability of big data, machine learning (ML) techniques are also suitable for nowcasting GDP. Among them is gradient boosting, which assembles weak predictions to form a good prediction (Friedman, 1999; Friedman, 2001; Richardson et al., 2018). Vapnik (1995) and Drucker et al. (1997) developed the supervised learning models (SVM) with associated learning algorithms for regression analysis and classification. Neural network captures complex non-linear relationships by estimating the model in an iterative process (Richardson et al., 2018). The ridge, lasso and elastic net regressions are regularization techniques to reduce model complexity when there is many features in a dataset (Jokubaitis et al., 2019; Richardson et al., 2018).

The nowcasting approaches mentioned above have proven success in forecasting GDP. However, when applying to Macau, the city’s situation that the gaming industry contributes the single, most important portion of the GDP should not be overlooked. Previous studies called such economy a “monotown,” in which the economic and social features were closely linked to the operation of several companies in a single industry, and the town’s future was interdependent with those companies or that industry (Kryukova et al., 2015). According to DSEC, in Q4 of 2020, 56% of Macau employment was made up of casino dealers and hard & soft count clerks (Shastitko and Fakhitova, 2015). In 2019, Macau’s gaming industry

generated more than 80% of the city's taxes (DSEC, 2021). Thus, Macau matches the definition of a monotown.

Furthermore, Macau's specialization in gaming production is expected to continue in the future. As an early investor in gaming and tourism infrastructure, Macau has comparative advantage over neighboring regions in Asia (Ruffin, 2002; Sraffa, 1952). Besides, since the liberalization of the gaming concessions in 2002, local and global resort brands have formed a Marshallian industrial district, benefiting from positive external economies of scale of an agglomeration – proximity of supporting businesses (such as retail, hotels, cuisines, gaming promoters, travel agents and transportation), shared skilled labor pool, and knowledge spillover (Marshall, 1890; Nordin, 2003; Porter, 1990; Porter, 1998).

To nowcast GDP of Macau, it is therefore necessary to incorporate industrial indicators. Macau's gaming operators, SJM Holdings Limited, Sands China Ltd, Galaxy Entertainment Group Limited, Wynn Macau Limited and MGM China Holdings Limited are listed in Hong Kong Stock Exchange, while Melco Resorts & Entertainment Limited is listed in NASDAQ. Their share prices should contain crucial information for the nowcasting of Macau GGR and GDP. The theoretical support for the argument include the efficient market hypothesis (EMH), which says that share prices reflect all available information about a company. On the other hand, the arbitrage pricing theory (APT) does not assume investors to be perfectly rational (Fama, 1998; Malkiel, 2003). Instead, if the public has any future information, the asset's underlying systematic risk factor, or future returns will shift positively. If the market price does not reflect this at that moment, traders will have an opportunity to arbitrage by trading on it (Fama 1981; Fama, 1990; Ferson and Harvey, 1991; French and Fama (1989); Schwert, 1990). The present value model (PVM) connects company share price with future expected cash flows and the discount rate (Chen et al., 1986, Humpe & Macmillan, 2009). In Macau, GGR is the aggregate cash flow of several gaming operators. If

there is market information that changes future GGR forecasts, investors will use it to adjust their expectations on gaming operators' future cash flow or discount rate, resulting in share price changes.

As shown in Fig. 2, most of Macau's casino customers are tourists, and most of them are from mainland China and Hong Kong (DSEC, 2021). Hence, it is reasonable to believe that economic indicators of China and Hong Kong should influence Macau's GGR. In fact, in national accounting, exports is seen as a GDP component, and so it is cyclical. In Macau, gaming services alone makes up most of the exports. Therefore, when nowcasting Macau's GGR and GDP, not only factors internal to Macau's economy, but also external factors of major trading partners should be accounted for. As suggested in the literature, common external economic indicators to be included for nowcasting are price indices and stock market indices (Chauvet, 1998; Chauvet & Potter, 2000; Estrella & Mishkin, 1998; Liu & Moench, 2014).

The observations of Macau's economic situation and the review of the GDP nowcasting literature motivate the construction of a theoretical and conceptual framework that is tailored to the nowcasting of GDP and GGR of Macau. Such framework should capture Macau's internal economic indicators, indicators that are specific to the gaming industry, and external indicators of mainland China and Hong Kong. At the same time, the framework should incorporate nowcasting models and techniques proven to have reasonable forecasting performance, which is commonly measured with root mean square error (RMSE) and mean absolute error (MAE).

## **Discussion**

From the GDP forecasting literature, we identify economic indicators that should be included in the nowcasting of GDP and GGR of Macau. These studies are summarized in Table 1. Some of the economic indicators are plotted in Fig. 3, and they demonstrate visible

co-movements. As a preliminary inspection, we compute coefficients of correlation between the economic indicators and Macau's GDP and GGR in the same quarter (t) and in the next quarter (t+1). A positive correlation coefficient indicates procyclical comovement, and a negative correlation indicates counter-cyclical comovement. A strong correlation in the same quarter shows how an economic indicator co-moves coincidentally, and a strong correlation in the next quarter shows how it can be a leading indicator. Table 2 shows that the coefficients are of the same signs and similar sizes in the GGR and the GDP columns. This is evidence that the economic indicators co-move with the two in a similar fashion. The correlation coefficients range from weak to strong positive correlation. These indicate that there are underlying relationships between the proposed economic indicators and Macau's GGR and GDP.

Future empirical studies can obtain secondary time series data of the economic indicators from various official sources, including statistics departments of China, Macau, and Hong Kong, stock exchanges and databases of international organizations such as the International Monetary Fund (IMF), the World Bank, the World Trade Organization (WTO). In particular, quarterly data of GDP and GGR of Macau are available in the DSEC's statistical database. Note that data of some time series, such as year-over-year (YOY) percentage changes of share prices, have become available only since 2012.

Before forecasting is performed, economic indicators that have low correlations with GDP and GGR of Macau can be removed. For regression models to be applied in the next step, the time series have to be tested for stationarity. Unit root tests such as the commonly used Dickey-Fuller unit root test can be performed. The non-stationary time series, if any, can be treated using standard procedures, such including trend, seasonal dummies and lags as explanatory variables in the regression models. Besides, potential structural breaks, such as the 2020 – 2021 COVID-19 pandemic should be identified. Existence of such structural break

is evidence for the “new normal” hypothesis. As a result, the forecasts should be adjusted accordingly.

The pre-processed data can then be put into different machine learning and econometric algorithms, including boosted trees, SVM, neural network, ridge, lasso, and elastic net regressions, and DFM to perform nowcasts of Macau’s GDP and GGR. We recommend using the statistical package of R in the data analysis as it is commonly used in the field and it is an open-source software with many freely available resources.

Fig. 4 demonstrates an example of performing nine forecasts and nowcasts for each of Macau’s GDP and GGR. The first forecast for each dependent variable can be performed in the first month of the quarter that is 2 quarters before the predicted quarter, using all available data up to the 16<sup>th</sup> of that month. In other words, the first forecast of each of GDP and GGR is made with data available 8.5 months in advance. The second forecast of each dependent variable is performed with data available up to the 16<sup>th</sup> of the next month, and so on. Starting from the seventh forecast, the prediction can be made for the same quarter, so it is considered as a nowcast. Since there are time lags for the statistical departments to process data and announce the statistics, a cut-off time should be set – tracing back to the month when a prediction is made, data of an explanatory variable used in the forecast have to be available before the 16<sup>th</sup> of the month.

Next is to compare the forecasting accuracy of the different algorithms in terms of RMSE and MAE. To do so, the dataset can be split into two periods, so that around 80% of the series is for training and 20% is for validation. The training data can be used to train different algorithms and to make predictions for the validation period. Algorithms with satisfactory predicting performance can be selected for the next step, and those with low accuracy can be dropped.

Finally, to avoid over reliance on a single algorithm, we suggest using simple and



applicable methods to combine forecasts and nowcasts of different algorithms into ensembles. One straight-forward ensemble method is to compute equal-weighted average of forecasts of different algorithms. Another ensemble methods is to assign higher inverse RMSE/MSE weights to algorithms with higher accuracy (Genre et al., 2013). For example, Fan (2019) made out-of-sample predictions with data of New Zealand, and produced “more stable and accurate” results. Different ensembles can then be compared with usual benchmark models, including ARIMA and random walk models. If an ensemble is not better than usual benchmark models, it will be considered as unsatisfactory, and the underlying reasons should be further investigated.

### **Conclusion**

This paper aims to build a theoretical and conceptual framework for short-term forecasting of GDP and GGR of Macau. Since Macau is a “monotown,” where the gaming revenue makes a significant contribution to the economy, forecasting the future performance of the gaming industry is crucial. It is especially important after the outbreak of the COVID-19 pandemic, as local businesses re-strategize themselves and policymakers improve their plan for the near future. Such forecasting framework cannot only be used for making predictions, but it also contributes a better understanding of Macau’s economy by investigating its internal and external economic variables.

This paper suggests to apply various nowcasting techniques, exploit the co-movements of leading and coincident economic indicators, and forecast Macau’s GDP and GGR within acceptable levels of error. In particular, future empirical studies can collect secondary time series data of economic indicators from statistics departments of China, Macau and Hong Kong, stock exchanges, and international organizations such as the IMF, the World Bank and the WTO. The data pre-processing stage should account for seasonality, trend, serial correlation and structural breaks in the time series. Afterwards, the data can be

input into different machine learning and econometric algorithms, including boosted trees, SVM, neural network, ridge, lasso, and elastic net regressions and DFM to perform forecasts and nowcasts of Macau's GDP and GGR. The forecasting accuracy of these algorithms should be compared. Final forecasts can be performed by creating ensembles of the forecasts by equal- and unequal-weighted average methods, and the results can be compared to benchmark models, including autoregressive integrated moving average (ARIMA) and random walk models.

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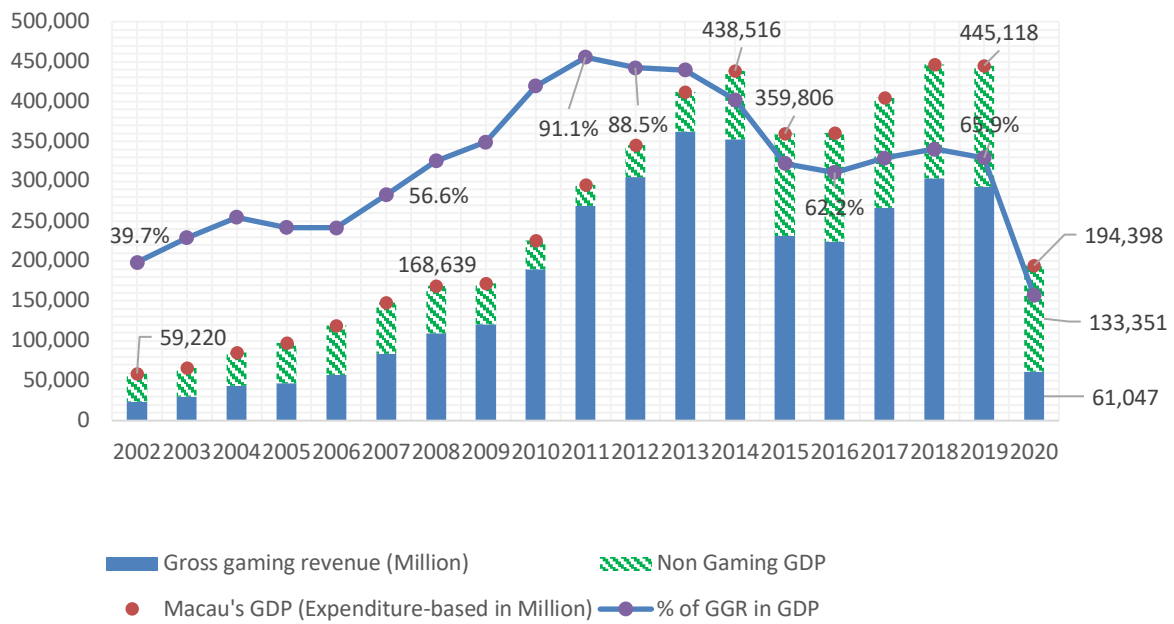
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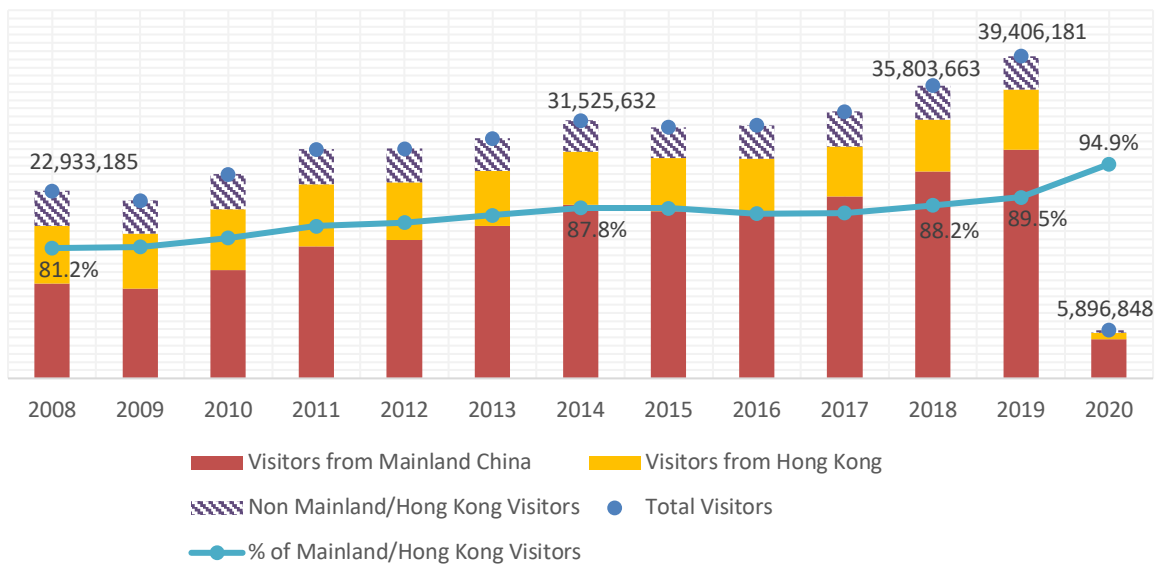
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**Figure 1. Percentage of Macau's GGR in GDP**

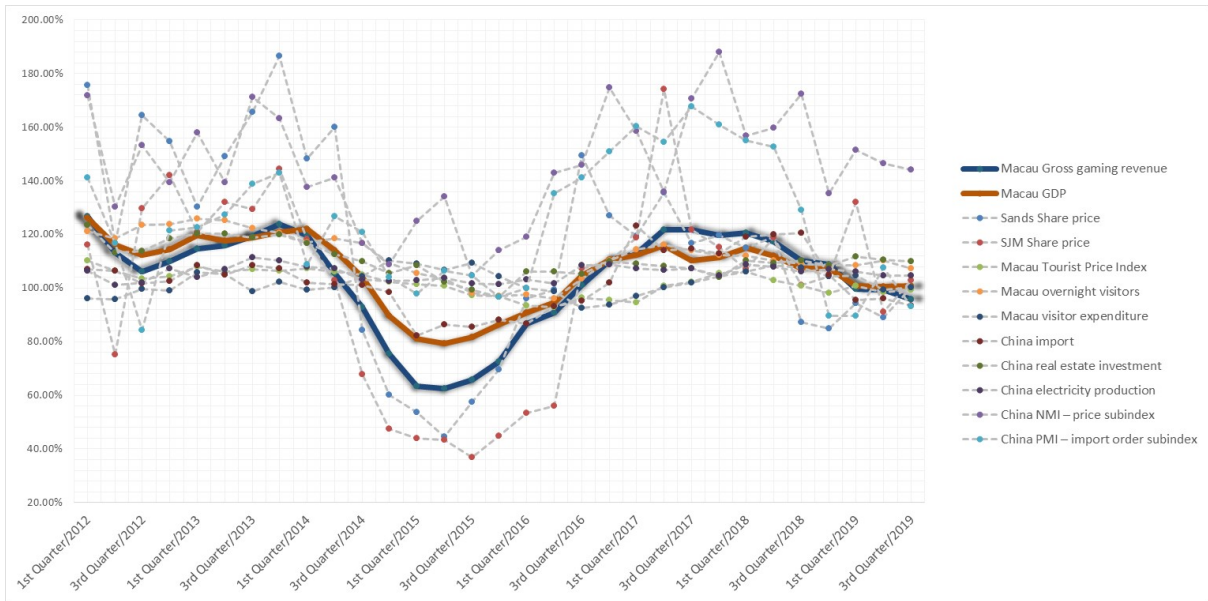


**Figure 2. Percentages of Macau's Visitors from China and Hong Kong**

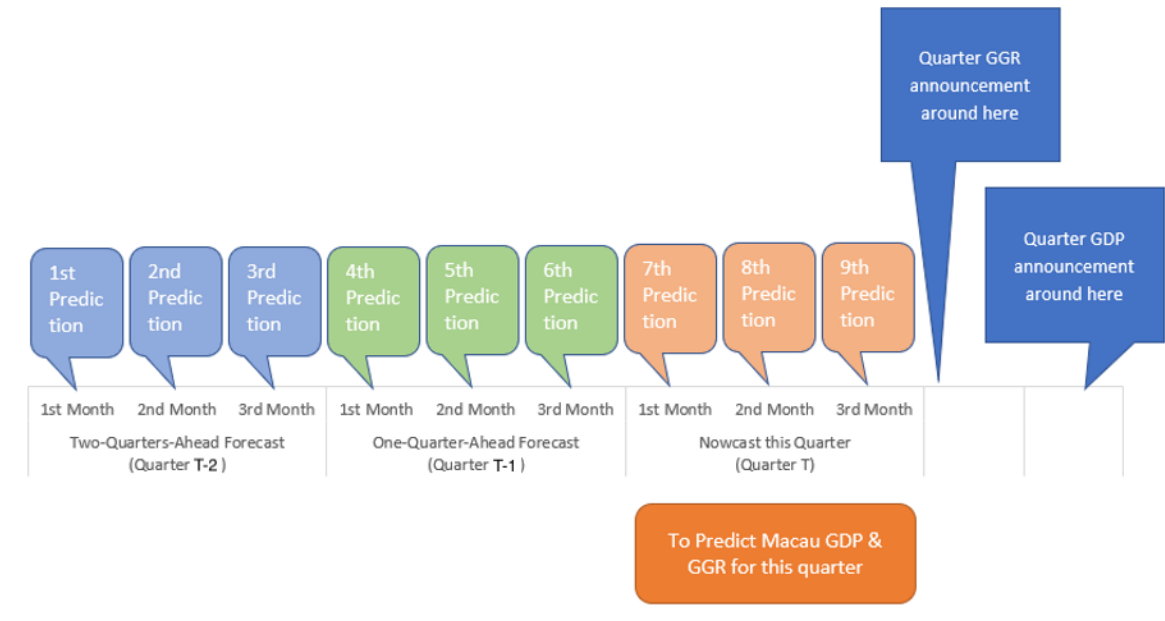




**Figure 3. Economic Indicators Versus Macau's GDP and GGR (YOY%)**



**Figure 4. Timeline for forecasting and nowcasting**



**Table 1. Economic indicators used as explanatory variables for forecasting GDP and/or GGR in the literature**

<b>Study</b>	<b>Forecast</b>	<b>Economic indicators used as explanatory variables</b>
Balcilar et al. (2013)	Nevada, USA GGR	The Nevada Leading Indicator, the Nevada Coincident indicator, and taxable retail sales
Kuzin et al. (2009)	Euro Area GDP	Industrial production Surveys: (e.g., business confidence industry, business production expectations) Interest rates, exchange rates, money stocks Raw material prices, car registrations
Barhoumi et al. (2009)	France GDP	Prices, Financial data: (e.g.) Rate of return on the long-term Government loans (monetary and financial statistics). Soft data: (e.g.) Business sentiment indicator in industry Hard data: (e.g.) Household consumption in manufactured goods, Disaggregated data: Business survey in industry Consumer confidence survey, Services activity survey
Aastveit and Trovik (2012)	Norway GDP	Interest rate, Financials, Commodity prices, Labor Market, Industrial production, Consumer Prices, Export & Import, Construction, Retail Trade, Credit
Liebermann, (2011)	USA GDP	Business Outlook Survey Business, Manufacturing ISM(NAPM), The conference board Consumer confidence index, University of Michigan Consumer sentiment index, University of Michigan inflation expectation, Employment situation, Industrial Production and capacity utilization, Manufacturing and trade Inventories and sales, Manufacturers' Shipments inventories and orders, New residential construction, Personal income, CPI, PPI, consumer credit, interest rates
Camacho et al. (2015)	Argentina GDP	Real Gross Domestic Product, Industrial Production Index, All Employees: Total Urban Population, Real Retail Sales: Total Supermarket Sales, Synthetic Indicator of Construction Activity
Porshakov et al. (2016)	Russia GDP	Survey Data (50 variables: includes statistics on leading indicators based on surveys studying producers' sentiments and preconditions for industry growth: primarily, Markit PMI data and diffusion indices published by Russian Economic Barometer for various industries). Hard Data (36 variables: industrial production, investments, domestic trade turnover, employment data, trade balance indicators, and other relevant variables). External & Financial Data (30 variables: indicators of economic growth among major trading partners, commodity prices, real sector, and interbank interest rates, money and credit growth, stock market indices, capital flows)
		GDP, Industrial Production, Construction Output, Retail Sales, Unemployment Rate, Consumer Price Index,

Rusnák (2013)	Czech Republic GDP	Exports, Imports, Export Prices, Import Prices, Exchange Rate, M2, credit, PRIBOR, EURIBOR, PX-50 Stock Index, Czech Government Bond Yield (10Y), Consumer Confidence Indicator, Industry Confidence, construction confidence, trade confidence, service confidence, Oil Price, Ifo Business Climate Germany, Euro Area Business Climate, Germany Exports
Bragoli (2017)	Japan GDP	Vehicle Sales, Average Monthly Earnings, Economy Watchers' Survey, Machinery Orders, Consumer Confidence, Capacity Utilization: Manufacturing, Tertiary Activity Industry Index, Exports, Imports, Retail Sales, Small & Medium Enterprises Survey, Industrial Production, Unemployed, Construction Orders: Housing Units, Housing Starts, PMI: Manufacturing, Passenger Car Production, GDP, Large Firms Survey
Luciani et al. (2015)	Indonesia GDP	Central Bank policy rate, PMI developing economies, Cement, domestic consumption, Exports, Car sales, Imports: Consumption goods, Imports: Capital goods, Imports: Raw materials, Gross domestic product, Business Tendency Index, Money supply (M2)
Bragoli and Fosten (2018)	India GDP	India Industrial Production, India Exports, India Imports, India PMI Services, India PMI Manufacturing, India Crude Oil Production, India Steel Production, India Electricity Generation, India Industrial Performance Assessment, India Money Supply (M1), India Exchange Rate, India 91-Day Treasury Bill, India Stock Prices Sensex/BSE 30, India Industrial Workers Consumer Price, India Agricultural Laborers Consumer Price, India Rural Laborers Consumer Price, India Consumer Price, India Wholesale Price Index (All Items), India Wholesale Price Index (Fuel and Power), US Industrial Production Index, US ISM Manufacturing PMI, Euro Area 19 Industrial Production, Euro-zone Manufacturing PMI, Asia (excluding Japan) Sentix Overall Index, India GDP at Market Prices
Clements and Galvão (2006)	US output growth and inflation	term spread (10year-Federal Funds), stock price index (500 common stocks), average weekly hours in manufacturing, news claims for unemployment insurance, building permits, vendor performance diffusion index, orders - consumer goods and materials, orders - nondefense capital goods, consumer confidence index (Michigan), real money supply M2, Total Industrial Production, Nonfarm payroll employment, Manufacturing Utilization Capacity, Civilian unemployment rate, M2 measure of the money stock
Andreou et al. (2013)	US GDP	Used daily financial assets under 6 categories: <ol style="list-style-type: none"> <li>1. Commodities prices such as Reuters/Jefferies CRB Futures Price Index: All Commodities, Europe Brent Spot Price FOB, etc.</li> <li>2. Corporate Risk such as Overnight London Interbank Offered Rate (%), London Interbank Offered Rate (%), etc.</li> </ol>

		<ol style="list-style-type: none"> <li>3. Equity prices such as S&amp;P 500 Stock price index</li> <li>4. Foreign exchange rate</li> <li>5. Government securities rates such as Fred funds rate and 3 Month T Bills</li> <li>6. Daily Aruoba Diebold Scotti Business Condition Index</li> </ol>
Schumacher (2014)	Euro area GDP	<p>Used monthly indicators under 5 categories:</p> <ol style="list-style-type: none"> <li>1. Industry indicators such as total industry output, energy output. New passenger car registrations</li> <li>2. Financial indicators such as DJ, Euro Stoxx 50 and Standard &amp; Poor's 500 Index USA</li> <li>3. Euro Area unemployment rate</li> <li>4. International indicators such as US PMI manufacturing and US unemployment rate</li> <li>5. Survey indicators such as industrial confidence</li> </ol>
Ferrara and Marsilli (2014)	GDP growth of 37 countries	<p>Economic variables under 4 categories:</p> <ol style="list-style-type: none"> <li>1. Real economic conditions: Housing, Car registrations, Retail Sales, Employment, Industrial production index, Unemployment rate, Producer price index, Consumer price index.</li> <li>2. Financial Series: Exchange rate, Money supply M2, Main national stock market index, 10 years government bond interest rate, 3 months interbank interest rate.</li> <li>3. Survey: Household confidence index.</li> <li>4. Overall indicators: Oil price (Brent, WTI, and Dubai), Baltic dry index, Import and export price (CPB), Energy price (HWWI), VIX index (CBOE).</li> </ol>
Chikamatsu et al. (2018)	Japan GDP	<p>Used Economic variables under 2 categories:</p> <ol style="list-style-type: none"> <li>1. Hard indicators such as the Index of industrial production and Current survey of commerce (sales value, wholesale)</li> <li>2. Soft indicators such as Reuters Tankan DI manufacturers, materials, oil refinery and ceramics, steel and metals, manufactured products, metal and machinery, electric machinery, precision machinery, real estate, retailers</li> </ol>
Mikosch and Solanko (2019)	Russian GDP	<p>Agricultural production yoy, Baker-Bloom-Davis economic policy uncertainty index level, CBR foreign exchange reserves yoy, economic output leading indicator yoy, Export price index for mineral fertilizers yoy, Ferrous metals railway freight turnover in tonnes yoy, Household banking deposits yoy, Household deposit rate for demand deposits in Russian rubels yoy, Industrial production yoy, Interbank loans yoy, Manufacturing production yoy, Monetary base level, Money supply M0 (cash) yoy, Money supply M2 yoy, OECD composite leading indicator yoy, Producer price index for construction materials (cement) yoy, Railway freight turnover yoy, REB diffusion index: Enterprises with rising stocks over 1 month yoy, Rosstat</p>

		key sectors economic output index yoy, RTS stock market index yoy.
Jardet and Meunier (2020)	World GDP	Explanatory variables over 17 economies include: Retail sales, Households' confidence, Car registrations, Number of employees, Unemployment rate, Industrial production, Manufacturing PMIs, Services PMI "headline", Composite PMI "headline"
Ankargren and Lindholm (2021)	Swedish GDP	Redundancy notices, Consumer confidence, PMI-total services, Production value index -industry, PMI total manufacturing in the USA, GDP, Unemployment rate, Prod. volume (expectations), PMI total manufacturing, Household consumption indicator, Economic sentiment – Euro Area, Production value index – services, Foreign trade – export, Hours worked, Total industry indicator, New orders (outcome)- manuf. Survey, Prod. volume (outcome) - manuf. Survey, Economic sentiment, PMI - planned production, PMI - planned business volume, New registrations of passenger cars, Retail trade sales volume, HOX real estate price index, Real estate transactions, SEB housing survey, Underlying inflation, Producer price index, Industrial production index – USA, Industrial production index – EU, Orders in industry, Electricity consumption, Foreign trade - import
Kočenda and Poghosyan (2020)	Countries in European Union Real GDP Growth	Total industrial production Index, Total manufacturing production Index, Production of electricity gas steam and air conditioning supply index, Total construction production Index, Total retail trade (Volume) Index, Passenger car registrations Index, Housing permits issued Index, Housing construction starts Index, Imports of goods, Exports of goods, Manufacturing production trend, Manufacturing production future trend, Manufacturing production employment future trend, Manufacturing production confidence indicators, Construction business activity tendency, Construction confidence indicators, Construction employment future trend, Real trade business situation activity trend, Real trade business situation activity future trend, Real trade confidence indicators, Retail trade employment future trend, Services (excluding retail trade) business situation activity trend, Services (excluding retail trade) confidence indicators, Services (excluding retail trade) employment trend, Services (excluding retail trade) employment future trend
Tiffin (2016)	Lebanon GDP	Tobacco Excises (real) Tourist Arrivals (number), Lending to the Private Sector (real) Property Taxes (real), Administrative Fees (real), Total Cleared Checks (real), Total Airport Passenger Flows (number), Cement Deliveries (volumes), Trade flows (imports plus exports, in real terms), Construction Permits (sq. m), Primary Fiscal Spending (real), Total Non-Resident Deposits (real), M3 (real), Port of Beirut Freight Incoming (volumes),

		Electricity Production (volumes), Port of Beirut Freight, Outgoing (volumes), Imports of Petroleum Derivatives (volumes), Imports of Machinery (volumes), Customs Revenue (real)
Loermann and Maas (2019)	US GDP	Real Personal Income, Real personal income ex transfer receipts, IP index, IP: Financial Products and Nonindustrial Supplies, IP: Final Products (Market Group), IP: Consumer Goods, IP: Durable Consumer Goods, IP: Nondurable Consumer Goods, IP: Business Equipment, IP: Materials, IP: Durable Materials, IP: Nondurable Materials, IP: Manufacturing (SIC), IP: Residential Utilities, IP: Fuels, ISM Manufacturing: Production Index, Capacity Utilization: Manufacturing, Help-Wanted Index for United States, Ratio of Help Wanted/No. Unemployed, Civilian Labor Force, Civilian Employment, Civilian Unemployment Rate, Average Duration of Unemployment (Weeks), Civilians Unemployed - Less Than 5 Weeks, Civilians Unemployed for 5-14 Weeks, Civilians Unemployed - 15 Weeks and Over, Civilians Unemployed for 15-26 Weeks, Civilians Unemployed for 27 Weeks and Over, Initial Claims, All Employees: Total nonfarm, All Employees: Goods-Producing Industries, All Employees: Mining and Logging: Industries, All Employees: Construction, All Employees: Manufacturing, All Employees: Durable Goods, All Employees: Nondurable Goods, All Employees: Service-Providing Industries, All Employees: Trade, Transportation and Utilities, All Employees: Wholesale Trade, All Employees: Retail Trade, All Employees: Financial Activities, All Employees: Government, Avg Weekly Hours: Goods-Producing, Avg Weekly Overtime Hours: Manufacturing, Avg Weekly Hours: Manufacturing, ISM Manufacturing: Employment Index, Avg Hourly Earnings: Goods-Producing, Avg Hourly Earnings: Construction, Avg Hourly Earnings: Manufacturing, Housing Starts: Total New Privately Owned, Housing Starts: Northeast, Housing Starts: Midwest, Housing Starts: South, Housing Starts: West, New Private Housing Permits, New Private Housing Permits: Northeast, New Private Housing Permits: Midwest, New Private Housing Permits: South, New Private Housing Permits: West, Real personal consumption expenditures, Real Manu. and Trade Industries Sales, Retail and Food Services Sales, ISM: PMI Composite Index, ISM: New Orders Index, ISM: Supplier Deliveries Index, ISM: Inventories Index, New Orders for Consumer Goods, New Orders for Durable Goods, New Orders for Nondefense Capital Goods, Unfilled Orders for Durable Goods, Total Business Inventories, Total Business: Inventories to Sales Ratio, Consumer Sentiment Index

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Jokubaitis and Celov (2019)	Gross Fixed Capital Formation (GFCF),  Private Final Consumption Expenditure (PFCE),  Imports,  Exports	3-Month or 90-day Rates and Yields, All Employees: Construction, All Employees: Education and Health Services, All Employees: Financial Activities, All Employees: Manufacturing, All Employees: Retail Trade, All Employees: Total Nonfarm, All Employees: Transportation and Warehousing, Auto Exports, Foreign Exchange Rate, Business Tendency Surveys for Manufacturing: Confidence Indicators, Cass Freight Index: Shipments, Commercial and Industrial Loans, Large Domestically Chartered Commercial Banks, Consumer Price Index of All Items, Current General Activity; Diffusion Index, Employment Rate, Exports of Goods and Services, Balance of Payments Basis, Exports: Value Goods for Japan, Exports: Value Goods for the Republic of Korea, Global price of Cocoa, Global price of Lead, Global price of Natural Gas, US Henry Hub Gas, Industrial Production: Computers, communications equipment, and semiconductors, Industrial Production: Construction supplies, Industrial Production: Durable Goods, Industrial Production: Durable manufacturing, Industrial Production: Durable Materials, Industrial Production: Nondurable Goods, Industrial Production: Nondurable manufacturing, Merchant Wholesalers, Except Manufacturers' Sales Branches and Offices Sales: Durable Goods Merchant Wholesalers, Except Manufacturers' Sales, Branches and Offices Sales: Nondurable Goods, New Private Housing Units Authorized by Building Permits, New Privately-Owned Housing Units Completed, Personal Consumption Expenditures, Producer Price Index by Commodity for Rubber and Plastic Products, Production in Total Manufacturing for Mexico, Production of Total Industry in Canada, Production of Total Industry in Korea, Production of Total Industry in Spain, Production of Total Industry in Sweden, Professional and Business Services: Temporary Help Services, Ratio of Manufacturers' Total Inventories to Shipments for Durable Goods Industries, Real Manufacturing and Trade Industries Sales, Real Personal Consumption Expenditures, Retail Trade: Building Materials, Garden Equipment and Supplies Dealers, Retail Trade: Electronics and Appliance Stores, Total Private Construction Spending, Total Share Prices for All Shares for the Republic of Korea, Unemployment Rate, US export, US Gross Fixed Capital Formation, US Import, US Private Final Consumption Expenditure, Value of Manufacturers' New Orders, Value of Manufacturers' Shipments for Capital Goods, Value of Manufacturers' Shipments for Durable Goods Industries, Value of Manufacturers' Total Inventories for Durable Goods Industries, Value of Manufacturers' Unfilled Orders for Durable Goods Industries
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Tamara et al. (2020)	Indonesian GDP	Gross Domestic Product Current Price, Consumption Expenditure, Private Consumption Expenditure, Government Expenditure, Gross Fixed Capital Formation, Change in Stocks, Export of Goods and Services, Import of Goods and Services, Agriculture Industry Services, Current Account, External Debt, Foreign Direct Investment, Consumer tendency index, BS: PC Utilization: Manufacturing Industry (MI), Business Tendency Index, Domestic Investment, Foreign Investment
Richardson et al. (2018)	New Zealand GDP	Real-time data include: New Zealand business surveys; consumer and producer prices; general domestic activity indicators (e.g., concrete production, milk-solids production, spending on electronic cards etc.); domestic trade statistics; international macroeconomic variables and international and domestic financial market variables.

**Table 2. Correlation between YOY% of economic indicators and GGR and GDP of Macau from 2012 Q1 to 2019 Q2**

Economic indicators	GDP (t)	GDP (t+1)	GGR (t)	GGR (t+1)
<i>Internal indicators:</i>				
Macau tourism visitor expenditure derived by extrapolation	89.4%	82.5%	89.6%	82.4%
Macau retail sales watches, clocks and jewelry	82.6%	82.5%	83.0%	79.0%
Macau index of retail sales (4/2015-3/2016) Index	86.1%	82.8%	83.9%	76.8%
Macau total retail sales	86.5%	81.1%	83.9%	74.9%
Macau number of overnight visitors	48.8%	58.2%	60.2%	71.5%
Macau money deposits of residents	81.5%	68.8%	68.3%	55.3%
Macau residential property price index (2011=100)	71.0%	58.4%	53.9%	41.2%
Macau average exchange rates of MOP per 100 units of Renminbi	48.4%	38.8%	45.3%	32.4%
Macau Consumer Price Index (CPI) (4/2018-/2019=100)	9.3%	-8.0%	-13.6%	-32.0%



*Gaming industry indicators:*

Share price of SJM Holdings Ltd	83.2%	82.5%	86.3%	84.8%
Share price of Galaxy Entertainment Group Ltd	84.8%	86.2%	81.4%	79.8%
Share price of Sands China Ltd	87.2%	88.0%	80.7%	78.2%
Share price of MGM China Ltd	73.0%	78.9%	71.8%	74.7%
Share price of Melco Resort and Entertainment Ltd	80.9%	80.9%	76.6%	74.3%
Share price of Wynn Macau Holdings Ltd	70.4%	69.9%	77.2%	73.1%

*External indicators:*

China NMI retail price subindex	62.6%	71.5%	72.6%	75.4%
China total import	74.3%	67.3%	82.2%	74.6%
China NMI price subindex	80.1%	77.6%	74.8%	67.4%
China PMI import subindex	50.5%	55.5%	61.4%	64.5%
China industrial value added	42.2%	50.4%	56.3%	64.4%
China electricity production	62.4%	61.2%	66.4%	62.5%
China total import & export	70.4%	56.8%	73.6%	60.0%
China PMI raw material subindex	37.0%	48.5%	52.3%	58.8%
China PMI employee subindex	62.5%	61.6%	60.6%	58.7%
China PMI purchase subindex	56.4%	51.5%	64.4%	56.0%
China PMI on hand order subindex	61.2%	50.3%	65.3%	52.9%
China Real estate investment	78.4%	68.0%	66.1%	52.3%
China PMI	58.4%	47.7%	63.7%	52.0%
China PMI new order subindex	51.9%	42.6%	60.6%	51.0%
China NMI	74.0%	62.6%	64.8%	51.0%
China NMI new order subindex	62.2%	60.1%	53.3%	50.2%
China PMI new export order subindex	48.3%	44.4%	52.0%	46.0%
Hong Kong retail sales of jewelry, watches, and clocks, and valuable gifts	63.5%	62.5%	65.8%	63.2%
Hong Kong total imports	60.2%	50.9%	63.1%	53.8%

Hong Kong total exports	52.9%	46.3%	57.0%	51.4%
Hong Kong total retail	66.4%	55.3%	61.9%	49.5%

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Sources: China National Bureau of Statistics (2021), DSEC (2021), Government of Hong Kong SAR (2021) and International Monetary Fund (2021).