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Interpolating Forecast Errors for Assessing Uncertainty in Macroeconomic Forecasts: An Analysis for Malta^{*}

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Abstract

This paper presents an analysis of forecasting errors for Malta for the Ministry for Finance and compares the results with those of the Central Bank of Malta and the European Commission. Apart from presenting a comprehensive analysis of past forecast errors, even at expenditure component level, this paper interpolates the results of past forecast errors to future forecasts through the application of the two-piece normal distribution thus conveying not only the degree of uncertainty but also the balance of risk inherent in GDP growth projections. Results are presented in the form of fan charts.

1. Introduction

Macroeconomic forecasts are the basis of all forms of governmental economic policy formulation and analysis and decision-making processes, particularly the budget process. Regular scrutiny and assessment of past forecasting performance is important to improve the accuracy of the forecasts and lend credibility to the forecasting exercise. This paper provides an assessment of the forecasting performance of the macroeconomic projections produced by the Economic Policy Department within the Ministry for Finance (MFIN) in Malta. It evaluates forecast accuracy and tests for any bias in the forecasts of the main macroeconomic projections produced by the Department. The paper evaluates the Ministry for Finance’s forecasting performance against that of other independent institutions. It also compares forecast accuracy for Malta against the accuracy of forecasts produced for other EU member states. On the basis of this evaluation and model based estimates, the paper proposes ways in which the uncertainty surrounding macroeconomic projections can be portrayed through the use of fan charts, in line with the methodologies used by reputable institutions such as the IMF, the Bank of England and the Office for Budget Responsibility in the UK.

The Economic Policy Department within the Ministry for Finance is responsible for producing macroeconomic forecasts for the Government of Malta through the use of its Short-term Quarterly Forecasting Econometric Model for Malta (STEMM) which was developed in collaboration with Cambridge Econometrics in 2002. Such macroeconomic forecasts serve as important inputs to various Government policy decisions; including the annual government budgetary projections, and are the basis of various policy direction documents by the Ministry for Finance in particular, the annual update of the Stability Programme in accordance with European Union Council regulations¹, the Draft Budgetary Plan, and the Budget Speech. Forecasts by the Economic Policy Department are published on a bi-annual basis: in spring and in autumn.

Whilst STEMM is central to the forecasting process at the Economic Policy Department it is supplemented by expert economic judgement partly to make up for the known limitations of the model itself and partly to make up for known idiosyncrasies in statistical data. Furthermore, as part of the forecasting process, the Economic Policy Department on behalf of the Ministry for Finance organizes frequent meetings with the main stakeholders and economic operators to get a better understanding of the main developments within the Maltese economy, each in their own respective field of expertise. Feedback obtained from such meetings is then used to adjust model forecasts in line with the expert judgment through what are called “residual adjustments”. These adjustments are

¹European Union Council Regulations- Council Regulation (EC) 1466/97 on the strengthening of the surveillance of budgetary positions and the surveillance and coordination of economic policies, as amended by Council Regulation (EC) 1055/2005 of 27 June 2005 and Regulation (EU) No 1175/2011 - the preventive arm of the Stability and Growth Pact.

in-built in STEMM and constitute a systematic framework which facilitates the recording of economic judgment and assumptions within the whole structural framework. This research provides the basis for an objective evaluation of the accuracy and impartiality of the systematic economic judgment incorporated into the forecasts produced by STEMM.

This research is also being carried out in the context of Council directive 2011/85/EU of the European Union on the requirements for budgetary frameworks of the Member States. As from 2014, macroeconomic and fiscal forecasts are to be produced or endorsed by an independent body such as a fiscal council. Member States are also required to guide their macroeconomic and budgetary forecasts by the performance of past forecasts and endeavor to take into account relevant risk scenarios. Member States are thus required to conduct a regular, unbiased and comprehensive evaluation based on objective criteria, including *ex post* evaluation. If the analysis of that evaluation detects a significant bias affecting macroeconomic forecasts over a period of at least 4 consecutive years, the Member State is expected to take the necessary effective action and communicate the results to the fiscal council.

Literature in the field of assessing forecast errors is vast and various studies take a panel approach by assessing forecast performances of a number of countries over different time horizons (Keereman, 1999; Melander et al. 2007; Gonzáles Cabanillas and Terzi, 2012;). Other studies such as those conducted by the Bank of England take a longitudinal approach and analyze the forecast performance of the inflation forecast and also the forecast for other macroeconomic aggregates such as GDP (Britton, Fisher, and Whitley, February 1998; Elder et al. 2005). This paper takes the longitudinal approach and assesses forecast errors of nominal and real GDP and its expenditure components for Malta.

The paper is structured as follows: Section 2 provides an evaluation of the n-step ahead forecast errors of GDP and the main expenditure components. It also illustrates how forecasting performance may have changed over time since the first set of forecasts which were published for 2004. Section 3 provides a more systemic evaluation of the Economic Policy Department's macroeconomic forecast performance and benchmarks it against the European Commission's forecasts for other European Economies as well as the forecasting performance of the Central Bank of Malta and the European Commission itself for the Maltese economy. Section 4 evaluates the impartiality of the Economic Policy Department's forecasts by testing for biasness in the macroeconomic forecast since 2004. Section 5 proposes a methodology to incorporate forecast uncertainty based on the variance of past forecast errors and the balance of risk based on model-based simulations into the forecasts through the use of fan charts. Section 6 concludes the paper.

2. Assessing GDP Growth Projections by Means of Forecast Errors

This paper reviews nine forecast variables: nominal GDP growth, together with real GDP, real private consumption, real public consumption, real gross fixed capital formation, changes in inventories, real exports, real imports, and real net export growth. Time series data for these variables was collected for the 2004–2013 period. Data was gathered from the Stability/Convergence Programmes for the Ministry for Finance, the Quarterly Reviews for the Central Bank of Malta, and from the spring/autumn forecasts for the European Commission.

For comparability purposes, forecasts data from 2004 to 2009 has been collected from the autumn forecast issue for the European Commission since at that time, the Stability/Convergence Programmes were published in November. As from 2011 onwards, the Stability Programmes were published in April. Consequently, forecast data from the Ministry for Finance is compared to the spring issue of forecasts from the European Commission. At the outset, one has to point out that in 2010, no Stability Programme was published by the Ministry for Finance however, the forecasts at that time were still computed for internal purposes, and thus, data is still used to preserve as much as possible the degrees of freedom given the small sample size. Central Bank of Malta's forecast projections are only available from 2008. In order to preserve comparability as much as possible due to different cut-off dates for the production of forecasts by the different institutions, Central Bank of Malta forecast data for 2008 and 2009 are collected from the fourth Quarterly Review issue, whereas from 2010 onwards, forecast data is collected from the second Quarterly Review issue.

Two main limitations of this research study are therefore worth pointing out at the outset: (i) different cut-off points for these forecasts limits the scope for comparability; (ii) only a small sample size is available for the forecast data for all institutions but especially for forecasts produced by the Central Bank of Malta. In terms of selecting forecast data, the methodology adopted here is similar to that used in the literature. Forecast data for the Ministry for Finance in the Stability/Convergence Programmes is available up to $t + 3$ whereas the European Commission and the Central Bank of Malta report forecasts for t and $t + 1$ only.

2.1 An Analysis of Forecast Errors: A Backward Looking Approach

Two main principles underpin this analysis of forecast errors; the unbiased principle requires that forecast errors should over time approximately be equal to zero and the efficiency principle, which requires forecast errors to be as small as possible. Thus, forecast

errors are efficient only if they are not linked to any information available at the time of projection. The unbiased principle is a required condition for efficiency but the converse may not be necessarily true.

Forecast errors are defined as the forecast at time t minus the actual data at time $t+1$ (González Cabanillas and Terzi, 2012). More formally,

$$e_{t,t} = y_{t,t} - y_t \text{ for the current year}$$

and

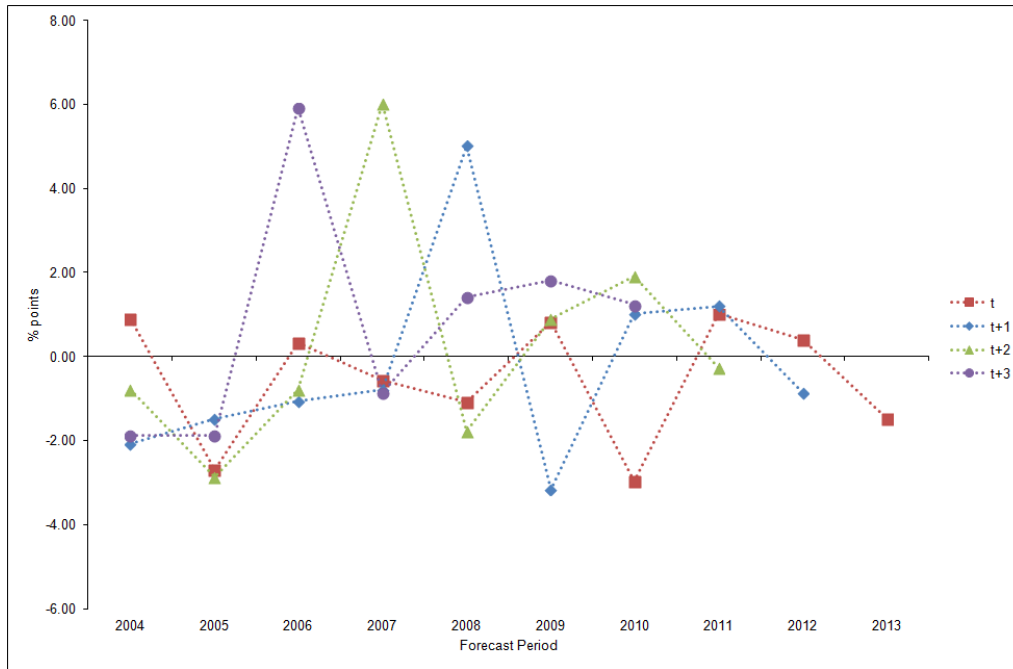
$$e_{t+1,t} = y_{t+1,t} - y_{t+1} \text{ for the following year}$$

where $y_{t,t}$ and $y_{t+1,t}$ are the projections made at time t and $t+1$ respectively, y_t is the actual data of y for year t , and y_{t+1} is actual data for variable y for year $t+1$. Therefore, a positive forecast error for real GDP growth implies over-estimation of the rate of growth while a negative value implies the contrary.

It is noteworthy that forecast errors partly depend on statistical errors in the data. Forecast errors are influenced by the vintage of input data used by the forecasting model and the vintage of data used as a benchmark to estimate the forecast errors. While the most up-to-date statistical data gives a more accurate and reliable estimate of forecast errors, it may underestimate the efficiency of a forecasting model by diluting statistical errors with the pure forecast errors of a given economic model. As long as statistical revisions are stationary errors, this should not influence results significantly. This is more likely to be the case if the number of forecast observations is large. Given the small sample size, using the latest national accounts release as a benchmark on which to compute forecast errors will add a further degree of uncertainty to the analysis in that any further revisions to national accounts data will have an impact on the accuracy of forecast projections both *ex-ante* and *ex-post*. The *ex-ante* effect is mainly through the trajectories of the forecast estimates while *ex-post* forecast errors may emerge as the base on which the forecast estimates were estimated in the first place would have changed.

Forecast errors for real GDP categorised by forecasting vintage since 2014 for current, one-year, two-year and three-year ahead forecasts are presented in Figure 1. Note that the horizontal axis represents the year in which the forecast is undertaken. For instance for 2008, the one-year ahead forecast error represents the difference between the forecast for 2009 made in 2008 and the actual data for 2009. Similarly, the two-year ahead forecast error represents the difference between the forecast produced in 2008 for 2010 and the

Figure 1: Forecast Error: Real GDP (forecast - actual)



actual for 2010 whilst the three-year ahead forecast error reported in the 2008 vintage represents the forecast error for 2011.

Unfortunately, there is a lot of noise surrounding the 2009/10 forecast due to the recession and the subsequent recovery which were not predicted by the model forecasts. Chart 2.2 removes the forecast errors related to these two years to give a more intuitive illustration of forecast accuracy. Forecast errors for real GDP growth generally range between +/-2 percentage points, with a significant improvement seen for forecasts produced after 2005 where the range declines to between 1.2 percentage points to -1.5 percentage points. There is no clear evidence that forecast accuracy deteriorates significantly with the forecast horizon. Whilst overall there appears to be no systematic bias, one could observe a tendency to underestimate growth for all n-year ahead forecasts carried out between the 2004 and 2007 forecasting vintages and a tendency to overestimate growth during the 2009 and 2011 forecasting vintages. This could be due to structural changes in the model, statistical revisions or a tendency to forecast growth pro-cyclically. However in the 2012 to 2013 forecasting vintages, growth was again generally underestimated.

Figure 2: Forecast Error: Real GDP* (forecast - actual)

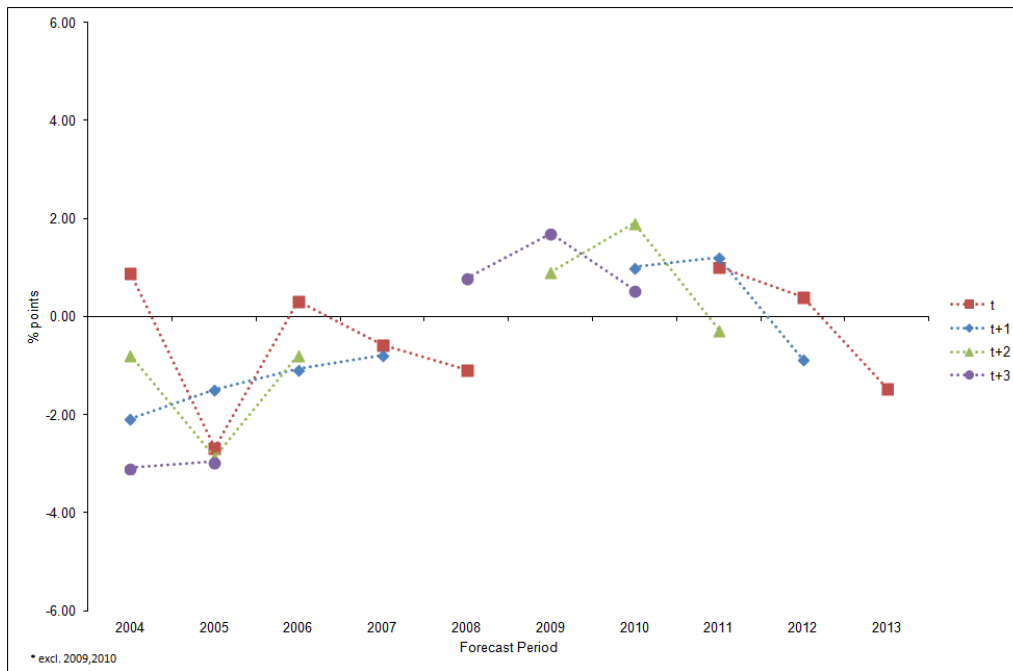


Figure 3: Forecast Error: Nominal GDP (forecast - actual)

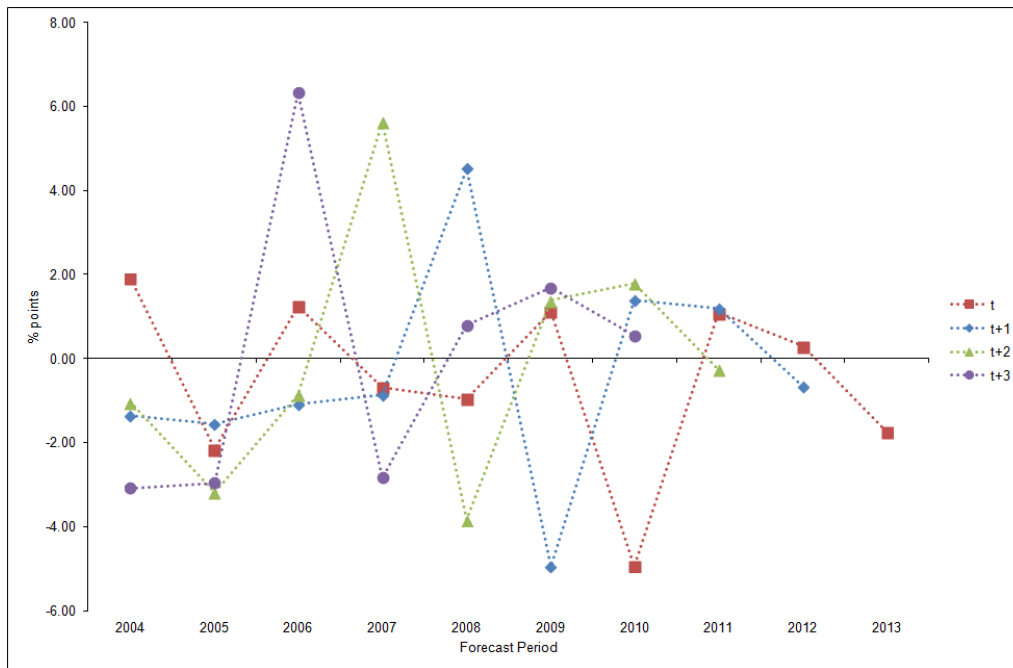
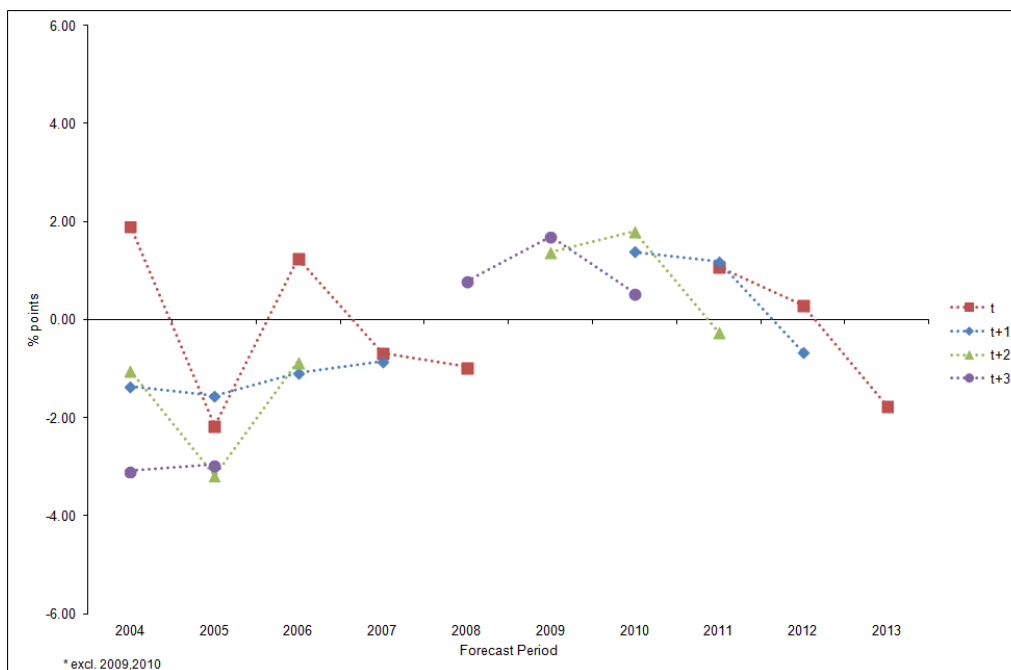


Figure 4: Forecast Error: Nominal GDP* (forecast - actual)

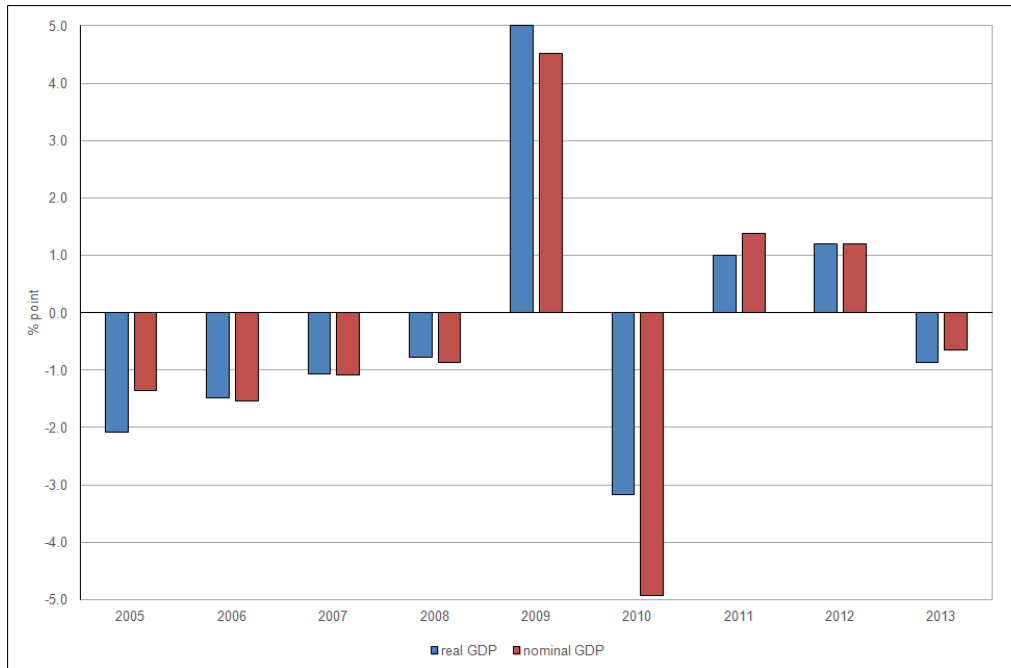


A similar pattern is evident for nominal GDP growth although forecast errors are marginally higher than for real GDP. This analysis is found in Figures 3 and 4, respectively. Figure 5 presents the one year ahead forecast errors for every year since 2005 for both nominal and real GDP. The one-year ahead forecasts are arguably the most important forecast errors for fiscal purposes. With the exclusion of 2009 and 2010, average one-year ahead forecast errors range from -1.3 to +1.1 percentage points. One-year ahead forecasts were overestimated for only $\frac{1}{3}$ of the sample period and underestimated for the remaining $\frac{2}{3}$ of the sample period suggesting a tendency to underestimate nominal and real GDP growth, although such a tendency pertains mostly to the earlier forecast years.

It is however worth pointing out that statistical revisions can have a significant influence on forecast accuracy. Figure 6 compares the real growth rate for $t - 1$ as reported in year t and the actual growth rate for that same year as reported in the latest national accounts news release². For instance growth for 2005 was estimated at 2.5 per cent in the March 2006 GDP Release. However, the latest news release reports that growth in 2005 was actually 3.6 per cent, an upward revision of 1.1 percentage points. Thus, forecasts carried out in 2006 were based on a weaker estimate of growth than actual growth. On

²The latest news release refers to the last release published under the ESA95 methodology since more recent releases based on ESA10 are not strictly comparable on a statistical basis. All comparisons in this paper are based on ESA95 data.

Figure 5: Forecast Errors for $t + 1$



the other hand in 2010, growth in 2009 was estimated at -1.9 per cent. Latest estimates suggests that the economy in 2009 had actually contracted by 2.8 per cent representing a downward revision of 0.9 percentage points indicating that the 2009 recession was stronger than statistical data at that time suggested.

Whilst statistical revisions are sizeable, it is salient to note that no clear biases are apparent in the direction of the statistical revision indicating that these revisions are purely stationary errors and should therefore not contribute to any biases in real GDP growth forecasts when evaluated over the forecast horizon. It is however interesting to note that the one-year ahead forecast error of real GDP for year t is actually found to be inversely related to the statistical revision of real GDP growth for year $t - 1$ with a negative correlation of 0.7. Given this high inverse correlation it is not possible to exclude that statistical revisions are affecting the accuracy of model forecasts.

Figure 6: Real GDP Growth Statistical Revisions

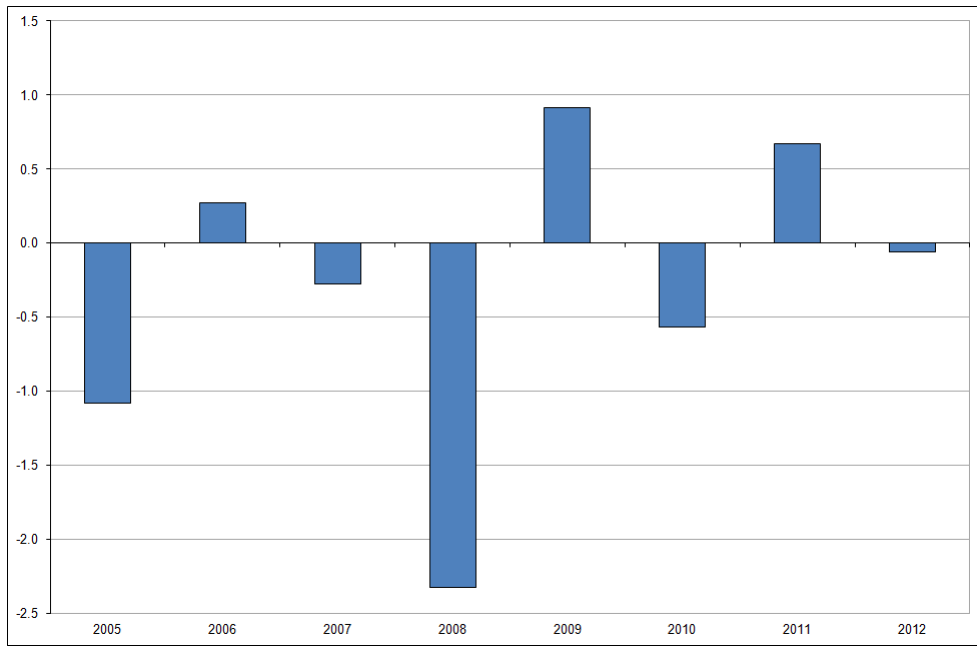


Figure 7: Statistical Revisions and Forecast Accuracy

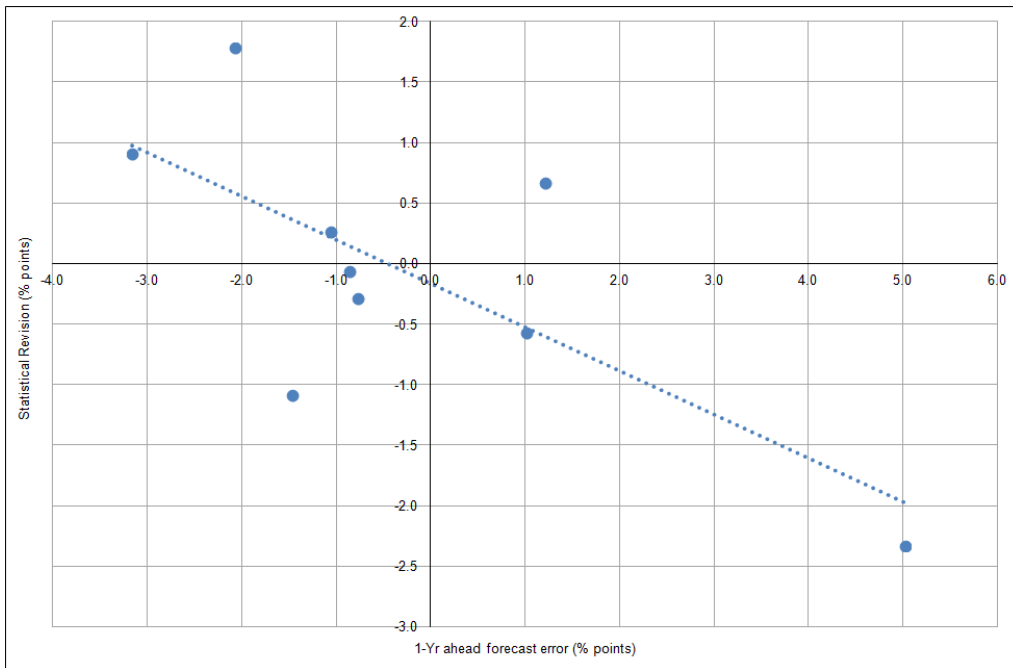


Figure 8: Forecast Error: Consumption (forecast - actual)

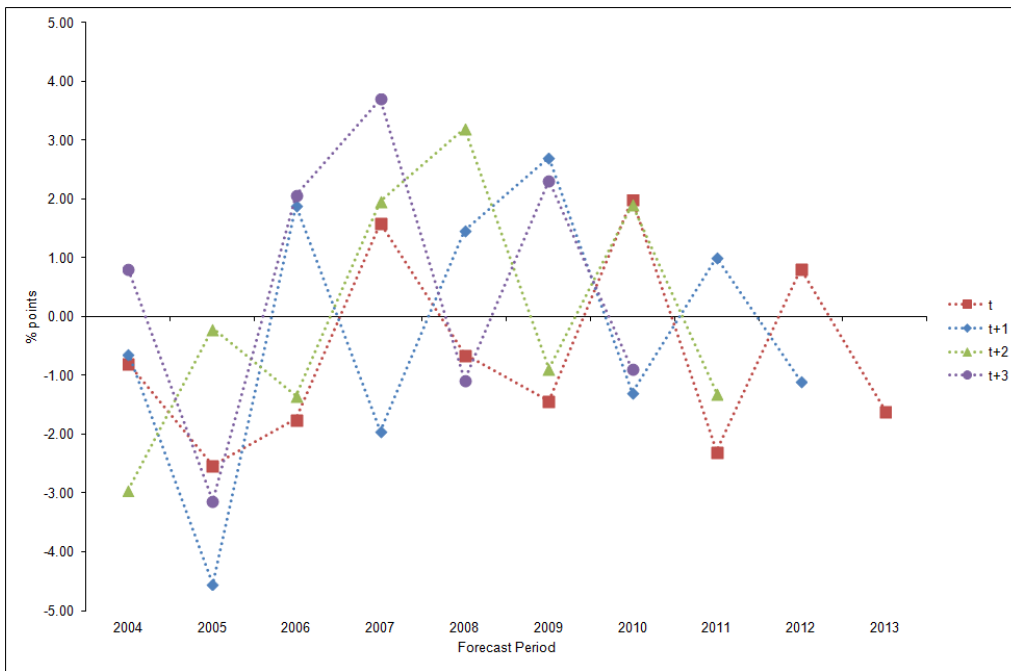
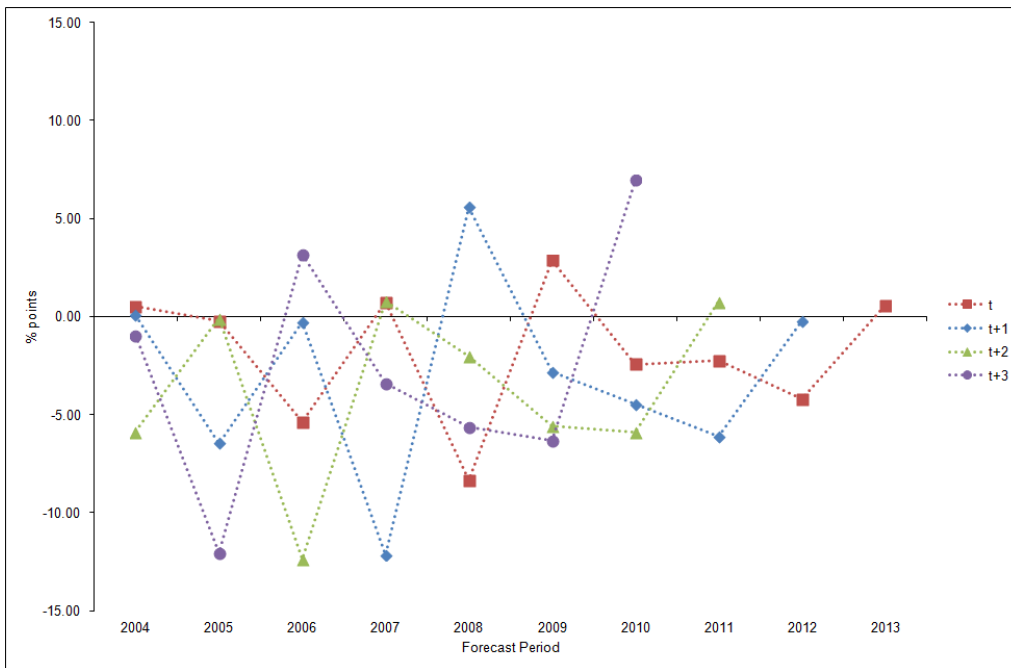


Figure 9: Forecast Error: Government Expenditure (forecast - actual)



Private consumption expenditure accounts for around 56 per cent of GDP and is therefore one of the most important contributors to growth. It is also a relatively tax-rich expenditure component and its forecast accuracy can have a significant effect on the accuracy of indirect tax revenue projections. In Figure 8, forecast errors typically range from +/- 2 percentage points irrespective of the forecast horizon. No clear biases exist in the forecasts for consumption. Forecast errors are higher than those for real GDP growth and suggest further scope for improvement in forecast accuracy.

Public expenditure is an exogenous variable in STEMM and is primarily dictated by the expenditure projections of the Ministry for Finance, particularly the forecasts for compensation of employees and intermediate consumption in the public sector. Figure 9 suggests a clear tendency to underestimate public expenditure with forecast errors often reaching 6.0 percentage points in the more recent forecasting vintages. Although the component for public expenditure accounts for under 20.0 per cent of GDP, it is one of the contributors to the tendency to underestimate GDP growth.

Gross fixed capital formation is arguably the most volatile and hence the most unpredictable component of national expenditure. Consequently, forecast errors are likely to be significant. It represents around 17.0 per cent of GDP but forecast errors are typically biased upwards and can reach 30.0 percentage points, as illustrated in Figure 10. It is however notable that in a small economy such as that of Malta, a single extraordinary investment in a given year can have a significant impact on the actual growth rates and unless such investment is known in advance, it is difficult to predict. This could include purchase of aircraft or sea-vessels which often have a significant impact on investment expenditure. An unusually unpredictable period can be discerned for the years 2008 to 2011. If we exclude these years, forecast errors range between +/- 12 percentage points and the bias is eliminated from the forecasts. It is noteworthy that public investment typically accounts for around $\frac{1}{5}$ th of total investment and this component is exogenous to the model. Discussions with major operators typically responsible for large-scale investments (such as Enemalta, Air-Malta, Malta Freeport or Gozo Channel) should contribute to improve forecast accuracy. Nevertheless, it is also pertinent to note that in view of the significant import content of such investment, the impact on GDP growth forecast accuracy is likely to be much less significant than these numbers suggest.

The inventory component is also a relatively unpredictable component of expenditure partly because it is a very volatile component and also because it partly contains all statistical errors identified in the reconciliation between the output and expenditure approaches in national accounts statistics. Its contribution to GDP ranges from -2 per cent to +4 per cent. It has been the practice by virtually all forecasting institutions working with Maltese national accounts data to forecast the inventory component such that its contribution to forecast growth is eliminated, typically by assuming that inventory at time $t + 1$ will equal the inventory at time t . This may not ensure forecast accuracy but should eliminate the bias assuming that statistical errors are normally distributed

over time. On the other hand, persistent forecast errors may also result from cyclical conditions which determine the true inventory term (as opposed to the statistical errors). Figure 11 suggests that there is a clear tendency to overestimate inventory growth in the earlier years and a tendency to underestimate the growth in inventories in more recent years. The gradual change in the direction of the forecast error is possibly attributable to changing cyclical conditions. Forecast accuracy typically ranges from +/- 3 percentage points.

Improvements in the compilation of national statistics, particularly the use of output deflators to compile real GDP from the output approach could significantly improve the forecast accuracy of inventories. In addition, the change to ESA10 and the statistical improvements that have taken place could also improve the forecast accuracy. In view of possible cyclical fluctuations, one should consider the option of modelling this item of expenditure or include some form of cyclical element, at least to provide an alternative forecast of GDP growth. Nevertheless, given that most forecasts of the Maltese economy rely on similar assumptions to those employed by Economic Policy Department, such changes should ideally be coordinated with other forecasting institutions and should also be carried out once the statistical improvements have been completed.

Figure 10: Forecast Error: Investment (forecast - actual)

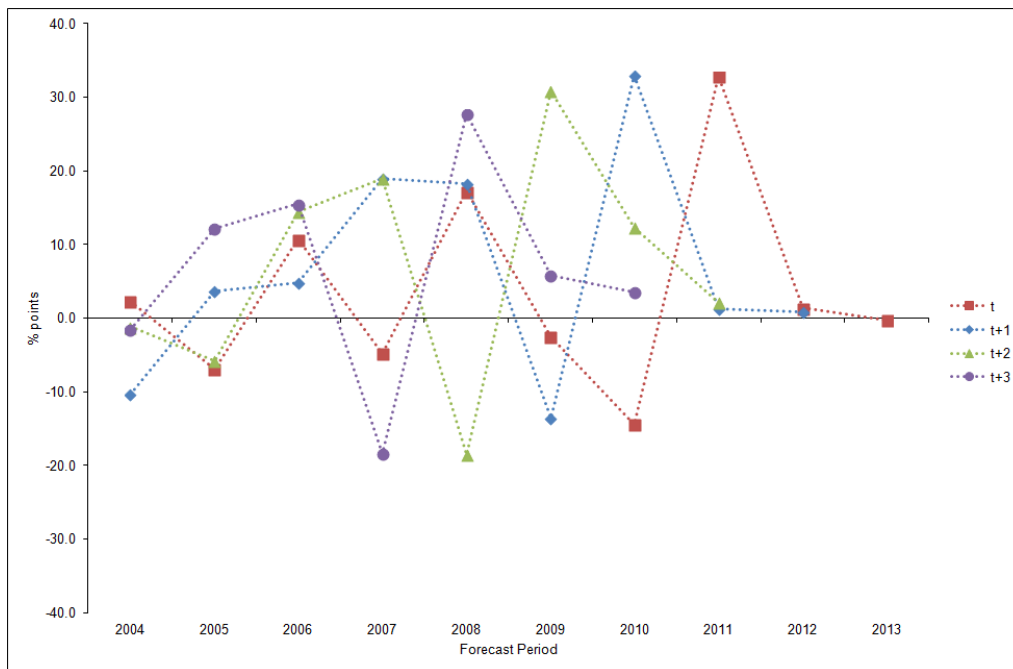


Figure 11: Forecast Error: Inventories (forecast - actual)

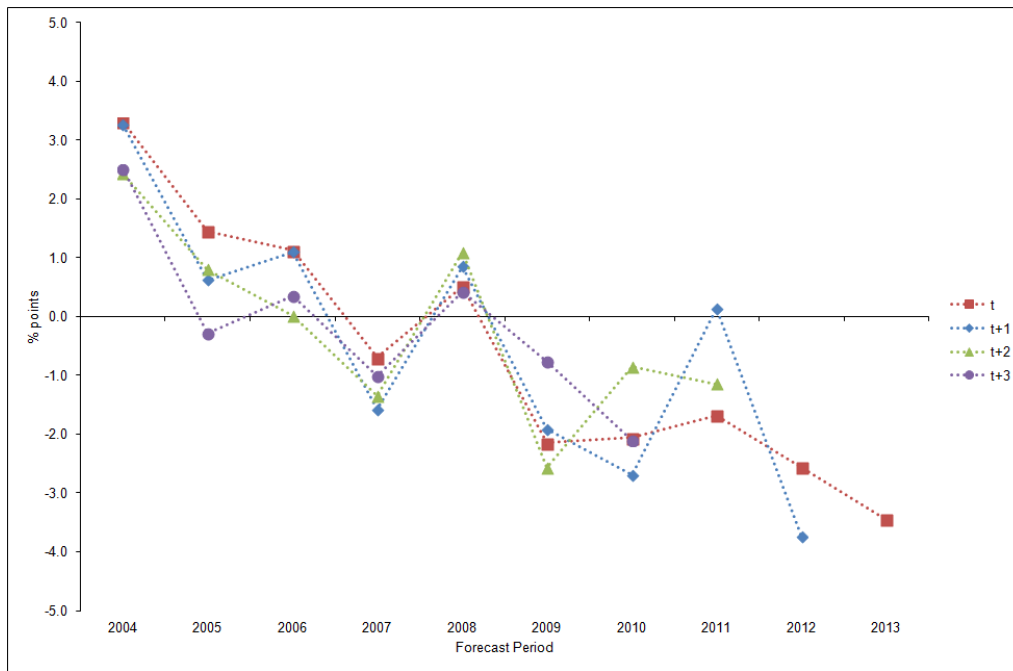


Figure 12: Forecast Error: Exports (forecast - actual)

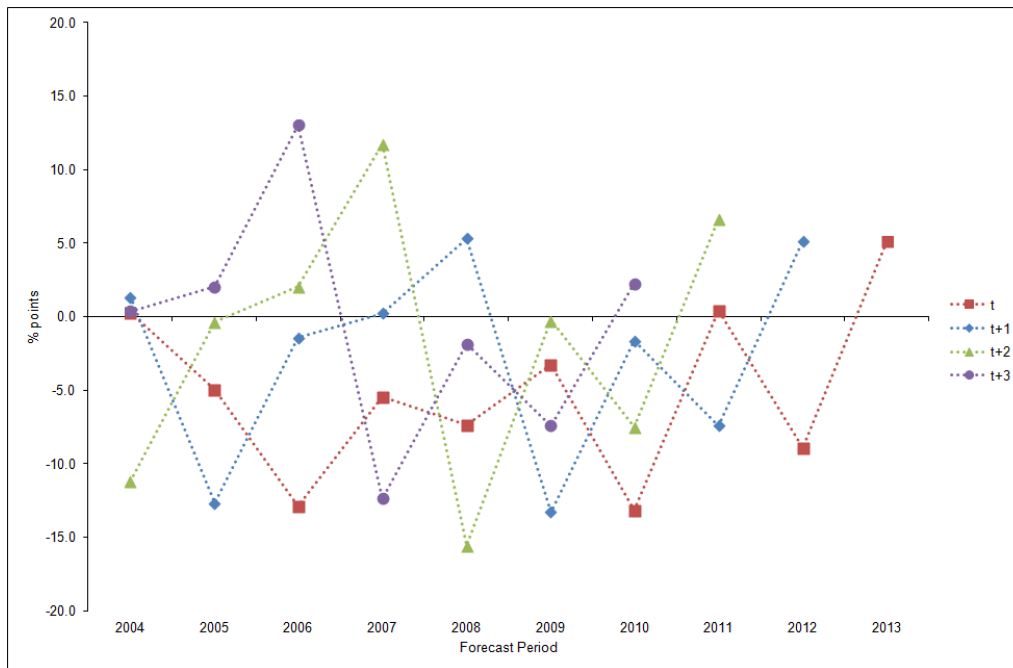
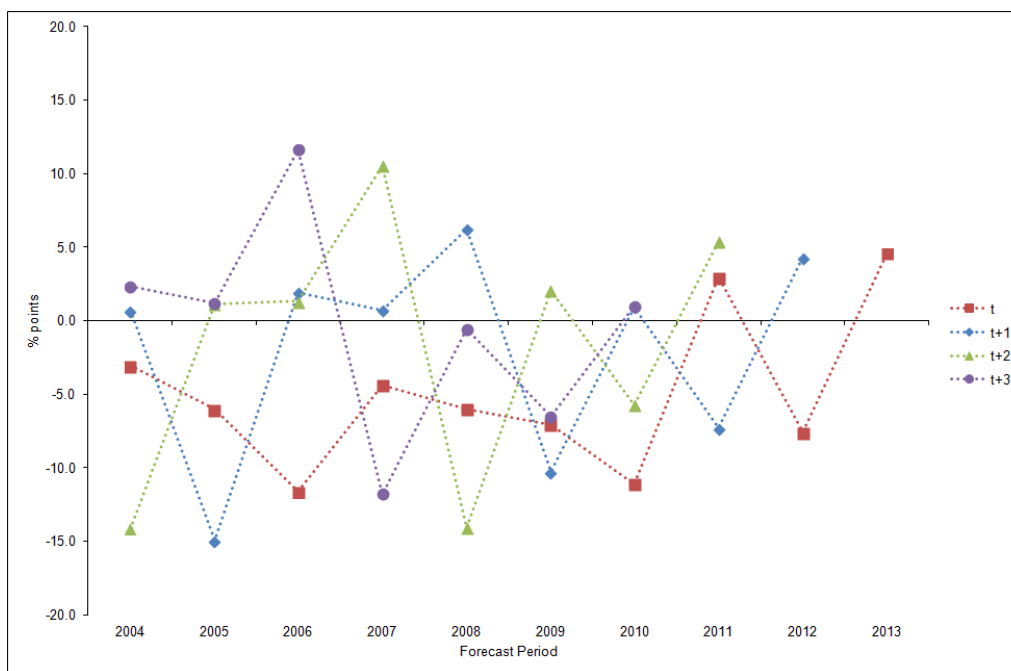


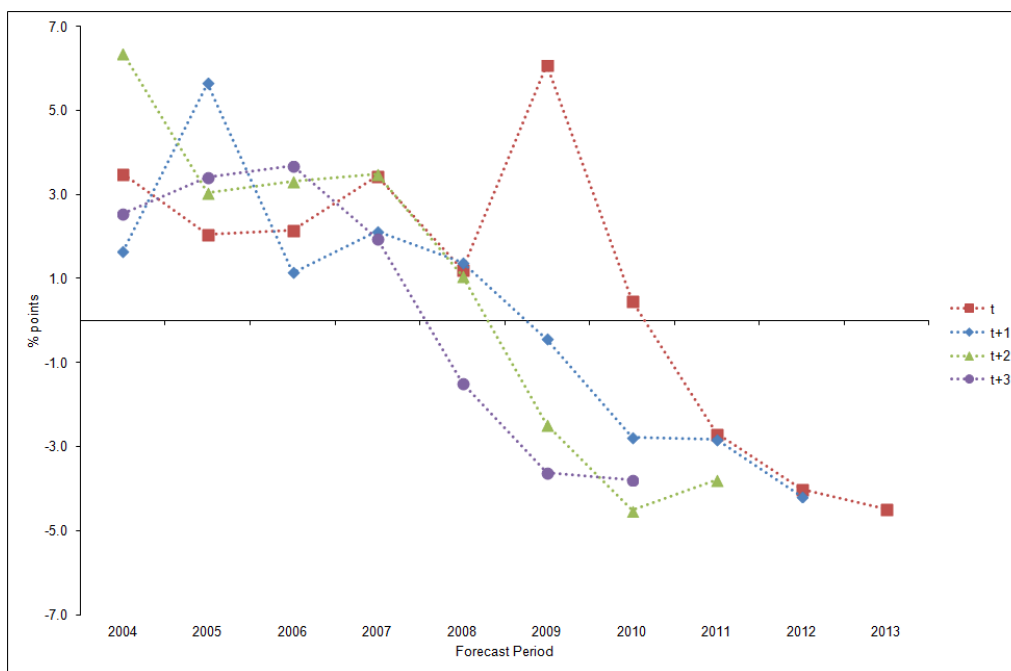
Figure 13: Forecast Error: Imports (forecast - actual)



Being a very open economy, growth in exports of goods and services can be a significant determinant of GDP growth. Exports of goods and services can also be a relatively volatile component of expenditure, susceptible to international trade developments which in modern economic history have tended to exceed the global growth in GDP by several factors. This component can also be influenced by volatile commodity price developments and exchange rate movements. The emergence of new growth sectors in recent years have also made projections of exports more difficult and subject to changes in the model structure in a span of few years. The volatility in oil prices and its effects on the fuel bunkering activity and offshore oil transshipment also presents a challenge to the forecast of exports of goods and services in the Maltese economy. Forecast accuracy is therefore likely to be less than that of the domestic components of GDP. This is confirmed in Figure 12 with forecast errors ranging between +/- 10 percentage points. A tendency to underestimate growth in exports of goods and services is notable, particularly for current period forecasts and for the one-year ahead forecasts.

A very similar pattern can be discerned for imports of goods and services, illustrated in Figure 13. This is primarily because of the high import content of Maltese exports. Indeed, imports of industrial goods and imports of oil (for bunkering and transshipment) in STEMM are primarily determined by exports of related goods typically with an elasticity which is close to unitary. Nevertheless, imports are also driven by domestic demand

Figure 14: Forecast Error: Net Exports (forecast - actual)



components; namely, investment is associated with imports of capital goods and private consumption is associated with imports of consumer goods. As a result, the contribution of net exports is not neutral on GDP growth and will depend on the composition of growth. The forecast error for net exports is illustrated in Figure 14. A tendency to overestimate net export growth by around +3 percentage points is evident in earlier forecasts and a tendency to underestimate the contribution of net exports to the tune of -3 percentage points is evident in more recent forecast exercises. This still represents a sizeable forecast error.

Overall, it is positive to conclude that no major biases can be identified for GDP growth forecasts. However eliminating the tendency to underestimate growth in government consumption and ensuring that forecast investment growth is not optimistic can help to make growth forecasts more reliable. In addition, constant updating of the model particularly the various components of exports and the frequent recalibration of import equations should improve forecast accuracy and minimise possible biases from net-exports. The use of meetings with major operators particularly with respect to forecasts for private investment should also contribute to improve forecast accuracy. Finally, improvements in statistical data are also expected to contribute to improve forecast accuracy.

3. Forecast Accuracy

3.1 Definitions of the Main Summary Statistics Used

Forecast accuracy and performance can be measured more formally using three summary statistics. These are the mean error (ME), the mean absolute error (MAE), and the root mean squared error ($RMSE$). These are explained below:

- The mean error (ME) is calculated by taking the average of forecast errors. This summary statistic has to be used with caution. The mean error as a summary statistic limits the size of the forecast error as negative forecast errors offset positive forecast errors. As a result, literature suggests the mean absolute error and the root mean squared error as a better measure of forecast accuracy. Though, it is only a rough indicator of quality, the mean error can however be used as an indication of forecast bias. Formally,

$$ME = \frac{1}{T} \sum_{t=1}^T e_{t,t} \text{ for the current year}$$

and

$$ME = \frac{1}{T} \sum_{t=1}^T e_{t+1,t} \text{ for the following year}$$

- The mean absolute error (MAE) is the average of the absolute forecast errors. As a measure of forecast accuracy, this summary statistic is preferred over the mean error as it provides a more accurate measure of forecast errors. More formally,

$$MAE = \frac{1}{T} \sum_{t=1}^T |e_{t,t}| \text{ for the current year}$$

and

$$MAE = \frac{1}{T} \sum_{t=1}^T |e_{t+1,t}| \text{ for the year ahead}$$

- The root mean squared error (*RMSE*) (also called the root mean squared deviation, *RMSD*) is another summary statistical measure of the magnitude of forecast errors. It accounts for the fact that large forecast errors are usually considered more problematic than small ones. Formally,

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^T e_{t,t}^2} \text{ for the current year}$$

and

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^T e_{t+1,t}^2} \text{ for the following year}$$

3.2 A Cross-Country Comparison of Forecast Accuracy

The small size and openness of the Maltese economy would a-priori suggest that forecast accuracy is likely to be less than in other larger and less open economies. The small size makes it more susceptible to single events, say a change in the output of one major operator. For instance, exports of goods in Malta are still dominated by one large operator. In recent years, fuel bunkering and transshipment accounted for a significant share of goods exports. The openness of the economy also makes it more susceptible to relatively volatile exchange rate developments. It also means that most sectors operate in a competitive market and are therefore price-takers with prices determined by changes in supply and demand. On the other hand, the servification of the Maltese economy in sectors which are more resilient to crisis may have made the Maltese economy less vulnerable to the volatility of international markets. Moreover, the restructuring towards higher value added manufacturing and the increase in wage flexibility following euro adoption may have made manufacturing production less susceptible to terms of trade shocks over the recent years. These opposing forces may have made developments in the Maltese economy more predictable.

Unfortunately, forecast errors for Malta can only be evaluated since 2004 and a full evaluation of the change in forecast errors over time cannot yet be made. Table 1 presents a cross-country comparison of forecast accuracy based on the root mean square error. Figures for EU member states are taken from Gonzales, Cabanillas and Terzi (2012). The forecast errors reported for Malta are not strictly comparable due to the smaller sample size and are therefore only indicative. Forecast errors reported for Malta for the current year are amongst the highest. However, this may depend on the period of the year in which the forecast is carried out with earlier forecasts tending to display a larger forecast error due to the lack of current year information.

A more meaningful comparison is that for the one-year ahead forecast errors. These range from 1.2 percentage points in France to 2.9 percentage points in Ireland. At 2.3 percentage points, Malta's *RMSE* is relatively high. The cross-country comparison portrayed in Figure 15 suggests that there seems to be some positive correlation with the openness of the economy (measured by exports as a per cent of GDP) but no strong correlation with the size of the economy (measured by GDP as a per cent of EU GDP). Thus, when compared with the *RMSE* of similarly open economies (i.e. Luxembourg which records an *RMSE* of 2.8 percentage points and Ireland which records an *RMSE* of 2.9 percentage points), Malta's forecast errors based on the Ministry for Finance forecasts are actually the lowest. Incidentally, these three economies are also amongst the smallest economies in the EU. On the other hand, Belgium and the Netherlands also have relatively open economies but their forecast errors as measured by the *RMSE* are somewhat lower at 1.5 percentage points.

The smaller sample size in the case of the forecasts for Malta can have a sizeable effect not just because the model is further away from achieving its asymptotic properties for maximum efficiency but also because the relative weight of the crisis years which is known to have contributed to a significant deterioration in forecast accuracy, is higher. Indeed, if we exclude the 2009 crisis and the subsequent recovery in 2010, the one-year ahead *RMSE* for Malta falls to 1.3 percentage points and is thus comparable to that displayed in larger and less open economies.

3.3 Inter-Institutional Comparison of Forecast Accuracy

The accuracy of forecast for Malta using the three summary statistics is evaluated over the period 2004-2013 for GDP and its expenditure components. Forecast accuracy is best measured using the *RMSE*. For completeness purposes, the *ME* and *MAE* is also reported. MFIN results are compared to the forecasting performance of the European Commission (EC) and the Central Bank of Malta (CBM)³. The results are presented hereunder in Tables 2-11.

Forecast accuracy deteriorates between current forecasts and the year ahead forecast. Nevertheless, because current year forecast errors are significantly influenced by the timing of forecasts carried out by the different institutions, the year ahead forecasts is deemed to be a better indicator of forecast accuracy of a model. The following analysis is based on the one-year ahead forecast errors although the current year forecast error is provided also

³It is also noteworthy that unlike the Ministry for Finance and the European Commission, forecast projections by the Central Bank of Malta are only available from 2008 onwards. Apart from this, the Central Bank of Malta publishes its forecasts at a later date when compared to the European Commission and the Ministry for Finance, and therefore it makes use of additional and more updated data for its current year forecasts. This could partly explain why the Central Bank of Malta records more accurate forecasts for the current year.

Table 1: Cross Country Comparison of Forecast Errors based on RMSE

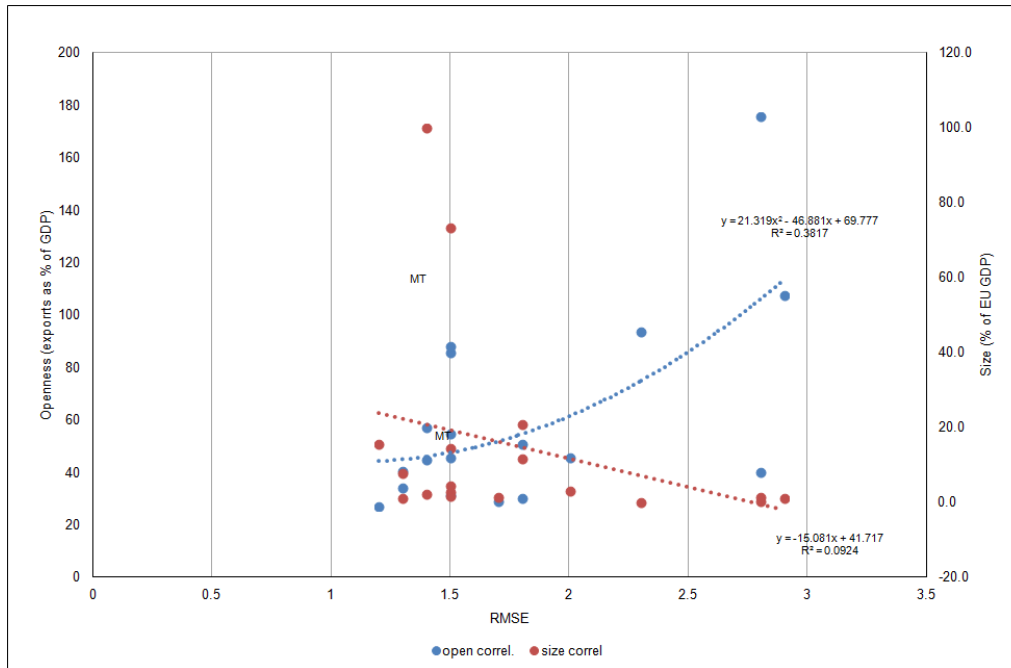
<i>pps.</i>	<i>Sample</i>	<i>t</i>	<i>t+1</i>	<i>open</i>	<i>size</i>
Malta	04/13	1.5	2.3	93.7	0.1
Belgium	69/11	0.8	1.5	85.9	2.9
Denmark	73/11	1.0	1.5	54.9	1.9
Germany	69/11	1.1	1.8	50.7	20.9
Ireland	73/11	2.0	2.9	107.8	1.3
Greece	81/11	1.1	1.7	29.1	1.4
Spain	86/11	0.7	1.3	34.1	7.8
France	69/11	0.7	1.2	27.2	15.8
Italy	69/11	1.2	1.8	30.4	11.9
Luxembourg	69/11	2.0	2.8	175.7	0.3
Netherlands	69/11	0.9	1.5	88.3	4.6
Austria	95/11	0.7	1.4	57.4	2.4
Portugal	86/11	0.9	1.3	40.7	1.3
Finland	95/11	1.6	2.8	40.1	1.5
Sweden	95/11	1.3	2.0	45.8	3.2
United Kingdom	73/11	0.9	1.5	31.4	14.5
European Union	69/11	0.7	1.4	44.9	100.0
Euro Area	98/11	0.6	1.5	45.9	73.5

Source: Gonzáles, Cabanillas, L., and Terzi, A. 2012.

for completeness purposes. Moreover, EC and MFIN forecasts are typically undertaken at the same time and use a generally consistent set of external assumptions, including world GDP, exchange rates, interest rates and oil prices. Therefore, the difference in the *RMSE* is partially an indicator of the forecast accuracy of the Ministry for Finance model when controlling for errors arising from the lack of forecast accuracy underlying the main external assumptions. It is however also influenced by the economic judgment employed by the respective institution, some divergent assumptions namely for government expenditure and also the degree to which the forecast by one institution is influenced by the forecast of the other institution in view of the discussions that take place between the same institutions prior to the finalization of forecasts.

The mean error suggests that the EC and to a lesser extent MFIN tend to underestimate real GDP growth. However, over the more recent sample period MFIN and CBM displayed a tendency to overestimate real GDP growth. Forecast accuracy is very similar

Figure 15: Size, Openness and Forecast Performance



for MFIN and EC and the deterioration in forecast accuracy for the more recent forecast period seems to be attributable to the crisis period. If one excludes the effect of the crisis period the EC (and to a lesser extent MFIN) has improved forecast accuracy. Nevertheless, due to the small sample size of the recent period, these inferences have to be considered only indicative.

The mean error also suggests that the EC and to a lesser extent MFIN tend to underestimate nominal GDP growth. However, over the more recent sample period the EC forecasts do not display any similar biases whilst MFIN displayed a tendency to overestimate nominal GDP growth. Forecast accuracy is also very similar for MFIN and EC and the deterioration in forecast accuracy for the more recent forecast period seems to be attributable to the crisis period. If one excludes the effect of the crisis period, the EC (and to a lesser extent MFIN) has substantially improved forecast accuracy. Nevertheless, due to the small sample size of the recent period, these inferences have to be considered only indicative.

Contrary to the graphical evaluation of forecast errors provided in Section 2 of this paper, the mean error suggests a general tendency to underestimate growth in private consumption expenditure, particularly if one excludes the crisis period. This generally applies for all the three institutions surveyed. Recent forecasts by CBM and MFIN may have tended

Table 2: Comparison of Forecast Errors for Real GDP by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM	
	t	t	t+1	t+1	t+1	t+1	t+1	
Mean Error	-0.53	-0.75	-0.25	-0.59	0.64	0.34	0.60	
<i>Mean Error (excl. crisis)</i>	<i>-0.40</i>	<i>-0.62</i>	<i>-0.58</i>	<i>-0.94</i>	<i>0.45</i>	<i>0.15</i>	<i>0.25</i>	
Mean Absolute Error	1.22	1.28	1.67	1.78	1.13	1.08	1.29	
<i>Mean Absolute Error (excl. crisis)</i>	<i>0.84</i>	<i>0.90</i>	<i>0.85</i>	<i>0.94</i>	<i>0.31</i>	<i>0.24</i>	<i>0.43</i>	
Root Mean Square Error	1.50	1.60	2.28	2.38	2.77	2.76	3.03	
<i>Root Mean Square Error (excl. crisis)</i>	<i>1.27</i>	<i>1.38</i>	<i>1.28</i>	<i>1.47</i>	<i>1.04</i>	<i>0.87</i>	<i>1.47</i>	
	Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
	Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
		2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

to overestimate growth in private consumption but this seems to have been the result of optimistic forecasts in the crisis years. Forecast accuracy for this important expenditure component is very similar to that of real GDP,

The tendency to underestimate growth in public expenditure is clearly evident in Table 5, with a mean error which is consistently negative irrespective of the time period under analysis. Forecast accuracy is also weaker than that observed for aggregate GDP growth forecasts. These observations apply for all the three institutions surveyed. The analysis of forecast errors suggests significant scope for improvement, particularly the tendency to underestimate growth in compensation of employees and intermediate consumption of general government, which are the two main components of public expenditure.

Table 3: Comparison of Forecast Errors for Nominal GDP by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM
	t	t	t+1	t+1	t+1	t+1	t+1
Mean Error	-0.48	-0.93	-0.37	-0.88	0.30	-0.06	na
<i>Mean Error (excl. crisis)</i>	<i>-0.13</i>	<i>-0.45</i>	<i>-0.42</i>	<i>-0.97</i>	<i>0.64</i>	<i>0.27</i>	<i>na</i>
Mean Absolute Error	1.62	1.79	1.75	1.93	1.27	1.17	na
<i>Mean Absolute Error (excl. crisis)</i>	<i>1.01</i>	<i>1.22</i>	<i>0.81</i>	<i>0.96</i>	<i>0.32</i>	<i>0.19</i>	<i>na</i>
Root Mean Square Error	2.03	2.39	2.47	2.69	3.12	3.16	na
<i>Root Mean Square Error (excl. crisis)</i>	<i>1.40</i>	<i>1.83</i>	<i>1.19</i>	<i>1.54</i>	<i>1.12</i>	<i>0.77</i>	<i>na</i>
Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
	2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

Table 4: Comparison of Forecast Errors for Consumption by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM
	t	t	t+1	t+1	t+1	t+1	t+1
Mean Error	-0.66	-0.96	-0.27	-0.39	0.56	0.18	0.32
<i>Mean Error (excl. crisis)</i>	<i>-0.90</i>	<i>-1.24</i>	<i>-0.94</i>	<i>-0.88</i>	<i>-0.46</i>	<i>-0.59</i>	<i>-0.52</i>
Mean Absolute Error	1.54	1.78	1.66	1.49	0.76	0.71	0.80
<i>Mean Absolute Error (excl. crisis)</i>	<i>1.20</i>	<i>1.41</i>	<i>1.24</i>	<i>1.22</i>	<i>0.34</i>	<i>0.44</i>	<i>0.48</i>
Root Mean Square Error	1.66	1.88	2.15	1.82	1.63	1.43	1.64
<i>Root Mean Square Error (excl. crisis)</i>	<i>1.64</i>	<i>1.89</i>	<i>2.15</i>	<i>1.94</i>	<i>1.14</i>	<i>1.47</i>	<i>1.62</i>
Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
	2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

Table 5: Comparison of Forecast Errors for Government Expenditure by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM	
	t	t	t+1	t+1	t+1	t+1	t+1	
Mean Error	-1.82	-1.42	-2.99	-1.97	-1.61	-0.55	-1.49	
<i>Mean Error (excl. crisis)</i>	-2.33	-2.31	-4.23	-3.29	-3.60	-2.66	-2.83	
Mean Absolute Error	2.75	3.01	3.82	3.13	1.92	1.37	1.87	
<i>Mean Absolute Error (excl. crisis)</i>	2.22	2.33	2.98	2.56	1.08	0.80	1.06	
Root Mean Square Error	3.70	3.92	5.64	4.94	4.39	3.53	4.05	
<i>Root Mean Square Error (excl. crisis)</i>	3.91	3.90	5.94	5.20	4.37	3.28	4.02	
	Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
	Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
		2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

Table 6: Comparison of Forecast Errors for Investment by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM	
	t	t	t+1	t+1	t+1	t+1	t+1	
Mean Error	3.53	4.42	6.29	4.56	7.91	6.75	9.23	
<i>Mean Error (excl. crisis)</i>	0.38	0.63	0.05	-0.01	1.05	3.85	4.25	
Mean Absolute Error	9.32	10.14	10.46	11.27	6.68	7.48	6.96	
<i>Mean Absolute Error (excl. crisis)</i>	2.63	2.97	2.10	3.05	0.21	0.77	0.85	
Root Mean Square Error	13.33	14.02	15.28	15.28	17.89	17.93	17.47	
<i>Root Mean Square Error (excl. crisis)</i>	5.66	5.83	5.43	7.68	1.07	3.85	4.88	
	Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
	Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
		2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

All three institutions surveyed display a tendency to overestimate growth in investment expenditure. As expected, forecasts accuracy for growth in investment is particularly low, especially in times of crisis, thus representing a main source of forecast errors for GDP growth.

All three forecasting institutions project no major change in inventory in the forecasting years such that the contribution of this component to GDP growth is neutral over the forecast horizon. Therefore, an inter-institutional comparison is not necessary. A mean error of -0.4 percentage points suggests a tendency to underestimate the contribution of the change in inventories. The *RMSE* is estimated at 2.1 percentage points (or 2.3 percentage points if one excludes crisis period), which is not very dissimilar to the forecast accuracy for GDP growth. Whilst scope for improvement exists, the current methodology for estimating change in inventories remains appropriate given these results.

It is notable that the methodology employed by the three institutions in forecasting exports of goods and services varies. In the case of MFIN, forecasts are disaggregated by product or service and the forecast is carried out in nominal terms, with separate estimates for aggregate export prices to derive growth in real exports. On the other hand, both the EC and CBM project exports of goods and services in aggregate. Furthermore, the EC forecasts are based on a cross-country consistency evaluation where Malta's exports will be equal to the sum of imports of Maltese goods and services by Malta's trading partners.

The *ME* for exports indicates a tendency towards prudence with all institutions (albeit to a greater extent in the case of MFIN) generally displaying a negative *ME*. Forecast accuracy for exports is relatively low with an *RMSE* ranging from 4.9 to 8.7 percentage points depending on the model and the period chosen. This suggests that this expenditure component can be an important source of forecast error for GDP growth. Despite the stronger tendency to underestimate export growth, forecasts by MFIN are not generally the least accurate of the three institutions.

Despite these methodological differences, forecast accuracy for this element of expenditure is very similar for the three institutions considered. There is still scope for improvement in forecasting exports for Malta. This is undeniably a difficult task in a small open economy which is susceptible to external shocks and exchange rate fluctuations which are difficult to predict with a sufficient degree of accuracy. Nevertheless, improvements in statistical data and information, particularly export deflators by category, could improve forecast accuracy. On the other hand, the inclusion of SPEs in ESA10 national accounts can make predictions of export growth more challenging in the future.

Demand for imports is a derived demand especially for Malta which lacks most natural resources and where manufactured goods have high import content. In this context, the forecast biases and accuracy for imports are influenced significantly by that displayed by the other demand components. In general, one observes a tendency among the three

Table 7: Comparison of Forecast Errors for Exports by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM
	t	t	t+1	t+1	t+1	t+1	t+1
Mean Error	-5.02	-3.96	-2.72	-1.80	-2.38	-0.32	-0.76
<i>Mean Error (excl. crisis)</i>	-4.22	-3.07	-2.36	-1.47	-1.32	1.42	-0.02
Mean Absolute Error	6.19	5.57	4.85	5.28	3.28	3.44	3.68
<i>Mean Absolute Error (excl. crisis)</i>	4.54	4.07	2.99	3.07	1.42	1.23	1.24
Root Mean Square Error	7.52	6.90	7.10	7.62	7.60	8.17	8.73
<i>Root Mean Square Error (excl. crisis)</i>	6.90	6.48	5.96	6.12	5.29	4.90	5.04
Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
	2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

institutions to underestimate the growth in imports. However, this tendency is weaker than the tendency to underestimate export growth (possibly reflecting the tendency to overestimate growth in investment and hence the growth in imports of capital goods).

More recent forecasts by CBM and EC have actually tended to overestimate growth in imports despite the tendency to underestimate growth in exports whilst MFIN continues to underestimate growth in imports. In general, forecast accuracy is not very dissimilar among the three institutions, with the *RMSE* ranging from 4.8 to 7.5 percentage points depending on the forecast period and institution. This is better than the forecast accuracy for exports but still significantly worse than the forecasting performance for real GDP. In terms of forecast accuracy, MFIN generally displays the best performance irrespective of the period covered although the EC displays the best performance if one excludes crisis years.

Table 8: Comparison of Forecast Errors for Imports by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM	
	t	t	t+1	t+1	t+1	t+1	t+1	
Mean Error	-4.94	-3.52	-1.98	-1.07	-1.24	0.90	0.72	
<i>Mean Error (excl. crisis)</i>	-3.90	-2.68	-1.96	-0.89	-0.70	2.63	1.53	
Mean Absolute Error	6.44	5.68	4.73	5.17	2.90	3.33	3.44	
<i>Mean Absolute Error (excl. crisis)</i>	4.62	4.30	3.08	3.17	1.25	1.33	1.42	
Root Mean Square Error	7.05	6.52	7.04	7.34	6.60	7.42	7.46	
<i>Root Mean Square Error (excl. crisis)</i>	6.36	6.37	6.55	6.31	4.92	4.81	4.94	
	Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
	Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
		2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

Table 9: Comparison of Forecast Errors for net Exports by Institution

forecast period	MFIN	EC	MFIN	EC	MFIN	EC	CBM	
	t	t	t+1	t+1	t+1	t+1	t+1	
Mean Error	0.77	0.41	0.19	0.20	-1.77	-1.85	-2.11	
<i>Mean Error (excl. crisis)</i>	0.14	0.07	0.11	-0.08	-3.27	-3.87	-4.20	
Mean Absolute Error	3.01	2.86	2.22	2.50	1.16	1.39	1.65	
<i>Mean Absolute Error (excl. crisis)</i>	2.35	2.47	2.04	2.27	0.98	1.16	1.26	
Root Mean Square Error	3.39	3.10	2.90	3.14	2.66	3.18	3.60	
<i>Root Mean Square Error (excl. crisis)</i>	3.12	3.21	3.24	3.47	3.33	3.92	4.29	
	Sample	2004/13	2004/13	2004/12	2004/12	2008/12	2008/12	2008/12
	Sample (excl. crisis)	2004/08	2004/08	2004/07	2004/07	-	-	-
		2011/13	2011/13	2010/12	2010/12	2010/12	2010/12	2010/12

In general, because imports tend to move with exports (due to the openness of the Maltese economy and the high import content in domestic production and consumption) the two flows tend to cancel each other out. This also applies for the bias and the accuracy of the forecasts for imports and exports. As a result, the forecast accuracy for net exports is likely to be better than for imports or exports individually. Over the entire sample the above a-priori expectations appear to hold with MFIN and EC displaying only a slight tendency to overestimate net export growth. Forecast errors for net exports are still marginally higher than those for real GDP growth. Nevertheless, one can observe a stronger tendency to underestimate net exports in the most recent forecast exercises. Despite this tendency, forecast accuracy has not deteriorated substantially. MFIN displays the most accurate forecast irrespective of the forecast period covered.

4. Testing for Forecast Biasedness

Macroeconomic forecasts produced by finance ministries are sometimes criticized of being too optimistic to allow greater room for maneuver when it comes to fiscal projections (Frankel and Schreger, 2012). One way to assess this hypothesis is to test for biasedness in the Ministry for Finance's projections. The presence of biasedness can be tested by running the following regressions:

$$e_{t,t} = \alpha + \varepsilon_t \text{ for the current year (1)}$$

and

$$e_{t+n,t} = \alpha + \varepsilon_{t+n} \text{ for the n-year ahead (2)}$$

where $e_{t,t}$ is the forecast error term from the variable we are forecasting at time t while ε_t is assumed to be white noise. To test for biasedness, regressions 1 and 2 above are estimated where $\alpha = 0$ reflects unbiasedness.

One main limitation behind the regression results presented in this research paper is the size of the sample which although it takes into account nearly all of the population, it is still considered to be a small sample size. In general, the effect of a small sample size is that regression tests lose their power due the limited degrees of freedom and consequently, regressions become less powerful. The degree of uncertainty around the estimated parameters would increase as the sample size gets smaller and consequently, results are less likely to be statistically significant (Elder et al. 2005).

Usually, for forecast accuracy exercises and forecast error evaluations, researchers use samples of at least 20 years as is found in Artis (1996), Melliss and Whittaker (1998), and Clements and Hendry (2001) with some exceptions Poulizac et al. (1996) which uses only 13 years of data. Therefore, with only 10 years of forecasts data for the Ministry for Finance and the European Commission and 6 years of forecasts data for the Central Bank of Malta for year t , the sample is probably too small for the policy-maker to draw strong conclusions.

A p-value below 0.05 would typically reject the null hypothesis that $\alpha = 0$, thus indicating presence of biasedness. However, given the small sample size of forecast errors for Malta, a p-value of 0.15 is being considered, whilst a p-value of 0.30 can also be used as a guide to indicate biasness (Lovell, 1983).

Table 10: Test for Unbiasness

	t	t+1	t+2	t+3
Real GDP	-0.53 (0.28)	-0.25 (0.76)	0.29 (0.77)	0.82 (0.46)
Nominal GDP	-0.48 (0.48)	-0.37 (0.68)	-0.05 (0.97)	0.07 (0.96)
Real Private Consumption	-0.66 (0.22)	-0.27 (0.73)	0.05 (0.95)	0.53 (0.57)
Real Public Consumption	-1.82* (0.13)	-2.99* (0.12)	-3.78** (0.05)	-2.61 (0.32)
Real Gross Fixed Capital Formation	3.53 (0.43)	6.29 (0.24)	6.63 (0.27)	6.38 (0.29)
Real Exports	-5.02** (0.02)	-2.72 (0.27)	-1.81 (0.59)	-0.58 (0.86)
Real Imports	-4.94** (0.02)	-1.98 (0.43)	-1.7 (0.60)	-0.39 (0.89)
Real Net Exports	0.77 (0.50)	0.19 (0.86)	0.81 (0.58)	0.39 (0.77)

(p-value in parenthesis; a p-value of less than or equal to 0.15 indicates the presence of bias)

Looking at the results for real and nominal GDP and the expenditure components, definite instances of bias (based on a p-value less than 0.05) can be detected for real exports and imports at year t and also for real public consumption for up to year $t+2$. Using a stronger p-value of 0.15, a tendency to underestimate public expenditure is evident. Using the even more restrictive p-value of 0.3, a tendency to overestimate growth in investment can be discerned whilst the year ahead forecasts of private consumption and the one-year ahead forecast of exports tends to be underestimated. Overall, with regards to real and nominal GDP, there appears to be no systemic bias in the projections for both year t and the outer forecast horizon.⁴ In particular, any biases in the individual components appear to cancel out each other. For instance, the tendency to underestimate exports is cancelled by the tendency to underestimate imports whilst the tendency to overestimate investment is offset by the tendency to underestimate private and public consumption. Detailed results for the alpha values and their respective p-values can be found in Table 10.

Of all the expenditure components, private consumption and imports are the tax-rich

⁴This is also in line with the conclusions derived for Malta in a similar study produced by the European Commission (Gonzales, Cabanillas and Terzi, 2012).

components which directly influence budgetary projections. Forecasts for private consumption growth is typically underestimated suggesting that fiscal projections for consumption related taxes such as VAT are not likely to be optimistic due to macroeconomic projections. The symmetry in the current year bias of external trade suggests that this is primarily due to exports of goods which are the main driver of imports of industrial supplies. This suggests that the impact on fiscal projections is likely to be marginal given that imports of industrial supplies do not constitute a relevant tax base for taxes on imports. Indeed as from 2014, projections for taxes on imports carried out by the Ministry for Finance are based on imports net of industrial supplies, thus completely eliminating any possible influence from such bias on fiscal projections.

5. Assessing Forecast Uncertainty: Constructing Fan Charts

Nobody can predict what will happen in the future with absolute certainty since forecast estimates are surrounded by various assumptions and embody a spectrum of both upside and downside risks, sometimes weighing more on one side of the spectrum than on the other. This is even more relevant for a small and open economy like Malta, where even the smallest change in the global economy can have a considerable effect. Therefore, it is impossible to gauge with certainty the distribution of possible future economic outcomes. Despite this complex nature of forecast estimates, single or ‘point’ estimates around which different outcomes with varying degrees of probabilities are possible.

Single or ‘point’ estimates make it highly improbable that the actual outcome coincides exactly with the forecasted figures, if not by pure chance. Consequently, it is useful to assess both in a qualitative and more importantly in a quantitative manner the uncertainty surrounding the baseline set of forecasts to inform the policymaker about the risks to the economic outlook and the likelihood of possible economic scenarios. The latter point can be achieved by the construction of a fan chart.

A fan chart conveys the medium-term probability distributions for the forecasts of GDP growth, based on the point estimates and the risks surrounding them. It suggests a range of forecasts based on alternative risks scenarios. Fan charts have today become a popular communications medium amongst forecasters since it is an easy way to convey to the layman person, the uncertainty surrounding the forecast projections. Fan charts have been used not only to illustrate the uncertainty in GDP projections, but also in fiscal projections and in inflation projections, amongst other key macroeconomic variables. The explicit quantification of the risks and uncertainties surrounding the macroeconomic variable in question, while allowing room for judgmental elements, originated from the Bank of England in 1996 through the publication of their ‘density’ inflation forecasts. Britton, Fisher and Whitley (1998) highlight that the main objective for the Bank of England to introduce fan charts in their inflation projections was to “*promote discussion of the risks to the economic outlook, and thus contribute to a wider debate about economic policy*”.

Other institutions followed along the same lines and introduced their own fan charts. The International Monetary Fund (IMF) has also (since 2006) made use of fan charts for its world GDP growth projections as it serves as a “visual communications device” to help elucidate three main issues: to illustrate the baseline forecast for the current and future years, to analyze the level of uncertainty that is surrounding the forecast projections, and to assess where the balance of risks lie on the projections. More recently, the United Kingdom’s Office for Budget Responsibility (OBR) has also introduced fan charts for its projections of real GDP growth and public net borrowing to “*promote transparency*”

and illustrate the uncertainty that the Government faces in planning fiscal policy, and in meeting any numerical target. Explicit recognition of uncertainty can help commentators assess the Government's fiscal plans”.

Following the methodology employed by Britton et al. (1996) and that by Elekdag and Kannan (2009), this section illustrates the fan charts for real GDP growth for the period 2014-2017, in order to better emphasize the inevitable uncertainty around the outlook for the Maltese economy. To determine the uncertainty regarding point estimates of GDP growth use will be made of historical forecast errors, a survey based evaluation of the main risk factors surrounding GDP growth in Malta and also model-based simulations of growth based on a set of alternative assumptions.

In essence, the variance of historical forecast errors of GDP growth and that of the risk factors can be used to determine the level of uncertainty surrounding a baseline forecast whilst the skewness of the distribution of alternative growth projections (whether model based or survey based) and of the risk factors can be used to determine the balance of upside or downside risks. In order to capture the balance of risk, the two-piece normal distribution is employed. Following the methodology employed by Elekdag and Kannan (2009) the following steps were followed:

1. Determine the growth forecasts for GDP (denoted as Y).
2. Compute the uncertainty parameter as the historical forecast error variance (denoted as σ_Y). If necessary, judgment can be used to adjust the variance upwards by a constant factor if say a period of increased uncertainty is expected.
3. In order to produce a skewed fan chart and thus represent better the balance of risk, the Pearson skewness indicator of alternative model-based simulations of GDP growth based on different assumptions (denoted as γ_Y) is computed as three times the difference between the mean and the mode divided by the standard error.
4. The confidence levels (q) to be displayed in the fan-chart are chosen (e.g. 50 per cent, 70 per cent, 90 per cent).
5. Once the variance (σ_Y) and skewness (γ_Y) parameters are established one can then characterise the distribution of forecasts in terms of the parameters of the 2-piece normal distribution; that is, the mean (μ) which represent the central forecasts, and the left (σ_1) and right (σ_2) standard deviations of the said distribution.

The density function of the 2-piece normal distribution can be thought of as a combination of two halves of a normal distribution, both with the same mean (μ) but with a different standard deviation (σ_1 and σ_2) on each side. The density function is represented by:

$$f(x) = A \exp \left\{ -\frac{(x-\mu)^2}{2\sigma_1^2} \right\} \text{ for } x \leq \mu$$

$$= A \exp \left\{ -\frac{(x-\mu)^2}{2\sigma_2^2} \right\} \text{ for } x > \mu$$

$$A = \frac{\sqrt{2}(\sigma_1 + \sigma_2)^{-1}}{\sqrt{\pi}}$$

If the distribution is skewed ($\sigma_1 \neq \sigma_2$), μ is the mode of the distribution. The mean, variance and skewness of the distribution is respectively given by the following equations:

$$E(x) = \mu + k(\sigma_2 - \sigma_1)$$

$$V(x) = \sigma_1\sigma_2 + (1 - k^2)(\sigma_2 - \sigma_1)^2$$

$$\gamma(x) = k(\sigma_2 - \sigma_1) \left[(2k^2 - 1)(\sigma_2 - \sigma_1)^2 + \sigma_1\sigma_2 \right]$$

Where:

$$k = \left(\frac{2}{\pi} \right)^{\frac{1}{2}}$$

Since the variance and skewness parameter are uniquely identified, we can reparametrise the distribution using the mode, variance and the skew. As in Blix and Sellin (1997) we will use $\gamma(x) = k(\sigma_2 - \sigma_1)$ as a proxy, positively related measure of the skew. Combined with the expression for the variance, this could be used to get closed-form expressions for σ_1 and σ_2 .

From the equations $E(Y)$, $V(Y)$ and $\gamma(Y)$ that determine the mean, variance and skew of the 2-piece normal distribution, respectively, one can show that $\sigma_{(1,Y)}$ (i.e. the left hand side standard deviation of the distribution of growth forecasts) is the highest real-valued solution to the following quadratic equation:

$$\sigma_{1,Y}^2 + b\sigma_{1,Y} + c = 0$$

Where:

$$b = \frac{\gamma_Y}{k}$$

$$c = \left[\left(1 - \frac{1}{k^2}\right) \gamma_Y^2 + \sigma_Y^2 \right]$$

Once one determines $\sigma_{1,Y}$, the right hand side standard deviation of the distribution of growth forecasts, $\sigma_{(2,Y)}$ can be determined by the approximation:

$$\gamma(Y) = k(\sigma_{2,Y} - \sigma_{1,Y})$$

6. The confidence interval surrounding each point estimate of GDP growth can be constructed for each level of confidence chosen (q), by solving for:

$$z_1 = \mu - \frac{\sigma_1}{\sigma_2} (z_2 - \mu)$$

$$z_2 = \mu - \sigma_2 \Phi^{-1} \left(\frac{1+q}{2} \right)$$

Where Φ^{-1} is the inverse of the standard normal distribution which ranges between 0 and 1.

By following this methodology, a skewed fan chart is constructed around the autumn 2014 GDP growth forecasts which were published in the 2015 Budget.

Table 11 shows the variance of the distribution of forecast errors, the skewness of alternative model based simulations of growth and the resulting confidence interval based on the past forecast errors whilst Figure 15 displays the resulting fan chart based on these parameters.

The level of uncertainty in this case is based entirely on the historical uncertainty surrounding forecasts, i.e. the variance of historical forecast errors. This is shown by the width of the fan chart. The Economic Policy Department uses the historical forecast errors of the growth projections of the Ministry for Finance to come up with estimates of the standard deviation of the distribution of possible outcomes for the projected future real and nominal GDP growth. However, as noted by Elekdag and Kannan (2009) and by the Office for Budget Responsibility (2010), this approach is limited by the fact that past forecast errors may be an imperfect guide to the future. Nevertheless, it is still one of the mostly employed methodologies in forecasting literature as it provides a “*clear, transparent, and objective method for quantifying the degree of uncertainty*”, (OBR, 2010).

On the other hand, the balance of risk is determined by the skewness indicator. Note how the skewness indicator is generally positive (with 2017 as the exception) indicating that the balance of risk in this case lies more on the upside than the downside. This is based on an alternative set of assumptions ranging from lower economic growth of Malta’s main trading partners, alternative scenarios for the main exchange rates, alternative assumptions for oil prices, alternative growth in investment activity, a weaker evolution of manufacturing output and an alternative model based simulation of the remote gaming exports.

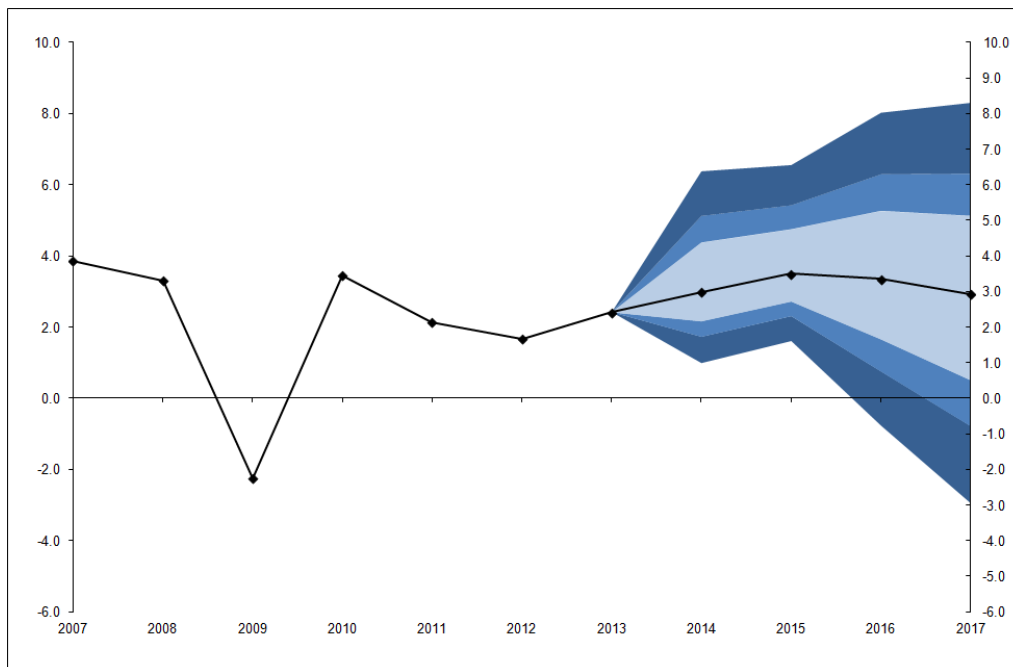
This analysis is merely used for illustrative purposes but shows how such model based simulations can be used to portray the balance of risk surrounding a set of growth projections. Given that the economic projections carried out by MFIN are purely model-based,

Table 11: Confidence Interval based on Past Forecast Errors and Model Based Simulations

	2014	2015	2016	2017
Y	3.0	3.5	3.4	2.9
σ_y	1.7	1.5	2.7	3.4
γ_y	0.7	0.6	0.3	-0.3

Confidence Interval								
	lower	upper	lower	upper	lower	upper	lower	upper
50	2.2	4.4	2.7	4.8	1.7	5.3	0.5	5.1
70	1.7	5.1	2.3	5.4	0.8	6.3	-0.8	6.3
90	1.0	6.4	1.6	6.6	-0.8	8.0	-3.0	8.3

Figure 16:



alternative growth projections are easily generated based on alternative assumptions. An element of economic judgement to determine alternative assumptions has to be employed. However, where a survey of alternative forecasts of these assumptions (or risk factors) is available this can be used instead of, or as a supplement to, the judgement employed by the Economic Policy Department.

6. Conclusion

This research paper provides an objective evaluation of the forecasting performance of the macroeconomic projections produced by the Economic Policy Department within the Ministry for Finance in Malta. Despite the small sample size and consequently the undue influence of the unpredicted 2009/10 recession and subsequent recovery on forecasting performance, the performance is comparable to that of other small open economies in the EU. If the crisis years are excluded, the forecasting performance compares favourably even with that of larger and less open economies in the EU. An inter-institutional comparison suggests that the forecasting performance of the Economic Policy Department is very similar to that of the Commission and does not indicate any systematic bias in the forecasts for nominal and real GDP. Nevertheless, this is not the case for the separate expenditure components.

A tendency to underestimate exports is typically offset by a tendency to underestimate imports. A tendency to underestimate private and public consumption is offset by a tendency to overestimate investment. Such biases are not dissimilar to those displayed by the other institutions surveyed.

Eliminating the tendency to underestimate growth in government consumption and ensuring that forecast investment growth is not optimistic (in particular public investment) can contribute to make growth forecasts more reliable. In addition, constant updating of the model particularly the various components of exports and the frequent recalibration of import equations should improve forecast accuracy and minimise possible biases from net-exports. The use of meetings with major operators to identify major investment potential by such operators should also contribute to improve forecast accuracy. Revisions in statistical data appear to have influenced forecasting performance suggesting that improvements in statistical data (particularly the development of output deflators) are also expected to contribute to improve forecast accuracy.

Finally, section 4 provides a methodology to incorporate forecast uncertainty based on the variance of past forecast errors and the balance of risk, based on model-based simulations, into the forecasts through the use of fan charts. An example based on the most recent forecast exercise undertaken in autumn 2014 is provided for illustration purposes. It is recommended that such an exercise is carried out and published with every vintage of forecasts. The model-based simulations of alternative growth projections should be guided as much as possible by objective criteria, such as, where possible, survey based information such as alternative forecasts of external conditions provided by Consensus Forecasts, clear indications provided by major operators, and an extensive review of international economic developments. Market based information such as risk indicators or forward prices should also be considered in order to evaluate more systematically the balance of risk. This should contribute significantly to give a more concrete indication

of the uncertainty and the balance of risk surrounding the baseline projections of GDP growth.

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