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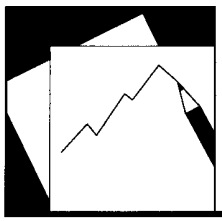

IMF Working Paper

Evaluating GDP Forecasting Models for Korea

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INTERNATIONAL MONETARY FUND

 WP/11/53

IMF Working Paper

Asia and Pacific Department

Evaluation of GDP Forecast Models for Korea

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Authorized for distribution by Subir Lall

March 2011

Abstract

This paper develops a new forecasting framework for GDP growth in Korea to complement and further enhance existing forecasting approaches. First, a range of forecast models, including indicator- and pure time-series models, are evaluated for their forecasting performance. Based on the evaluation results, a new forecasting framework is developed for GDP projections. The framework also generates a data-driven reference band for the projections, and is therefore convenient to update. The framework is applied to the current World Economic Outlook (WEO) forecast period and the Great Recession to compare its performance to past projections. Results show that the performance of the new framework often improves the forecasts, especially at quarterly frequency, and the forecasting exercise will be better informed by cross-checking with the new data-driven framework projections.

JEL Classification Numbers:

Keywords: Forecast, GDP, Korea, indicator model, reference band

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* The author would like to thank Meral Karasulu for her immense help throughout the preparation of this paper.

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I. INTRODUCTION

The purpose of this paper is to evaluate and enhance growth forecasts for Korea by developing a purely data-driven forecast framework. The paper uses high frequency economic indicators as well as pure time-series methods to project GDP. The initial selection of the indicators is driven by economic theory, and is evaluated using various forecast models. The new forecast framework is fully data-driven and therefore convenient to update. This differs from many existing forecasting approaches, which often involve a significant amount of subjective judgment. The simulation results suggest that, at annual frequency, the WEO forecasts are in line with the forecasts of the data-driven framework, although they can be improved at quarterly frequency by better incorporating seasonal factors.

The rest of the paper is organized as follows. Section II introduces the forecast models evaluated in the paper. Section III explains the evaluation method, including issues related to data, evaluation periods and estimation samples. Section IV provides the evaluation results and Section 5 develops the new forecast framework based on the evaluation results. Two application examples are also included in Section V—an assessment of the current WEO forecasts and an evaluation of the forecasts by the new framework at the onset of the recent Great Recession. SectionVI summarizes and concludes.

II. FORECAST MODELS

Indicator models

The forecast models estimated and evaluated in this paper can be divided into two categories, *indicator models* and *pure time-series models*. Suppose V is the variable to forecast, which could either be GDP itself or one of its demand components, and M is a vector of economic indicators. The indicator models include:

i) VAR – Vector autoregression models in levels:

   The VAR models include the first two lags of all related variables, and are estimated in the levels of V and M to produce dynamic out-of-sample forecasts.[1]

ii) GVAR – Vector autoregression models in growth rates:

   GVAR is similar to the previous method, but includes the growth rates of V and M instead, to address potential nonstationarity and non-cointegration issues among

[1] The selection of the lag structure for various models is motivated by the need to find a parsimonious specification that could be applied across the board and easily updated, while being sufficiently long to capture the time series properties of the variables.

the data.[2] Like VAR, the GVAR models also include the first two lags of all variables.

iii) INDAR

This method forecasts *V* based on the following regression:

$$V_t = \alpha + \beta M_t$$

where the out-of-sample projections of *M* are derived from an AR(1) process.

iv) INDLAG(*L*)

The *n*-period ahead forecast of *V* is based on the following regression:

$$V_t = \alpha + \sum_{l=1}^{L} \beta_l M_{t-n-l}\,, \text{where } L = 1 \text{ or } 2\,.^{3}$$

Unlike INDAR, this method involves no forecast of the indicators. However, in order to obtain the out-of-sample forecasts for different horizons, the above equation needs to be estimated multiple times, one for each forecast horizon.[4] For instance, for INDLAG(1), the one-period ahead out-of-sample forecast is based on the estimation of $V_t = \alpha + \beta M_{t-2}$, while the two-period ahead forecast is based on $V_t = \alpha + \beta M_{t-3}$. The out-of-sample projections by this method are static forecasts.

Pure time-series models

Pure time-series models estimated and evaluated in this paper include:

i) GRW - Random walk models in growth rates[5]:

The GRW method assumes that the future growth rates of *V* are given by the last available observation. This simple forecast method serves as the benchmark for the forecast evaluations. The forecast performance of all models will first be

[2] If *V* and the variables in *M* are I(1) processes, the VAR in their growth rates will still be a stable system, even when the variables are not cointegrated.

[3] For any period *T*, the assumption is that only information up to period *T-1* is available for out-of-sample forecasting. Thus the first out-of-sample forecast at period *T* would actually be for period *T* itself. See the concept of *standing point* in Section 3.

[4] This is different from the AR models, which estimate only one regression for any period *T* and then forecast out *V* dynamically.

[5] All growth rates in the forecast models are calculated on sequential basis. For instance, for quarterly data, this means quarter-on-quarter growth rate, rather than growth rate over the same period of last year.

compared to that of the GRW model, and then compared to each other on the basis of their relative performance with respect to the GRW model.

ii) GMA – Moving average models in growth rates:

The GMA model projects the future path of *V* by assuming that its growth rate is a moving average process. MA(6) is used for all variables in this paper.

iii) GAR – Autoregression models in growth rates:

GAR is similar to GMA, but models the growth rate of *V* as an autoregressive process instead. AR(4) is used for all variables in this paper.

iv) AR(1) and AR(6) – autoregression models in the level of *V*.

v) LAG – Ordinary least square regressions on the lag of *V:*

The *n*-period ahead forecast of *V* is based on the following regression:

$$V_t = \alpha + \beta V_{t-n-1}.$$

As the INDLAG models, LAG runs a regression for each forecast horizon and produces static out-of-sample projections.

III. Model Evaluations

Evaluation method

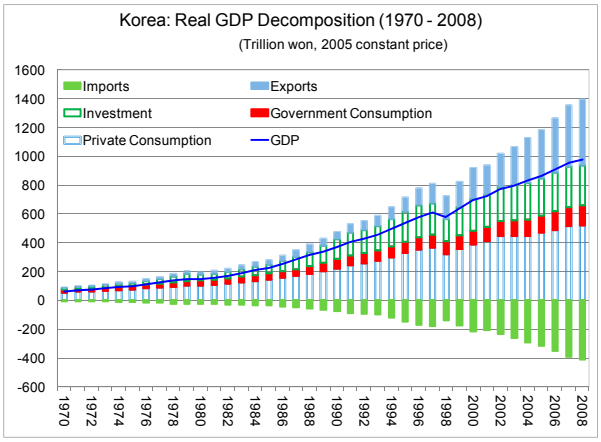
The paper first evaluates the forecast performance of different models for the individual demand components of GDP, namely, private consumption (C), investment (I), government consumption (G), exports (X) and imports (M). Based on the results, it will then construct forecast models for the aggregate GDP, by summing up, respectively, the best performing indicator models and pure time-series models for each component. Finally, these forecast-by-components models will be compared to several other methods that forecast GDP directly, including the WEO framework.

There are two main reasons to forecast GDP by components. First, although there are *broad* indicators for GDP, the use of more tailored indicators to capture the developments of a certain component of GDP, may improve the forecasts. For instance, the consumption goods shipment index would be more helpful to forecast consumption than the GDP. The paper tries to take advantage of such *specific* indicators. Secondly, in addition to forecasting GDP itself, another objective of the new framework is to provide better insight into the key driving factors behind the GDP forecasts.

To sift through various models in a consistent manner, the paper utilizes a *standing point* concept to define the information set used for estimation as well as the beginning of the forecast period. For instance, when a model is applied to forecast a variable at *standing point T*, the estimation sample extends up to period T-1, and the first out-of-sample forecast would be for period *T*. For each *standing point* T, eight out-of-sample forecasts are obtained, for

periods *T* to *T+7*, resulting in eight series of out-of-sample forecast, one for each forecast horizon.

While GDP and its components are forecasted in levels, the performance of the models is evaluated using their growth rates. This is partly because GDP and its components have a trend, thus the same percentage deviations in forecasts would imply larger and larger level forecast errors over time. It should also be noted that, for any *standing point T*, the growth rates for evaluation purposes are calculated relative to the same fixed period, *T-1*, instead of on a sequential basis. For example, after a model produces out-of-sample forecasts $\hat{V}_T$ to $\hat{V}_{T+7}$, the projected growth rates of *V* will be calculated as $(\hat{V}_t - V_{T-1})/V_{T-1}$, where *t* is any period between *T* and *T+7*.[6]



The main evaluation metric used is the root mean squared forecast error (RMSFE), relative to that of the GRW model. If the model being evaluated outperforms the GRW model at a certain forecast horizon, its RMSFE ratio will be less than unity for that forecast horizon. For two different forecast models, smaller RMSFE ratios suggest better forecast performance.[7]

Data

Data are summarized in Appendix I, which includes quarterly data on real GDP and its demand components, and monthly data on various economic indicators. Some data series go back to as far as 1970, while the last observations are either 2008Q4 or 2008M12.

Since GDP and its components are at quarterly frequency, the monthly indicators need to be converted into quarterly data before being used for forecasting. For the VAR, GVAR and INDLAG models, the quarterly indicators are calculated as the average of the available monthly observations, whereas for INDAR, the indicators are first forecasted using AR models with monthly data and then averaged into quarterly numbers.

[6] Why does the paper not adopt sequential growth rates as the basis for evaluations? Suppose the actual sequential growth rates for periods *T* and *T+1* are 4 percent and 5 percent, respectively, while the projected sequential rates are 5 percent and 4 percent. If the evaluations were based on sequential growth rates, both projections for *T* and *T+1* would have missed the actual by 1 percentage point. However, the evaluations based on the growth rates relative to the fixed period *T-1* would suggest the projection for period *T+1* as exactly right.

[7] Two alternative criteria were also utilized in cases where clear conclusions could not be reached using the RMSFE ratio. These are the mean absolute forecast errors (MAE) ratio and the mean absolute percentage deviations (MAPD), both relative to the GRW model as well.

Although the indicator models use quarterly data to forecast GDP and its components, there will actually be three monthly updates at each *standing point T*, when new monthly indicators become available.[8] These monthly updates are divided into three groups, M1, M2 and M3, depending on how many monthly observations are available for that particular *standing point*. Comparing the M1, M2 and M3 forecasts could shed some light on whether high frequency update of the indicator models, incorporating the most recent information, is really helpful to improve the forecasts. If the answer is positive, then the M3 forecasts, which incorporate the latest information, should be better than the M2 forecasts, which in turn should be better than the M1 forecasts.

Evaluation periods and estimation samples

All forecast models are evaluated based on their performance in two evaluation periods, the *standard* one, which starts in 2003Q1 and ends in 2008Q4, and the *extended* one, which extends the standard one to include earlier periods going as far back as 1970s, and whose starting point varies across models depending on data availability. The purpose of studying different evaluation periods is to check whether the predictive power of the economic indicators and forecast models has changed over time.

When a forecast model is evaluated for the standard evaluation period, it is estimated using two different estimation samples at each *standing point*, one starting in 1997Q1 (the *standard* estimation sample) while the other extending as far back as allowed by the data (the *extended* estimation sample). The purpose of using different estimation samples is to find out whether longer data series or a more homogenous sample helps to improve forecasts. When the forecast model is evaluated for the extended evaluation period, the estimations are always based on extended estimation samples.

IV. Evaluation Results

Demand components of GDP

The candidate indicators for the demand components of GDP are listed in Table 1. Some of them are specific indicators capturing the development of a certain component, such as the consumption goods shipment index. There are also general indicators, such as the stock market index, KOSPI, and the CPI. These are included to capture mechanisms such as wealth effects and linkages between the financial and real sectors of the economy.[9] Based on these indicators, the paper evaluates various indicator models for each demand component, whose specifications are explained in Appendix II. In addition, there are five pure time-series models evaluated for each demand component, *GMA*, *GAR*, *AR1*, *AR6* and *LAG*.

[8] The standing point *T* here refers to a certain quarter.

[9] Among the demand components, it is most difficult to find good indicators for government consumption, which is often regarded as exogenous in macroeconomic models. Therefore, the correlations between G and some of its candidate indicators are weak.

Table 1. Candidate Economic Indicators for Demand Components of GDP

Private consumption (C)	Consumption production shipment index (PSI)	Investment (I)	Investment index (IVD)
	Retail trade index (RTL)		Index of machinery equipment for investment (MIV)
	Passenger car sales (CSL)		Leading composite index (LCI)
	Stock market index (KOSPI)		Stock market index (KOSPI)
	Consumer price index (CPI)		Housing price index (PHO)
Government consumption (G)	Leading composite index (LCI)	Exports (X)	
	Government current expenditure (GCE)		Industrial production index of Korea (IPI)
	Employment (EPL)		Industrial production index of US (IPU)
	Stock market index (KOSPI)		Industrial production index of China (IPN)
	Consumer price index (CPI)		Purchasing manager index (PMI)
Imports (M)	Industrial production index of Korea (IPI)		Semiconductor industry book to bill ratio (BBR)
	Leading composite index (LCI)		Consumer confidence index of US (CIU)
	Coincident composite index (CCI)		Stock market index (KOSPI)
	Stock market index (KOSPI)		Real effective exchange rate of Won (RER)
	Real effective exchange rate of Won (RER)		

Summarized in Table 2 are the best performing models based on the evaluation results.[10]

Table 2. Evaluation Results - Best Forecast Models

Demand Component	Model type	Evaluation Period 1/	Estimation Sample	Model name 2/	Forecast method	Indictors
Private consumption (C)	Indicator	S	S	*VARPSI**	*VAR*	PSI
		S	E	*VARPSI*	*VAR*	PSI
		E	E	*KOSPICPI*	*INDLAG1*	PSI, RTL, CSL, KOSPI, CPI
	Time-series	S	S	*AR1*		
		S	E	*AR1**		
		E	E	*AR1*		
Investment (I)	Indicator	S	S	*VARIND*	*VAR*	IND
		S	E	*LCIIVD3**	*INDAR*	LCI, IVD
		E	E	*MIVIVD3*	*INDAR*	MIV, IVD
	Time-series	S	S	*AR1*		
		S	E	*LAG**		
		E	E	*AR1*		
Government consumption (G)	Indicator	S	S	*VARLCI*	*VAR*	LCI
		S	E	*VARLCI**	*VAR*	LCI
		E	E	*VARLCI*	*VAR*	LCI
	Time-series	S	S	*AR1*		
		S	E	*GAR**		
		E	E	*AR1*		
Exports (X)	Indicator	S	S	*VARCCI*	*VAR*	CCI
		S	E	*VARIPI**	*VAR*	IPI
		E	E	*VARPMI*	*VAR*	PMI
	Time-series	S	S	*AR1*		
		S	E	*LAG**		
		E	E	*AR1*		
Imports (M)	Indicator	S	S	*LCICCI3**	*INDAR*	LCI, CCI
		S	E	*VARIPI*	*VAR*	IPI
		E	E	*IPI*	*INDLAG1*	IPI
	Time-series	S	S	*AR1*		
		S	E	*LAG**		
		E	E	*LAG*		

1/ "S" stands for standard evaluation period or estimation sample, while "E" stands for extended ones.
2/ * indicates the best forecast models for the standard evaluation period.

[10] Detailed evaluation results are not reported to save space, but available upon request.

The evaluation process suggests the following key findings:

- For each demand component, the forecast performance varies greatly across the indicator models, although they are based on the same small set of indicators. This suggests that the forecast performance depends not only on the selection of indicators, but also on the forecasting methods.

- The best forecast models are different for the standard and extended evaluation periods in most cases, which implies that the predictive power of the indicators and forecast models have changed over time. This could be due to improvements in data quality, or more fundamentally due to structural breaks, or both.

- Comparisons of the M1, M2 and M3 forecasts show that, although there are cases where as expected, monthly updates improve forecasts at the quarterly frequencies, it is not a consistent finding and the improvements from M1 to M2 and from M2 to M3 are often very small. Such results suggest that incorporating the most recent monthly observations of the indicators does not always improve the forecasts, and when it does, the benefits tend to be marginal.

- Neither the indicator models nor the pure time-series models show consistently better performance over the other. This partly explains why the new forecast framework developed in the next section, takes advantage of both types of models.

- Among the indicator models, for the standard evaluation period, there is a clear trade-off between estimation samples. Forecasts based on the standard estimation samples are often better than those based on the extended ones at short forecast horizons, while it is the opposite for longer forecast horizons. This seems to suggest that for short-term forecasts, the homogeneity of the sample matters more than the size of the sample, while longer data series are better suited for medium-term forecasts. This trade-off pattern is less evident among the pure time-series models, for which longer data series often perform better despite the potential risk of structural breaks.

Aggregate GDP

Based on the above results, two forecast-by-component GDP models are constructed for each evaluation period. To keep the illustration simple, these models are built by simply summing up the best indicator models (*INDGDP*) and the best time-series models (*TSGDP*), respectively.[11] The paper then compares them against several other models that forecast the aggregate GDP directly, which include time-series models, the growth rate random-walk model (*GRW*) and the AR(1) model (*AR1GDP*), and the current forecasting framework (referred to as *WEO*).[12] As before, *GRW* is still the underlying

[11] For the indicator models, the M3 forecasts are used for the evaluations in this section.

[12] For the standard evaluation period, there are two *AR1GDP* models, one based on standard estimation samples and the other on extended ones.

benchmark for the evaluations. The WEO observations used for the evaluations include all the published WEO forecasts between 2000 and 2008.

Table 3 summarizes the evaluations of the aggregate GDP forecast models.[13] A notable result is the relative performance of the WEO forecast. For both the standard and extended evaluation periods, the benchmark random walk model outperforms *WEO* at most forecast horizons, although the WEO forecasts seem to perform quite well only at *T+3*. Since the *T+3* projections are actually four quarters ahead forecasts relative to the information set, the strong performance of *WEO* at this particular forecast horizon suggests that its overall performance could be due to the less well-developed seasonal pattern in its quarterly forecasts. To verify this, the models are compared again after the quarterly forecasts are aggregated into annual ones.[14] The conjecture is to a large extent confirmed by the results in Table 4. For the standard evaluation period, the existing forecasting framework turns out to be the second best forecast model, only next to *AR1GDP*. For the extended evaluation period, although *WEO* still trails both *AR1GDP* and *TSGDP* at *T+0* and *T+1*, the difference is significantly smaller compared to what was reported in Table 3, and it actually has the best performance at *T+2* and *T+3*.

Table 3. Forecast Evaluation Result for Aggregate GDP (Quarterly) 1/

	T	*T+1*	*T+2*	*T+3*	*T+4*	*T+5*	*T+6* 4/
Standard evaluation period							
INDGDP	0.719	0.732	0.823	1.019	1.094	0.953	0.914
TSGDP	0.849	0.778	0.771	0.865	0.865	0.823	0.782
AR1GDP_S 2/	0.788	0.735	0.723	0.789	0.794	0.748	0.721
AR1GDP_E 2/	0.801	0.734	0.701	0.738	0.720	0.654	0.599
WEO 3/	1.771	1.720	2.370	0.693	1.557	1.826	3.385
Extended evaluation period							
INDGDP	1.357	1.046	0.949	1.012	0.801	0.789	0.788
TSGDP	0.605	0.590	0.593	0.650	0.509	0.473	0.457
AR1GDP	0.586	0.550	0.567	0.587	0.451	0.391	0.357
WEO 3/	2.384	2.222	2.596	0.623	1.246	1.423	2.160

1/ Reported are the ratios of RMSFE between the forecast models in the table and the growth random walk model.

2/ *AR1GDP_S* and *AR1GDP_E* are based on standard and extended estimation samples, respectively.

3/ The evaluations for WEO are based on the published WEO forecasts between 2000 and 2008. In the rare case of two published WEO in a quarter, the latest forecasts are used. There are 15 observations for the standard evaluation period and 22 for the extended evaluation periled.

4/ Since *T+6* is the longest horizon for the WEO forecasts, *T+7* is not included for the comparisons.

[13] Since there is no observation of WEO forecasts for *T+7*, the table covers only the forecast horizons from *T* to *T+6*.

[14] The annual GDP forecasts used in the evaluations do not necessarily coincide with the calendar year. Rather, they are based on a moving window. For instance, for standing point *T*, the annual GDP forecast for *T* is the sum of the quarterly forecasts for *T* to *T+3*, while the annual GDP forecast for *T+1* is the sum of the quarterly forecasts for *T+1* to *T+4*. Because of this, based on the quarterly GDP forecasts for *T* to *T+6*, 4 annual GDP forecasts can be constructed, for *T* to *T+3*.

Table 4. Forecast Evaluation Result for Aggregate GDP (Annual) 1/

	T 3/	*T+1*	*T+2*	*T+3*
Standard evaluation period				
INDGDP	0.922	1.016	1.004	1.012
TSGDP	0.707	0.720	0.726	0.710
AR1GDP_S 2/	0.667	0.683	0.691	0.697
AR1GDP_E 2/	0.581	0.537	0.484	0.428
WEO	0.571	0.544	0.505	0.699
Extended evaluation period				
INDGDP	0.966	0.830	0.791	0.750
TSGDP	0.529	0.510	0.479	0.450
AR1GDP	0.496	0.468	0.428	0.382
WEO	0.573	0.528	0.412	0.340

1/ Reported are the ratios of RMSFE between the forecast models in the table and the growth random walk model.

2/ *AR1GDP_S* and *AR1GDP_E* are based on standard and extended estimation samples, respectively.

3/ The annual GDP forecasts used in the evaluations do not necessarily coincide with the calendar year. Rather, they are based on a moving window. For instance, for standing point *T*, the annual GDP forecast for *T* is the sum of the quarterly forecasts for *T* to *T+3*, while the annual GDP forecast for *T+1* is the sum of the quarterly forecasts for *T+1* to *T+4*.

At quarterly frequency, the performance of the indicator model, *INDGDP*, is not satisfactory either. It fails to beat the underlying benchmark model consistently. Unlike the WEO, converting the quarterly forecasts into annual ones does not help improve its performance, especially for the standard evaluation period.

The time-series models, on the other hand, generally perform well. For both evaluation periods, whether at quarterly or annual frequency, the time-series models consistently beat the benchmark with large margins. There are two additional interesting observations. First, the model that forecasts the aggregate GDP directly (*AR1GDP*) outperforms the forecast-by-component model (*TSGDP*). This result shows that although forecasting GDP by components may provide helpful interpretations to the projections, it does not necessarily improve the accuracy of the forecasts. Second, for the standard evaluation period, the model based on the extended estimation samples (*AR1GDP_E*) consistently outperforms the one based on the standard estimation sample (*AR1GDP_S*).

To summarize: (i) The *WEO* forecast performs well at annual frequency, but its quarterly projections do not seem to capture seasonality properly; (ii) In spite of their simplicity, the selected time-series models generally perform well. Compared to the AR models that forecast the aggregate GDP directly, forecasting each component using time-series models does not seem to improve the accuracy of the forecasts significantly; (iii) Although the indicator models provide good projections for some individual GDP components, and are helpful for interpreting the GDP forecasts, simply summing them up does not produce better forecasts of the aggregate GDP.

V. THE NEW FORECAST FRAMEWORK: AN APPLICATION

This section discusses how to apply the findings in the previous section to forecast GDP. The first subsection illustrates the new forecast framework through an example assessing the current WEO forecasts, and the second subsection examines how this forecast framework would have performed at the onset of the recent Great Recession.

New forecast framework

There are four steps in the new forecast framework. First, at least two forecast models are selected for each individual demand component of GDP, based on their forecast performance evaluated in Section IV. The next step is to forecast the demand components of GDP using the selected models based on available information. Currently most of the indicators are available up to July 2010, and the paper forecasts the demand components out for eight quarters, from 2010Q3 to 2012Q2. The forecast results are reported in Table 5 below.

Table 5. Forecasts on Demand Components of Real GDP (2010Q3 - 2012Q2, trillion KRW, 2005 constant price)

Demand Component	Forecast Model	2010Q3	2010Q4	2011Q1	2011Q2	2011Q3	2011Q4	2012Q1	2012Q2	Accumulative
Private consumption	*VARPSI* (standard) 1/	134.7	134.7	134.6	134.7	134.9	135.2	135.5	135.8	1080.2
	AR1 (extended)	135.8	137.0	138.1	139.3	140.4	141.6	142.8	143.9	1118.9
Government consumption	LCIIVD3 (extended)	39.0	39.5	40.0	40.5	41.1	41.6	42.1	42.7	326.4
	LAG (extended)	38.5	38.0	40.2	40.4	40.6	40.1	42.5	42.7	323.1
Gross capital formation	VARLCI (extended)	74.2	74.6	75.1	75.6	76.2	76.7	77.3	77.9	607.7
	GAR (extended)	69.8	70.0	70.2	70.3	70.4	70.6	70.8	71.3	563.4
Exports	VARIPI (extended)	132.5	135.7	138.7	141.7	144.7	147.8	150.9	154.1	1146.0
	LAG (extended)	131.8	134.3	137.0	139.8	142.6	145.0	147.8	151.5	1129.8
Imports	*LCICCI* (subsample)	115.1	117.1	119.2	121.4	123.5	125.7	127.9	130.2	980.2
	LAG (extended)	113.2	114.7	116.2	117.7	119.1	120.3	122.0	124.6	947.7

1/ The selection of the forecast models is based on the standard evaluation period. Indicated in the parenthesis are estimation samples.

The next step is to aggregate the forecasts of the individual demand components into an aggregate GDP forecast. Here, the framework allows us to construct a high path and a low path for GDP forecasts, respectively, based on the individual demand component forecasts. For instance, in the Table 5, the indicator model, *VARPSI*, has a higher cumulative forecast for private consumption than the time-series model, *AR1*. This suggests that the forecasts of private consumption by *VARPSI* will be part of the high path forecast, while those by *AR1*

will be part of the low-path forecast.[15] For investment, on the other hand, the indicator model, *LCIIVD3*, will be part of the low-path profile, while the time-series model, *LAG* will be part of the high path profile. For the net exports, the paper uses high/high and low/low combinations for exports and imports, since high export activities are often associated with high import volumes, and vice versa.[16] The projected high path and low path forecasts form a *model-based reference band* for the GDP forecasts.

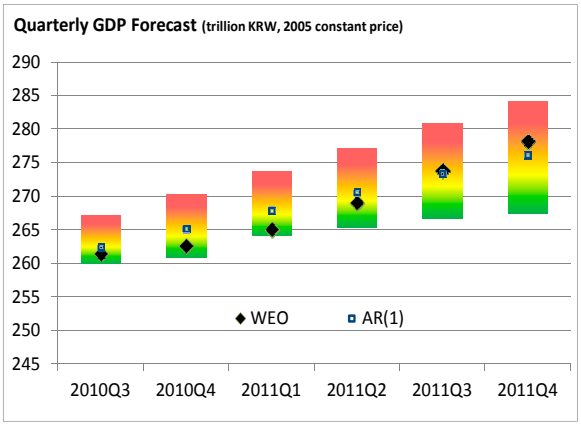
The last step of the new framework is to forecast the aggregate GDP directly using the AR(1) model, which has the best forecasting power. The projections by the AR(1) model provide another reference for forecasting the aggregate GDP, which complements the reference band established by the high path and low path forecasts.

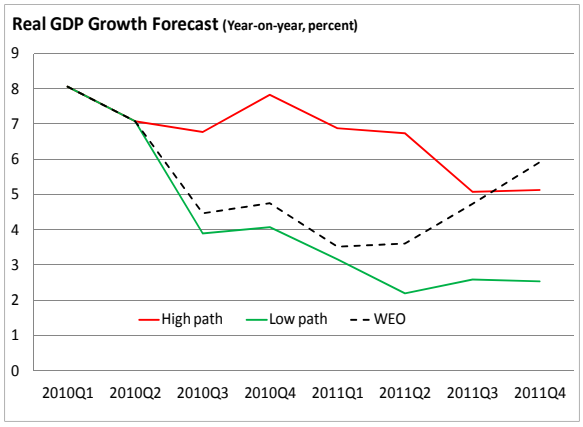
The first example applies the above framework to assess the current WEO projections. The projections are reported in Appendix III. For 2010 annual projections, the high path, low path and *AR1* projections of the real GDP growth are 7.4, 5.7 and 6.4 percent, respectively. The WEO projection, at 6.1 percent, is within the reference band defined by the high and low paths, but much closer to the low path and below the *AR1* forecast. The components of the forecast reveal that this is primarily due to a conservative—relative to the data-driven models—forecast of government consumption by *WEO*. Had the WEO forecast used even the low path forecast of government consumption, its annual growth projection for 2010 would be 7.0 percent, much closer to the high path projection. Preliminary estimates for 2010 indicate that actual GDP growth in Korea was indeed 6.1 percent, exactly in line with the staff's WEO projection.

For 2011 annual forecasts, the assessment is based on the projected GDP levels, instead of growth rates, to avoid bias caused by base effects. The WEO projection is very close to the level projected by the *AR1* model, and both projections are near the middle of the band defined by the high path and low path forecasts. These results provide support to the current annual WEO projection for 2011. However, a closer examination of the components of the GDP forecasts reveals that the only demand component for which the WEO projection lies roughly in the middle of the reference band is investment. The WEO projection for private consumption is more optimistic than the high path projection, while for the net foreign balance, it is very close to the upper bound of the reference band. Nonetheless, the conservative WEO projection on government consumption ensures that the WEO forecast for the aggregate GDP is still within the reference band.

[15] Previously, to compare the performance of time-series models and indicator models, the paper summed up the demand component forecasts based on the types of models. Since the primary goal of this section is to generate a forecast band, the aggregation takes into account the numeric value of forecasts from both indicator and time-series models.

[16] Depending on magnitude, the high/high combination could be the low path net exports, and vice versa.



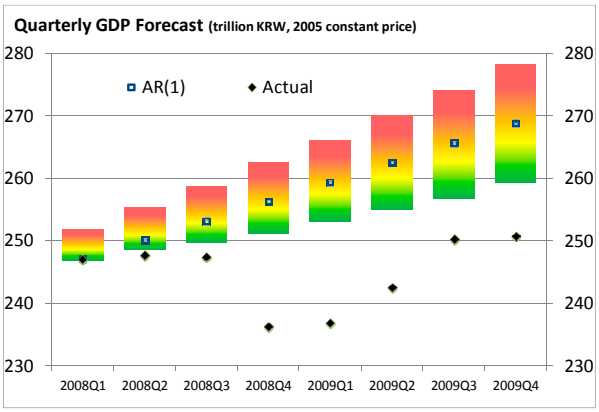


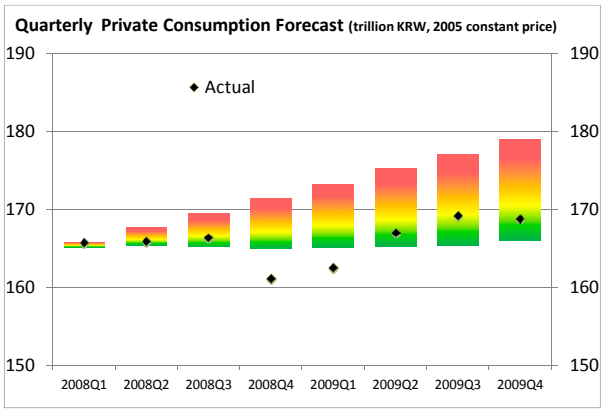
At quarterly frequency, the results are similar. While all the WEO forecasts stay within the reference band, the projection for 2011Q1 is very close to the lower bound. a closer look at individual demand components reveals that *WEO* actually has higher projections for private consumption and net foreign balance than the high path, but its forecast for government consumption is lower than suggested by the band, which lowers the overall forecast for 2011Q1. Furthermore, the WEO projections suggest a sharp pickup in growth starting from 2011Q2, relative to the band. The main driving factor behind this acceleration is the projected strong pickup in consumption, both private and public, nearly 70 percent higher than the projected increase in 2011Q1–Q2 by the high path.

New forecast framework and the Great Recession

There are two key components in the new forecast framework—the reference band based on the forecast models for individual components of GDP, and the level reference forecast for the aggregate GDP provided by the AR(1) model. The performance of the AR(1) model was already evaluated in the previous section and proved to be one of the best forecasting models. In this section, the paper tests the robustness of the reference band by evaluating its performance at the onset of the recent Great Recession.

As expected, the actual GDP levels from 2008Q1 onwards are below the reference band, given the large negative shock to the economy the data-driven models are not able to forecast well. Nonetheless, the new forecast framework seems to perform better in forecasting consumption and net external balance, especially in 2009 and at annual frequency (Table 6).





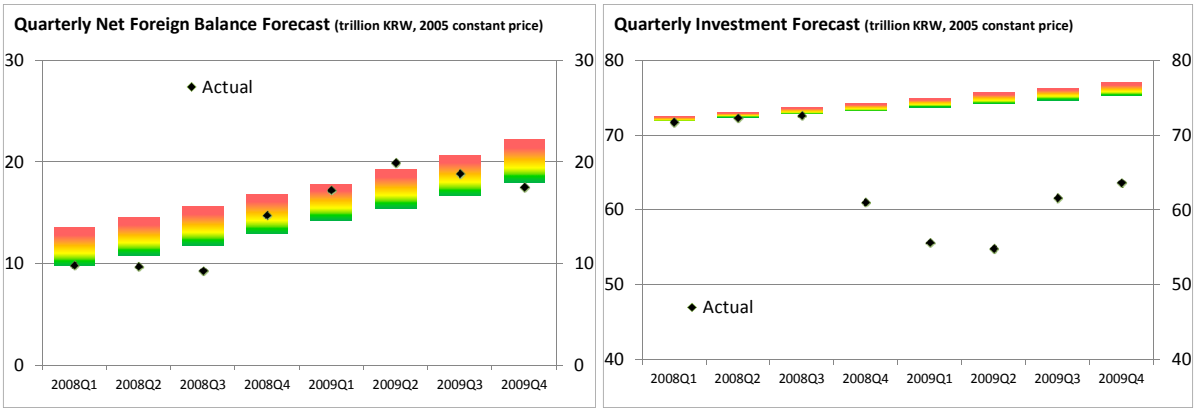


Table 6. Forecasts by the New Framework (2008-09, trillion KRW, 2005 constant price)

	2008			2009		
	High	Low	Actual	High	Low	Actual
GDP	1028.5	996.7	978.5	1088.6	1024.3	980.4
Consumption	674.4	660.7	659.5	704.6	661.9	667.9
Investment	293.6	290.5	277.8	303.9	298.0	236.0
Net foreign balance	60.6	45.5	43.7	80.0	64.5	73.5

VI. CONCLUSION

This paper develops a purely data-driven forecasting framework for the Korean real GDP to complement the staff's existing WEO forecasting approach. It first evaluates various forecast models for the indicidual demand components of GDP and finds that: (i) the performance of an indicator model depends not only on the indicator used, but also the forecast method adopted; (ii) incorporating the most recent monthly observations of the indicators does not necessarily improve the forecasts, and when it does, the benefits tend to be marginal; (iii) the performance of indicator models varies over time, suggesting that the evaluation results of this paper should be updated periodically; (iv) simple time-series models such as *AR1* and *LAG* generally perform well, and for these models, the benefits of using longer data series seem to always outweigh the concerns of a potential structural break in the longer sample; and(v) neither the indicator models nor the time-series models dominate each other.

For the aggregate GDP, the main findings of the paper are: (i) despite the strong performance of the selected indicator models for individual demand components, simply summing them up does not seem to produce good forecasts for the aggregate GDP; (ii) the time-series models forecast the aggregate GDP better than the indicator models; (iii) among the time-series models, those forecasting the individual demand components do not seem to generate more accurate forecasts than those forecasting the aggregate GDP directly, and forecasts based on larger estimation samples seem to perform better than those based on smaller estimation samples; and (iv) the existing WEO forecasting approach performs well at annual frequency, although its predictive power at quarterly frequency can be improved.

A new forecasting framework is developed based on the evaluation results. The key component of this framework is the construction of a high path and a low-path forecast for GDP. The two paths are derived from a combination of pure time-series and indicator models for the individual demand components of GDP, and together they provide a model-based reference band for forecasting. The reference band could help inform the existing WEO forecasting framework for Korea, or any other judgment-or model based forecasts, by providing a purely data-driven range of forecasts. A test run of this framework shows that even at the onset of the recent Great Recession, it would have provided good guidance to forecasting economic activity.

Appendix I. Data Summary

Variable 1/	Symbol	Frequency	Unit	1st obs. 2/	No. of obs.	Mean	Std dev	Min	Max
United States: Semiconductor industry book to bill ratio	BBR	M	Ratio	1995M5	173	1.0	0.2	0.4	1.4
Coincident composite index	CCI	M	Index	1970M1	477	51.7	31.7	9.3	119.8
United States: Consumer confidence index	CIU	M	Index	1977M6	388	95.1	23.5	25.6	147.7
Consumer price index	CPI	M	Index	1970M1	477	54.2	32.9	5.9	113.3
Domestic passenger car sales	CSL	M	Unit	1981M1	345	60868	34418	3223	124366
Employment	EPL	M	1000 person	1982M7	327	19638	2913	13812	23658
Government current expenditure 3/	GCE	M	Bil KRW	1971M1	464	29084	34283	112	147919
Industrial production index	IPI	M	Index	1975M1	417	46.6	35.5	4.6	130.9
China: Industrial production index	IPN	M	Index	1991M12	212	15.0	5.3	2.2	38.0
United States: Industrial production index	IPU	M	Index	1970M1	477	73.7	22.0	40.7	112.4
Investment index	IVD	M	Index	1991M3	223	96.5	12.0	34.1	115.1
Korea Composite Stock Price Index	KOSPI	M	Index	1976M1	405	625.2	448.0	93.7	2064.9
Business leading composite index	LCI	M	Index	1970M1	477	49.6	34.1	9.3	124.3
Index of machinery for equipment investment	MIV	M	Index	1985M1	297	72.3	31.8	13.5	119.6
Housing price index	PHO	M	Index	1986M1	285	69.7	15.3	42.0	101.2
United States: Purchasing manager index	PMI	M	Index	1970M1	477	52.0	6.9	29.7	71.8
Consumption product shipment index	PSI	M	Index	1985M1	297	87.0	22.6	34.6	120.9
Real effective exchange rate	RER	M	Index	1980M1	356	109.6	12.6	67.9	131.9
Retail trade (except motor vehicles & motorcycles)	RTL	M	Index	1980M1	356	70.1	29.5	23.3	114.3
Gross domestic production 4/	GDP	Q	Bil KRW	1970Q1	156	87913	58722	16582	208609
Private consumption	C	Q	Bil KRW	1970Q1	156	48493	28902	11370	100278
Investment	I	Q	Bil KRW	1970Q1	156	26636	18578	2570	57392
Government consumption	G	Q	Bil KRW	1970Q1	156	11755	6684	3489	26493
Exports	E	Q	Bil KRW	1970Q1	156	30789	36435	730	135106
Imports	M	Q	Bil KRW	1970Q1	156	29687	29642	1564	109522

Source: CEIC Data.

1/ All variables are seasonally adjusted.

2/ The last observations are either 2008M12 or 2008Q4.

3/ Observations prior to June 1999 are backcasts based on the growth rates of government general expenditures, a series that discontinued in January 2001.

4/ GDP and the demand components are in 2005 constant price.

Appendix II.1 Summary of Indicator Forecast Models - Private Consumption

Model Name	Forecast Method (Model Type) 1/	Indicators					Model Name	Forecast Method (Model Type)	Indicators				
		PSI	RT	CS	KOSP	CPI			PSI	RT	CS	KOSP	CPI
VARPSI	VAR	√					*RTL2*	INDLAG2		√			
VARRTL	VAR		√				*CSL2*	INDLAG2			√		
VARCSL	VAR			√			*PSI2*	INDLAG2	√				
VARIND	VAR	√	√	√			*RTLCSL2*	INDLAG2		√	√		
GVARPSI	GVAR	√					*RTLPSI2*	INDLAG2	√	√			
GVARRTL	GVAR		√				*CSLPSI2*	INDLAG2	√		√		
GVARCSL	GVAR			√			*IND2*	INDLAG2	√	√	√		
GVARIND	GVAR	√	√	√			*KOSPI2*	INDLAG2	√	√	√	√	
RTL	INDLAG1		√				*CPI2*	INDLAG2	√	√	√		√
CSL	INDLAG1			√			*KOSPICPI2*	INDLAG2	√	√	√	√	√
PSI	INDLAG1	√					*RTL3*	INDAR		√			
RTLCSL	INDLAG1		√	√			*CSL3*	INDAR			√		
RTLPSI	INDLAG1	√	√				*PSI3*	INDAR	√				
CSLPSI	INDLAG1	√		√			*RTLCSL3*	INDAR		√	√		
IND	INDLAG1	√	√	√			*RTLPSI3*	INDAR	√	√			
KOSPI	INDLAG1	√	√	√	√		*CSLPSI3*	INDAR	√		√		
CPI	INDLAG1	√	√	√		√	*IND3*	INDAR	√	√	√		
KOSPICPI	INDLAG1	√	√	√	√	√							

1/ Please refer to Section 2 for details on each type of forecast models.

Appendix Table II.2 Summary of Indicator Forecast Models - Investment

Model Name	Forecast Method (Model Type) 1/	Indicators					Model Name	Forecast Method (Model Type)	Indicators				
		IVD	LCI	MIV	KOSP	PH			IVD	LCI	MIV	KOSP	PH
VARIVD	VAR	√					*LCI2*	INDLAG2		√			
VARLCI	VAR		√				*MIV2*	INDLAG2			√		
VARMIV	VAR			√			*IVD2*	INDLAG2	√				
VARIND	VAR	√	√	√			*LCIMIV2*	INDLAG2		√	√		
GVARIVD	GVAR	√					*LCIIVD2*	INDLAG2	√	√			
GVARLCI	GVAR		√				*MIVIVD2*	INDLAG2	√		√		
GVARMIV	GVAR			√			*IND2*	INDLAG2	√	√	√		
GVARIND	GVAR	√	√	√			*KOSPI2*	INDLAG2	√	√	√	√	
LCI	INDLAG1		√				*PHO2*	INDLAG2	√	√	√		√
MIV	INDLAG1			√			*KOSPIPHO2*	INDLAG2	√	√	√	√	√
IVD	INDLAG1	√					*LCI3*	INDAR		√			
LCIMIV	INDLAG1		√	√			*MIV3*	INDAR			√		
LCIIVD	INDLAG1	√	√				*IVD3*	INDAR	√				
MIVIVD	INDLAG1	√		√			*LCIMIV3*	INDAR		√	√		
IND	INDLAG1	√	√	√			*LCIIVD3*	INDAR	√	√			
KOSPI	INDLAG1	√	√	√	√		*MIVIVD3*	INDAR	√		√		
PHO	INDLAG1	√	√	√		√	*IND3*	INDAR	√	√	√		
KOSPIPHO	INDLAG1	√	√	√	√	√							

1/ Please refer to Section 2 for details on each type of forecast models.

Appendix Table II.3 Summary of Indicator Forecast Models - Government Consumption

Model Name	Forecast Method (Model Type) 1/	Indicators					Model Name	Forecast Method (Model Type)	Indicators				
		LCI	EP	GC	KOSP	CPI			LCI	EP	GC	KOSP	CPI
VARLCI	VAR	√					*EPL2*	INDLAG2		√			
VAREPL	VAR		√				*GCE2*	INDLAG2			√		
VARGCE	VAR			√			*LCI2*	INDLAG2	√				
VARIND	VAR	√	√	√			*EPLGCE2*	INDLAG2		√	√		
GVARLCI	GVAR	√					*LCIEPL2*	INDLAG2	√	√			
GVAREPL	GVAR		√				*LCIGCE2*	INDLAG2	√		√		
GVARGCE	GVAR			√			*IND2*	INDLAG2	√	√	√		
GVARIND	GVAR	√	√	√			*KOSPI2*	INDLAG2	√	√	√	√	
EPL	INDLAG1		√				*CPI2*	INDLAG2	√	√	√		√
GCE	INDLAG1			√			*KOSPICPI2*	INDLAG2	√	√	√	√	√
LCI	INDLAG1	√					*EPL3*	INDAR		√			
EPLGCE	INDLAG1		√	√			*GCE3*	INDAR			√		
LCIEPL	INDLAG1	√	√				*LCI3*	INDAR	√				
LCIGCE	INDLAG1	√		√			*EPLGCE3*	INDAR		√	√		
IND	INDLAG1	√	√	√			*LCIEPL3*	INDAR	√	√			
KOSPI	INDLAG1	√	√	√	√		*LCIGCE3*	INDAR	√		√		
CPI	INDLAG1	√	√	√		√	*IND3*	INDAR	√	√	√		
KOSPICPI	INDLAG1	√	√	√	√	√							

1/ Please refer to Section 2 for details on each type of forecast models.

Appendix Table II.4a Summary of Indicator Forecast Models - Exports (I)

Model Name	Forecast Method (Model Type) 1/	Indicators					Model Name	Forecast Method (Model Type)	Indicators				
		IPI	IPU	IPN	KOSP	RE			IPI	IPU	IPN	KOSP	RE
VARIPI	VAR	√					*IPU2*	INDLAG2		√			
VARIPU	VAR		√				*IPN2*	INDLAG2			√		
VARIPN	VAR			√			*IPI2*	INDLAG2	√				
VARIND	VAR	√	√	√			*IPUIPN2*	INDLAG2		√	√		
GVARIPI	GVAR	√					*IPUIPI2*	INDLAG2	√	√			
GVARIPU	GVAR		√				*IPNIPI2*	INDLAG2	√		√		
GVARIPN	GVAR			√			*IND2_a*	INDLAG2	√	√	√		
GVARIND	GVAR	√	√	√			*KOSPI2_a*	INDLAG2	√	√	√	√	
IPU	INDLAG1		√				*RER2_a*	INDLAG2	√	√	√		√
IPN	INDLAG1			√			*KOSPIRER2_a*	INDLAG2	√	√	√	√	√
IPI	INDLAG1	√					*IPU3*	INDAR		√			
IPUIPN	INDLAG1		√	√			*IPN3*	INDAR			√		
IPUIPI	INDLAG1	√	√				*IPI3*	INDAR	√				
IPNIPI	INDLAG1	√		√			*IPUIPN3*	INDAR		√	√		
IND_a	INDLAG1	√	√	√			*IPUIPI3*	INDAR	√	√			
KOSPI_a	INDLAG1	√	√	√	√		*IPNIPI3*	INDAR	√		√		
RER_a	INDLAG1	√	√	√		√	*IND3_a*	INDAR	√	√	√		
KOSPIRER_a	INDLAG1	√	√	√	√	√							

1/ Please refer to Section 2 for details on each type of forecast models.

Appendix Table II.4b Summary of Indicator Forecast Models - Exports (II)

Model Name	Forecast Method (Model Type) 1/	Indicators					Model Name	Forecast Method (Model Type)	Indicators				
		CIU	PMI	BB	KOSP	RE			CIU	PMI	BB	KOSP	RE
VARCIU	VAR	√					*PMI2*	INDLAG2		√			
VARPMI	VAR		√				*BBR2*	INDLAG2			√		
VARBBR	VAR			√			*CIU2*	INDLAG2	√				
VARIND	VAR	√	√	√			*PMIBBR2*	INDLAG2		√	√		
GVARCIU	GVAR	√					*PMICIU2*	INDLAG2	√	√			
GVARPMI	GVAR		√				*BBRCIU2*	INDLAG2	√		√		
GVARBBR	GVAR			√			*IND2_b*	INDLAG2	√	√	√		
GVARIND	GVAR	√	√	√			*KOSPI2_b*	INDLAG2	√	√	√	√	
PMI	INDLAG1		√				*RER2_b*	INDLAG2	√	√	√		√
BBR	INDLAG1			√			*KOSPIRER2_b*	INDLAG2	√	√	√	√	√
CIU	INDLAG1	√					*PMI3*	INDAR		√			
PMIBBR	INDLAG1		√	√			*BBR3*	INDAR			√		
PMICIU	INDLAG1	√	√				*CIU3*	INDAR	√				
BBRCIU	INDLAG1	√		√			*PMIBBR3*	INDAR		√	√		
IND_b	INDLAG1	√	√	√			*PMICIU3*	INDAR	√	√			
KOSPI_b	INDLAG1	√	√	√	√		*BBRCIU3*	INDAR	√		√		
RER_b	INDLAG1	√	√	√		√	*IND3_b*	INDAR	√	√	√		
KOSPIRER_b	INDLAG1	√	√	√	√	√							

1/ Please refer to Section 2 for details on each type of forecast models.

Appendix Table II.5 Summary of Indicator Forecast Models - Imports

Model Name	Forecast Method (Model Type) 1/	Indicators					Model Name	Forecast Method (Model Type)	Indicators				
		IPI	LCI	CCI	KOSP	RE			IPI	LCI	CCI	KOSP	RE
VARIPI	VAR	√					*LCI2*	INDLAG2		√			
VARLCI	VAR		√				*CCI2*	INDLAG2			√		
VARCCI	VAR			√			*IPI2*	INDLAG2	√				
VARIND	VAR	√	√	√			*LCICCI2*	INDLAG2		√	√		
GVARIPI	GVAR	√					*LCIIPI2*	INDLAG2	√	√			
GVARLCI	GVAR		√				*CCIIPI2*	INDLAG2	√		√		
GVARCCI	GVAR			√			*IND2*	INDLAG2	√	√	√		
GVARIND	GVAR	√	√	√			*KOSPI2*	INDLAG2	√	√	√	√	
LCI	INDLAG1		√				*RER2*	INDLAG2	√	√	√		√
CCI	INDLAG1			√			*KOSPIRER2*	INDLAG2	√	√	√	√	√
IPI	INDLAG1	√					*LCI3*	INDAR		√			
LCICCI	INDLAG1		√	√			*CCI3*	INDAR			√		
LCIIPI	INDLAG1	√	√				*IPI3*	INDAR	√				
CCIIPI	INDLAG1	√		√			*LCICCI3*	INDAR		√	√		
IND	INDLAG1	√	√	√			*LCIIPI3*	INDAR	√	√			
KOSPI	INDLAG1	√	√	√	√		*CCIIPI3*	INDAR	√		√		
RER	INDLAG1	√	√	√		√	*IND3*	INDAR	√	√	√		
KOSPIRER	INDLAG1	√	√	√	√	√							

1/ Please refer to Section 2 for details on each type of forecast models.

Appendix III.I Seasonally Adjusted Real GDP and Demand Components (High Path of New Forecast Framework) 1/

	2009				2010				2011				2009	2010	2011
(In trillions of 2005 won, unless otherwise indicated)	Q1	Q2	Q3	Q4	Q1	Q2 Prel.	Q3 Proj.	Q4 Proj.	Q1 Proj.	Q2 Proj.	Q3 Proj.	Q4 Proj.			
Real GDP	236.9	242.5	250.3	250.7	256.0	259.7	267.2	270.3	273.6	277.2	280.8	284.2	980.4	1053.3	1115.8
% change (YonY)	-4.1	-2.1	1.1	6.1	8.1	7.1	6.8	7.8	6.9	6.7	5.1	5.1	0.2	7.4	5.9
% change (QonQ)	0.2	2.4	3.2	0.2	2.1	1.4	2.9	1.2	1.2	1.3	1.3	1.2			
Total consumption	162.6	167.1	169.3	168.9	172.0	173.2	174.8	176.4	178.1	179.8	181.5	183.2	667.9	696.5	722.6
Private consumption	125.6	129.8	132.0	132.6	133.6	134.7	135.8	137.0	138.1	139.3	140.4	141.6	520.1	541.0	559.4
% change (YonY)	-4.4	-0.9	0.7	5.8	6.3	3.8	2.9	3.3	3.4	3.4	3.4	3.4	0.2	4.0	3.4
% change (QonQ)	0.3	3.3	1.7	0.4	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8			
Government consumption	36.9	37.2	37.2	36.3	38.4	38.4	39.0	39.5	40.0	40.5	41.1	41.6	147.6	155.3	163.2
% change (YonY)	7.2	6.3	5.3	1.1	3.9	3.3	4.9	8.7	4.2	5.5	5.3	5.4	5.0	5.2	5.1
% change (QonQ)	2.9	0.7	0.0	-2.4	5.8	0.1	1.5	1.2	1.4	1.3	1.3	1.3			
Gross capital formation	55.8	54.9	61.7	63.7	67.1	69.4	74.2	74.6	75.1	75.6	76.2	76.7	236.0	285.3	303.7
% change (YonY)	-22.3	-24.1	-15.1	4.3	20.3	26.5	20.3	17.2	12.0	8.9	2.7	2.8	-15.0	20.9	6.4
% change (QonQ)	-8.7	-1.6	12.4	3.3	5.3	3.5	6.8	0.6	0.6	0.7	0.7	0.7			
Net foreign balance	17.2	19.9	18.9	17.5	16.6	17.6	18.6	19.6	20.8	22.1	23.5	24.7	73.5	72.5	91.1
Exports of goods and services	102.7	113.0	118.0	116.8	120.2	128.9	131.8	134.3	137.0	139.8	142.6	145.0	450.5	515.3	564.4
% change (YonY)	-10.7	-3.1	1.3	10.0	17.1	14.1	11.7	15.0	13.9	8.5	8.2	7.9	-0.8	14.4	9.5
% change (QonQ)	-3.2	10.0	4.4	-1.0	2.9	7.2	2.2	1.9	1.9	2.1	2.0	1.7			
Imports of goods and services	85.5	93.1	99.1	99.3	103.6	111.3	113.2	114.7	116.2	117.7	119.1	120.3	376.9	442.8	473.3
% change (YonY)	-18.7	-12.9	-7.5	8.6	21.2	19.6	14.2	15.6	12.1	5.7	5.2	4.9	-8.2	17.5	6.9
% change (QonQ)	-6.4	8.8	6.5	0.1	4.4	7.4	1.7	1.4	1.3	1.3	1.2	1.1			

1/ For comparison with the current WEO projection, we only report forecasts up to 2011.

Appendix III.2 Seasonally Adjusted Real GDP and Demand Components (Low Path of New Forecast Framework) 1/

	2009				2010				2011				2009	2010	2011
(In trillions of 2005 won, unless otherwise indicated)	Q1	Q2	Q3	Q4	Q1	Q2 Prel.	Q3 Proj.	Q4 Proj.	Q1 Proj.	Q2 Proj.	Q3 Proj.	Q4 Proj.			
Real GDP	236.9	242.5	250.3	250.7	256.0	259.7	260.0	260.9	264.1	265.4	266.8	267.5	980.4	1036.6	1063.8
% change (YonY)	-4.1	-2.1	1.1	6.1	8.1	7.1	3.9	4.1	3.2	2.2	2.6	2.5	0.2	5.7	2.6
% change (QonQ)	0.2	2.4	3.2	0.2	2.1	1.4	0.1	0.3	1.2	0.5	0.5	0.3			
Total consumption	162.6	167.1	169.3	168.9	172.0	173.2	173.2	172.7	174.9	175.2	175.5	175.3	667.9	691.1	700.9
Private consumption	125.6	129.8	132.0	132.6	133.6	134.7	134.7	134.7	134.6	134.7	134.9	135.2	520.1	537.6	539.5
% change (YonY)	-4.4	-0.9	0.7	5.8	6.3	3.8	2.0	1.6	0.8	0.0	0.1	0.4	0.2	3.4	0.3
% change (QonQ)	0.3	3.3	1.7	0.4	0.7	0.8	0.0	0.0	0.0	0.1	0.1	0.2			
Government consumption	36.9	37.2	37.2	36.3	38.4	38.4	38.5	38.0	40.2	40.4	40.6	40.1	147.6	153.3	161.4
% change (YonY)	7.2	6.3	5.3	1.1	3.9	3.3	3.5	4.7	4.8	5.2	5.6	5.6	5.0	3.9	5.3
% change (QonQ)	2.9	0.7	0.0	-2.4	5.8	0.1	0.2	-1.3	5.9	0.5	0.5	-1.3			
Gross capital formation	55.8	54.9	61.7	63.7	67.1	69.4	69.8	70.0	70.2	70.3	70.4	70.6	236.0	276.3	281.4
% change (YonY)	-22.3	-24.1	-15.1	4.3	20.3	26.5	13.1	9.9	4.6	1.3	0.9	0.8	-15.0	17.1	1.9
% change (QonQ)	-8.7	-1.6	12.4	3.3	5.3	3.5	0.5	0.3	0.2	0.2	0.2	0.2			
Net foreign balance	17.2	19.9	18.9	17.5	16.6	17.6	17.4	18.6	19.5	20.3	21.2	22.0	73.5	70.2	83.0
Exports of goods and services	102.7	113.0	118.0	116.8	120.2	128.9	132.5	135.7	138.7	141.7	144.7	147.8	450.5	517.4	572.8
% change (YonY)	-10.7	-3.1	1.3	10.0	17.1	14.1	12.3	16.2	15.4	9.9	9.2	8.9	-0.8	14.9	10.7
% change (QonQ)	-3.2	10.0	4.4	-1.0	2.9	7.2	2.8	2.4	2.2	2.1	2.1	2.1			
Imports of goods and services	85.5	93.1	99.1	99.3	103.6	111.3	115.1	117.1	119.2	121.4	123.5	125.7	376.9	447.1	489.8
% change (YonY)	-18.7	-12.9	-7.5	8.6	21.2	19.6	16.2	18.0	15.1	9.0	7.3	7.3	-8.2	18.6	9.5
% change (QonQ)	-6.4	8.8	6.5	0.1	4.4	7.4	3.4	1.7	1.8	1.8	1.8	1.8			

1/ For comparison with the current WEO projection, we only report forecasts up to 2011.

Appendix III.3 Seasonally Adjusted Real GDP and Demand Components (WEO Projections) 1/

	2009				2010				2011				**2009**	**2010**	**2011**
(In trillions of 2005 won, unless otherwise indicated)	Q1	Q2	Q3	Q4	Q1	Q2 Prel.	Q3 Proj.	Q4 Proj.	Q1 Proj.	Q2 Proj.	Q3 Proj.	Q4 Proj.			
Real GDP	236.9	242.5	250.3	250.7	256.0	259.7	261.5	262.6	265.0	269.1	273.9	278.2	980.4	1039.8	1086.2
% change (YonY)	-4.1	-2.1	1.1	6.1	8.1	7.1	4.5	4.8	3.5	3.6	4.7	5.9	0.2	6.1	4.5
% change (QonQ)	0.2	2.4	3.2	0.2	2.1	1.4	0.7	0.4	0.9	1.5	1.8	1.6			
Total consumption	162.6	167.1	169.3	168.9	172.0	173.2	170.3	169.6	172.7	175.5	178.1	181.2	667.9	685.2	707.5
Private consumption	125.6	129.8	132.0	132.6	133.6	134.7	135.8	137.1	138.2	139.3	140.7	142.4	520.1	541.1	560.7
% change (YonY)	-4.4	-0.9	0.7	5.8	6.3	3.8	2.8	3.4	3.5	3.4	3.6	3.9	0.2	4.1	3.6
% change (QonQ)	0.3	3.3	1.7	0.4	0.7	0.8	0.8	1.0	0.8	0.8	1.0	1.2			
Government consumption	36.9	37.2	37.2	36.3	38.4	38.4	34.6	32.5	34.5	36.2	37.3	38.8	147.6	143.9	146.8
% change (YonY)	7.2	6.3	5.3	1.1	3.9	3.3	-7.0	-10.4	-10.2	-5.8	8.0	19.5	5.0	-2.5	2.0
% change (QonQ)	2.9	0.7	0.0	-2.4	5.8	0.1	-10.0	-6.0	6.0	5.0	3.2	4.0			
Gross capital formation	55.8	54.9	61.7	63.7	67.1	69.4	71.3	71.8	71.2	71.7	73.3	73.9	236.0	279.5	290.1
% change (YonY)	-22.3	-24.1	-15.1	4.3	20.3	26.5	15.5	12.7	6.1	3.3	2.8	3.0	-15.0	18.4	3.8
% change (QonQ)	-8.7	-1.6	12.4	3.3	5.3	3.5	2.6	0.7	-0.8	0.7	2.2	0.9			
Net foreign balance	17.2	19.9	18.9	17.5	16.6	17.6	20.3	21.6	21.5	22.3	22.9	23.4	73.5	76.1	90.1
Exports of goods and services	102.7	113.0	118.0	116.8	120.2	128.9	129.6	132.5	134.9	137.9	141.1	144.7	450.5	511.2	558.6
% change (YonY)	-10.7	-3.1	1.3	10.0	17.1	14.1	9.8	13.5	12.2	7.0	8.9	9.2	-0.8	13.5	9.3
% change (QonQ)	-3.2	10.0	4.4	-1.0	2.9	7.2	0.5	2.3	1.8	2.2	2.3	2.5			
Imports of goods and services	85.5	93.1	99.1	99.3	103.6	111.3	109.3	110.9	113.4	115.6	118.2	121.3	376.9	435.1	468.5
% change (YonY)	-18.7	-12.9	-7.5	8.6	21.2	19.6	10.3	11.7	9.5	3.9	8.1	9.4	-8.2	15.4	7.7
% change (QonQ)	-6.4	8.8	6.5	0.1	4.4	7.4	-1.8	1.4	2.3	2.0	2.2	2.6			

1/ For comparison with the current WEO projection, we only report forecasts up to 2011.

Appendix III.4 Seasonally Adjusted Real GDP and Demand Components (Forecasts by AR(1) Model) 1/

	2009				2010				2011				**2009**	**2010**	**2011**
(In trillions of 2005 won, unless otherwise indicated)	Q1	Q2	Q3	Q4	Q1	Q2 Prel.	Q3 Proj.	Q4 Proj.	Q1 Proj.	Q2 Proj.	Q3 Proj.	Q4 Proj.			
Real GDP	236.9	242.5	250.3	250.7	256.0	259.7	262.4	265.1	267.8	270.6	273.4	276.2	980.4	1043.2	1088.0
% change (YonY)	-4.1	-2.1	1.1	6.1	8.1	7.1	4.8	5.7	4.6	4.2	4.2	4.2	0.2	6.4	4.3

1/ For comparison with the current WEO projection, we only report forecasts up to 2011.

REFERENCE

J. D. Hamilton, 1994, *Time Series Analysis* (New Jersey: Princeton University Press).