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中 文 摘 要 ： 本研究旨在評估美國國會預算局(Congressional Budget Office, CBO)經濟及預算預測之效率，並探討其無效率之肇因。國預算局之預測，儘管支出方面是被接受的，在歲入以及經濟預測上，則出入甚大。預算預測無效率之原因，部分是由於基本的經濟預測無效之故。本研究以專家預測者調查(Survey of Professional Forecasters, SPF)之經濟預測數據，調整國會預算局之預算預測，並發現此調整能使原國會預算局之預算預測的精確性在部分情況下獲得極大的改善。

中 文 關 鍵 詞 ： 美國國會預算局、預測評估、有條件預測、專家預測者調查

英 文 摘 要 ： This paper evaluates the efficiency of the Congressional Budget Office's (CBO) budgetary and economic projections, and investigates the causes of the inefficiency in its projections. While the efficiency is accepted for the CBO's projections for outlays, it is strongly rejected for its revenue and economic projections. The inefficiency in the budgetary projections is partially due to the inefficiency in the underlying economic projections. By adjusting the CBO's budgetary projections using the Survey of Professional Forecasters' (SPF) economic forecast, I find that the accuracy CBO's budgetary projections is significantly improved in some cases.

英 文 關 鍵 詞 ： Congressional Budget Office (CBO), Forecast Evaluation, Conditional Forecasts, Survey of Professional Forecasters (SPF), Asymmetric Loss Function

Investigating the Inefficiency of the CBO's Budgetary Projections

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PRELIMINARY AND INCOMPLETE

Abstract

This paper evaluates the efficiency of the Congressional Budget Office's (CBO) budgetary and economic projections, and investigates the causes of the inefficiency in its projections. While the efficiency is accepted for the CBO's projections for outlays, it is strongly rejected for its revenue and economic projections. The inefficiency in the budgetary projections is partially due to the inefficiency in the underlying economic projections. By adjusting the CBO's budgetary projections using the Survey of Professional Forecasters' (SPF) economic forecast, I find that the accuracy CBO's budgetary projections is significantly improved in some cases.

Keywords: Congressional Budget Office (CBO), Forecast Evaluation, Conditional Forecasts, Survey of Professional Forecasters (SPF), Asymmetric Loss Function

J.E.L. codes: E43, E44, E52, E58

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1 Introduction

Larry Summers recently noted that "The Congressional Budget Office (CBO) is an American national treasure. Without the impartial objectivity it brings to the budget process, our country would make much worse policy." As a nonpartisan organization producing independent analyses of budgetary and economic issues, the CBO's forecasts are widely accepted as a benchmark among academics and policymakers.

In this paper, I evaluate the efficiency of the CBO's budgetary and economic projections, and investigate the possible sources of inefficiency in its forecasts. Since the CBO's projections are important inputs for both fiscal and monetary policies and their accuracy is crucial for sound macroeconomic policy, evaluating the efficiency of the CBO's projections is very important. For fiscal policy, CBO's projections are essential inputs for the congressional debates and public discussion in the U.S.[1] For monetary policy, the CBO's projections influence the expectation of future path of monetary policy. Laubach (2009) found that a percentage point increase in the projected deficit to GDP ratio could increase the long-run forward rates by 25 basis points, which is consistent with a textbook loanable funds model. This connection between budget deficits and the interest rates is particularly relevant in the current economic environment, where U.S. economy gradually moves out of the zero-lower bound and the interest rates start to rise.

Investigating the possible sources of forecast inefficiency is essential in order to improve the forecast accuracy of the CBO's projections. Since the efficiency is evaluated by testing the unpredictability of forecast errors or revisions, the rejection of the efficiency implies that information is not fully incorporated, or there is some systematic mistakes or tendency in the CBO's projections. Finding the evidence against the forecast efficiency, a number of papers suggest possible explanations: behavioral bias by Ehrbeck and Waldmann (1996), information rigidity by Coibion and Gorodnichenko (2010, 2012), asymmetric loss function by Elliott et al. (2005), and the existence of structural breaks by Rossi and Sekhposyan (2015). Since each explanation has different policy implications, identifying the reasons why the CBO makes inefficient forecasts is crucial.

The results of forecast efficiency evaluation show that the efficiency is strongly rejected for CBO's

[1] For the role that CBO's forecasts play in budget making process, see Elmendorf (2015).

revenue and economic forecasts, while it is accepted for the forecasts for outlays. These results suggest that CBO's revenue projections may be affected by their poor conditioning assumptions.

By controlling the differences in underlying economic assumptions based the SPF forecasts, I show that there is a systematic errors in CBO's projections, and correcting it could significantly improve the accuracy of original CBO's projections in some cases.

The remainder of the paper is organized as follows: Section 2 explains the data and related literature, Section 3 describes the methodology used in the paper, Section 4 presents the results. Section 5 concludes.

2 Data and Related Literature

2.1 Data

The CBO's projections are the yearly projections released semiannually, typically in February and August. The horizon of the projections is long, and the CBO currently provides the projections for next ten years.[2] The projections cover a wide range of variables, not only the variables in the federal budget, but also underlying economic conditions.

In this paper, I focus on both budgetary projections and economics projections: budget deficit, revenue, and outlays for budgetary projections, and nominal and real GDP, CPI, the unemployment rate, and 3-month t-bill rate for economic projections. The budgetary projections are normalized by the real-time nominal GDP of the target year. In other words, I focus on the ratio of budget deficit, revenue and outlays to nominal GDP to evaluate the efficiency.

The real-time data are obtained from the Philadelphia Fed's website. In this paper, I follow convention in the literature and treat the data released two quarters after the forecasted date as the realized value.[3] The calculation of growth rates is based on the percentage changes relative to the previous year, to be consistent with CBO's calculation. The realized values in the budget are based on CBO's releases, which will not be revised.

[2]The horizon of the projections was initially five years, and extended to ten years after 1991.

[3]For details, see Tulip (2009) and Faust and Wright (2009). For example, I treat the level of nominal GDP in 2000 recorded in the second quarter of 2001 as the realized value. The growth rates are calculated in the same way: the growth rate of nominal GDP in 2001 relative to 2000 is computed using the vintage in the second quarter of 2002.

The descriptive statistics are presented in Table 1. The average ratio of revenue to nominal GDP is 18.16%, smaller than the ratio of outlays to nominal GDP, 21.57%. It implies the average ratio of budget deficit to nominal GDP is positive, with the level of 3.41%

2.2 Related Literature

This paper is based on two sets of literature about (1) the accuracy of the CBO's projections and (2) the evaluation of forecast efficiency. First, this paper is based on previous papers that analyzed the accuracy of the CBO's projections. Kliesen and Thornton (2001) showed that the CBO's deficit projections beyond a year are unreliable, and projections have a positive bias. In other words, the CBO tends to underpredict the budget deficit and overpredict the budget surplus. Kliesen and Thornton (2012) updated their analysis and confirmed these results. They also investigated the sources of systematic bias by looking at the different components of deficit (revenue or expenditure forecasts) and the relationship between budget projections and economic projections, but did not reach any definitive conclusion. Booth et al. (2015) found that the CBO's revenue estimates are slightly high on average, by 1.1 percent relative to the actual revenue, but the accuracy of its forecast is comparable to the projections made by the Office of Management and Budget (OMB).

Second, this paper is related to a large body of literature analyzing the efficiency of forecasts. The evaluation of forecast efficiency is important for three reasons: first, an efficiency evaluation could have important implications in terms of economic theories when efficiency is rejected, suggesting a deviation from full-information models. More specifically, the rejection of efficiency could be associated with economic models with dynamic properties or information friction. Second, efficiency evaluation provides an important benchmark for the quality control of forecasts. In other words, the rejection of efficiency indicates that there are systematic errors in the forecasts and that the forecasters can improve the accuracy of the forecasts by correcting them. Lastly, an efficiency evaluation is a useful tool for comparing the performance of different forecasts. Such comparisons can give us a better understanding of the nature of forecasts and the differences in underlying loss functions.

In particular, this paper is closely related with the two papers that combine these two literatures, Auerbach (1999) and Croushore and van Norden (2016). Auerbach (1999) tested the efficiency of

the CBO's and the OMB's budget projections and finds inefficiency in their projections. Furthermore, he found significant serial correlations in their forecast revisions and associated these serial correlations with their gradualism or conservatism as political institutions. Croushore and van Norden (2016) compared the budgetary forecasts made by the CBO and the Greenbook forecasts, prepared by the staff of the Federal Reserve, and concluded that the Greenbook's efficiency is accepted in most cases, while the Greenbook makes systematic errors in its long-term projections.

3 Methodology

In this section, I describe an analytical framework to evaluate and investigate the efficiency of the CBO's budgetary projections. First, I introduce the forecast evaluation across multiple horizons to evaluate the efficiency. Second, I extend the framework to focus on the conditional nature of the forecasts to test whether the inefficiency is due to their conditioning assumptions or the econometric model. Then, I construct the forecasts based on different economic assumptions by Survey of Professional Forecasters (SPF) forecasts to determine whether I could improve the accuracy of the forecasts. Lastly, I test whether the loss function of the CBO is symmetric to determine whether there is any evidence of asymmetry in their loss function.

3.1 Forecast Evaluation Across Multiple Horizons

Recently, Patton and Timmermann (2012) proposed a more powerful kind of forecast efficiency regression at multiple horizons, testing the internal consistency of forecasts. Let y_{t+h} be a variable at time $t+h$ to be forecasted, and $\hat{y}_{t+h|t+j}$ for any $0 < j < h$ be a forecast of y_{t+h} at time $t+j$. The standard Mincer-Zarnowitz regression to test the forecast efficiency is given by the following equation:

$$y_{t+h} = \alpha + \beta \hat{y}_{t+h|t+j} + \varepsilon_{t+h}. \tag{1}$$

Since forecast efficiency under a symmetric loss function implies that forecasts are the conditional mean of forecasted variables, the null hypothesis is $[\alpha, \beta] = [0, 1]$.

Now define the forecast revision for period $t+h$ between t and $t+j$, for any j such that $0 < j < h$, as $r_{t+h|t,t+j} \equiv \hat{y}_{t+h|t+j} - \hat{y}_{t+h|t}$. By definition, a recent forecast is described as the sum of the forecast

at a longer horizon and subsequent forecast revisions; $\hat{y}_{t+h|t+j} = \hat{y}_{t+h|t} + \sum_{k=1}^{j} r_{t+h|t+k-1,t+k}$. By replacing the forecast in equation (1), $\hat{y}_{t+h|t+j}$, with the sum of an old forecast and subsequent revisions, $\hat{y}_{t+h|t} + \sum_{k=1}^{j} r_{t+h|t+k-1,t+k}$, Equation (1) can be rewritten as follows:

$$y_{t+h} = \alpha + \beta\ \hat{y}_{t+h|t} + \sum_{k=1}^{j}\ \gamma_k\ r_{t+h|t+k-1,t+k}\ \ + \varepsilon_{t+h}, \tag{2}$$

with the null hypothesis of $[\alpha, \beta, \gamma_1, \ldots, \gamma_j] = [0, 1, 1, \ldots, 1]$, where j denotes the number of forecast revisions included in the regression. The F-test is used for this regression to test the null hypothesis jointly. This regression jointly tests the implications of forecast efficiency that both forecasts errors and forecast revisions are orthogonal to the past forecasts. Based on a Monte Carlo simulation, Patton and Timmermann (2012) showed that this multi-horizon forecast efficiency evaluation has significantly higher power to detect forecast inefficiency in finite samples.

Inference is based on conventional critical value and bootstrap. Conventional critical values are based on F-statistic. Bootstrap critical value is based on the null hypothesis that forecasts are efficient, and therefore it is a conditional mean of the realized series. By resampling from the residuals of the VAR model, I first make an artificial realized series. I form the VARs separately for budgetary and economic variables. The VAR for budgetary variables are based on revenue and outlays, and deficit is computed as their difference. The VAR for economic variables is based on real GDP, CPI, the unemployment rate, and 3-month t-bill rate, and the nominal GDP is computed as the sum of real GDP and CPI growth.

Then I treat the conditional mean of the artificial series as artificial CBO's forecasts and apply the Patton-Timmerman tests in the exactly the same way. By computing the F-statistic of these artificial forecasts and repeating this procedure an arbitrarily many times, I can form the distribution of the bootstrap F-statistics and report p-values of the realized F-statistic.

3.2 Conditional Forecast Evaluations

3.2.1 Baseline specification

Both of Mincer-Zarnowitz and Patton-Timmermann forecast evaluations in the previous subsection implicitly assume that forecasters make unconditional forecasts. However, most economic forecasts

are conditional in practice, in the sense that the forecasts are based on a particular path of some conditioning variables. For example, the Federal Reserve's Greenbook forecasts and FOMC's Summary of Economic Projections (SEP) are based on the assumption of a specific path of the federal funds rate in the future. Similarly, the CBO's budgetary projections are based on its long-term economic projections.

Therefore, ignoring this conditional nature of forecasts in forecast evaluations may result in a serious size distortion or lack of power of the statistical tests. To overcome this issue, I employ the method of conditional forecast evaluation proposed by Faust and Wright (2008). Essentially, I decompose observed conditional forecasts into two components: unconditional forecasts and the deviation in the conditioning from the unconditional forecasts. After controlling the effect of conditioning, I test the unpredictability of estimated unconditional forecast errors in the same manner as Micer-Zarnowitz test.

Suppose that the conditional forecast for y_{t+h} is described as $\hat{y}^c_{t+h|t}$. Suppose further that these forecasts are constructed on the $k \times 1$ vector of forecasts of conditioning variables, $\hat{\mathbf{z}}^c_{t+h|t}$, where k is the number of conditioning variables. The unconditional forecasts of conditioning variables are described as $\hat{\mathbf{z}}^u_{t+h|t}$. Under this setup, the baseline regression is described as follows:

$$y_{t+h} = \alpha + \beta y^c_{t+h|t} + \boldsymbol{\delta}'_k(\hat{\mathbf{z}}^c_{t+h|t} - \hat{\mathbf{z}}^u_{t+h|t}) + \varepsilon_{t+h}, \tag{3}$$

with the null hypothesis of $[\alpha, \beta] = [0, 1]$. The only change from the standard Mincer-Zarnowitz test in Equation (1) is that I control the differences in the conditioning assumptions between conditional and unconditional forecasts, to effectively test the unpredictability of unconditional forecast errors. Note that there is no testable implication on the vector $\boldsymbol{\delta}_k$, since they simply control the differences in conditioning assumptions.

3.2.2 Using the Realized Value as an Instrument

The baseline regression assumes that the researchers observe the unconditional forecasts of conditioning variables, $\hat{\mathbf{z}}^u_{t+h|t}$. However, it is often difficult to find unconditional forecasts for relevant applications. Therefore, Faust and Wright (2008) discussed the specification replacing the uncon-

ditional forecasts of conditioning variables with the realized values:

$$y_{t+h} = \alpha + \beta y^c_{t+h|t} + \boldsymbol{\delta}'_k(\hat{\mathbf{z}}^c_{t+h|t} - \mathbf{z}_{t+j+k}) + u_{t+h}, \tag{4}$$

with the same null hypothesis of $[\alpha, \beta] = [0, 1]$. However, the error term u_{t+h} contains the unconditional forecast error of the conditioning variables, $\mathbf{z}_{t+j+k} - \hat{\mathbf{z}}^u_{t+j+k|t+j}$, in this specification. Since this unconditional forecast errors are correlated with the conditional forecast errors in the regression, $\mathbf{z}_{t+j+k} - \hat{\mathbf{z}}^c_{t+j+k|t+j}$, we need an instrument for the estimation. Following the suggestion from Faust and Wright (2008), I use the forecast error of another forecasts as an instrument. More specifically, I use Survey of Professional Forecasters (SPF) forecasts or the Greenbook forecast as an instrument. Inference is based on conventional F-test and bootstrap.

Recently, Clark and McCracken (2015) proposed another kind of conditional forecast evaluation, assuming that the model generating the conditional forecasts is relatively accurate. More specifically, they evaluate the forecast assuming that the path of conditioning variables is equal to the ex-post realized values of these variables. Therefore, adding the forecasts of the conditional path would introduce some noise, rather than improving the forecast accuracy, and correcting the bias due to such noise by regression would improve the statistical property of the tests, as in Clark and West (2007). However, since the focus of this paper is to evaluate the CBO's forecasts compared to other conditional forecasts, I will not adopt this methodology.

3.3 Adjusted Forecasts Based on Conditional Forecast Evaluations

Using the method of conditional forecast evaluation, I propose the method to adjust the forecast based on alternative economic assumptions. [4] Essentially, I use the results of the conditional forecast evaluation to adjust the differences in the assumptions of conditioning variables. Since the estimated coefficients in the forecast evaluation reflect how much conditioning assumptions influence the CBO's budgetary projections, predicted values of the estimated regression could correct this systematic tendencies.

Specifically, the alternative forecast is defined based on the conditional forecast evaluation in

[4] Arai (2014) conducted similar exercise using the Federal Reserve's Greenbook forecast, and found significant improvement in its forecast accuracy.

Equation (4):

$$\tilde{y}^a_{t+h} \equiv \hat{\alpha} + \hat{\beta} y^c_{t+h|t} + \hat{\boldsymbol{\delta}}'_k(\hat{\mathbf{z}}^c_{t+h|t} - \mathbf{z}_{t+h}), \tag{5}$$

where $\hat{\alpha}, \hat{\beta}$, and $\hat{\boldsymbol{\delta}}'$ are the estimated coefficients from Equation (4).

The intuition behind this procedure is that the new forecast adjusts the systematic errors in the CBO' s budgetary projections. If the null hypothesis in Equation (4) is rejected, this means that the conditional forecasts were systematically too optimistic or pessimistic, or too sensitive or insensitive to their forecasts on the conditioning variables, leading to the inefficiencies in the forecast. In other words, the estimated coefficients capture the forecaster's systematic tendencies in its forecasting practice, and predicted value of forecast evaluation will correct such tendencies, which may give us an opportunity to improve the accuracy of the original forecasts. In the context of ts paper, this adjusted forecast can be interpreted as the CBO's forecasts based on alternative forecasts on the conditioning variables.

3.4 Comparison of Forecast Accuracy

The natural metric to compare the forecast accuracy of the original forecasts and the adjusted forecasts is the Relative Root Mean Square Prediction Error (RRMSPE). The RRMSPE is defined as the ratio of the RMSPE of the adjusted forecast for h-period ahead to the RMSPE of the original forecast for h-period ahead:

$$RRMSPE_h \equiv \sqrt{\frac{\sum_{t=1}^{T}(\tilde{y}^a_{t+h|t} - y_{t+h})^2}{\sum_{t=1}^{T}(\hat{y}^c_{t+h|t} - y_{t+h})^2}}, \tag{6}$$

where $\tilde{y}_{t+h|t}$ is the adjusted forecast for $t+h$ made at t, and $\hat{y}_{t+h|t}$ is the original forecast for $t+h$ made at t, and T is the number of predictions. Since the RMSPE of the original forecast is in the denominator, the RRMSPE smaller than unity indicates that the adjusted forecast improves the forecast accuracy. Under the null hypothesis that the original forecast is efficient, the RRMSPE has an expected value greater than unity.

If I set $\hat{\alpha}, \hat{\beta} = [0, 1]$ and $\hat{\boldsymbol{\delta}}'_k = \mathbf{0}$ in equation (5), the adjusted forecast becomes identical

to the original forecast. In other words, the adjusted forecast nests the original forecast. When forecasting models are nested, the distribution of the test statistic presented in Diebold and Mariano (1995) is not asymptotically normal. The literature on forecast evaluation shows that testing the null hypothesis of equal MSPE for nested models with normal critical values results in severe size distortion and poor power in practice.[5] Similarly, the RRMSPE for nested models has a nonstandard distribution and assessing its statistical significance raises a number of econometric issues. In order to avoid these issues, this paper uses two different methods of inference: bootstrap and the CW test.

3.4.1 Bootstrap

The bootstrap p-values are constructed by using the null hypothesis that the original forecast is efficient, and thus the conditional mean of the series. By resampling from the residuals of the VAR(1) model, I first make an artificial realized series. Then I treat the conditional mean of an artificial series as artificial forecasts. By generating the artificial forecasts of underlying economic variables in the analogous way, I conduct the conditional forecast evaluation in Equation (4) to obtain the adjusted forecasts in exactly the same way. By computing the RRMSPE of these artificial forecasts and repeating this procedure arbitrarily many times, I can form the distribution of the bootstrap RRMSPE and report p-values of the realized RRMSPE. The specific algorithm is described in detail in the Appendix.

3.4.2 The CW test

This paper uses the CW test as an alternative method of inference on nested forecasts. The CW test first adjusts the noise in the MSPE due to the estimation of additional parameters in an alternative forecasting model, which nests a parsimonious null forecasting model. Then it tests the hypothesis that the null forecasting model is correctly specified and the prediction errors of these two models are the same in the population, by using normal critical values.[6]

The specific procedure is succinctly summarized in Section 2 of Clark and West (2007). In the

[5] For details, see West (2006) and Faust and Wright (2013).

[6] On the other hand, Clark and McCracken (2009) and Clark and McCracken (2011) discuss inference to test the null hypothesis that two models have the equal RMSPE in *finite sample*.

context of this paper, I first compute the following statistic:

$$f_{t+h|t} \equiv (\hat{y}_{t+h|t} - y_{t+h})^2 - [(\tilde{y}_{t+h|t} - y_{t+h})^2 - (\hat{y}_{t+h|t} - \tilde{y}_{t+h|t})^2] \tag{7}$$

where $\hat{y}_{t+h|t}$ is the CBO's forecast for $t+h$ made at t, $\tilde{y}_{t+h|t}$ is the adjusted forecast for $t+h$ made at t using j revisions, and y_{t+h} is the realized value at $t+h$. Then I regress $f_{t+h|t}$ on a constant and derive the t-statistic. If this t-statistic is larger than 1.282 or 1.645, I reject the null hypothesis at the significance level of 10% or 5%, respectively. On the evidence from the Monte Carlo exercise in finite samples, Clark and West (2007) argue that this t-statistic is well approximated by a normal distribution, even though it has a nonstandard asymptotic distribution.

3.5 Estimating the Asymmetric Loss Function of the Forecaster

Though the CBO is a bipartisan organization and its mandate is to provide objective budgetary analysis to the US Congress, it could be suggested that it is subject to implicit pressure from the US Congress or administration in relation to budget projections. Therefore, I use the method developed by Elliott et al. (2005), to test the symmetry of the CBO's underlying loss function. If I detect any asymmetry in the CBO's loss function, it implies that the CBO prefers a budget surplus or a budget deficit relative to the other.

Let the forecast error for $t+h$ made at t as $e_{t+h|t} \equiv y_{t+h} - \hat{y}_{t+h|t}$, and assume that the forecaster has the following loss function:

$$L_h(p, \alpha) \equiv [\alpha + (1 - 2\alpha) \cdot \mathbb{1}(e_{t+h|t} < 0)]|e_{t+h|t}|^p, \tag{8}$$

where p is an integer (typically 1 or 2) and $\alpha \in (0, 1)$. This loss functions implies that the forecaster assigns different weights on their forecast errors to evaluate the loss: α if the forecast error is positive, and $1 - \alpha$ if it is negative. In this paper, α could be interpreted as the CBO's stance on budgetary projections. For example, when the parameter α is smaller than 0.5, it implies that the CBO prefers the positive forecast error to the negative forecast error, which suggests that the CBO tends to make the level of the budget deficit larger than the actual level.

For simplicity, suppose that the forecasters form a forecast as a linear combination of the variables in the information set at time t, V_t. In other words, we have $y_{t+h|t} = \theta_{t+h|t} V_t$, which implies that the forecasters observe V_t and adjust $\theta_{t+h|t}$ to form their forecasts minimizing the loss.[7] By solving the minimization problem of the forecaster with respect to $\theta_{t+h|t}$ for given $p = p_0$, the moment condition is derived as follows:

$$E[f_{t,h}(\alpha)] = 0, \tag{9}$$

where

$$f_{t,h}(\alpha) = V_t[\mathbb{1}(e_{t+h|t} < 0) - \alpha]|e_{t+h|t}|^{p_0 - 1}.$$

Therefore, the GMM estimate of α can be obtained by solving the minimum distance problem:

$$\alpha_{GMM} = \arg\min_{\alpha} f_T(\alpha)' \, W \, f_T(\alpha), \tag{10}$$

where $f_T(\alpha) = \sum_{t=1}^{T} f_t(\alpha)$ and W is an appropriate weighting matrix. In principle, any variables that are included in the forecaster's information set could be used as an instrument, but I will use the constant, the lagged forecast error and lagged forecast as instruments for a benchmark, as implemented in Elliott et al. (2005).

4 Results

The results of Mincer-Zarnowitz (MZ) and Patton-Timmermann (PT) tests for the nowcasts ($h = 1$) up to two-year ahead forecasts ($h = 3$) are reported in Table 2.[8] The results of the efficiency evaluation is mixed, and the efficiency for some variables are strongly rejected in both budgetary and economic projections.

For the budgetary projections, the efficiency of revenue forecasts are strongly rejected for both tests, while the efficiency of outlays and deficit is accepted. Since the deficit is just a difference

[7] As Elliott et al. (2005) discussed, it is straightforward to generalize the formulation of the forecasts, which carries the same intuition as the linear case.

[8] The PT test based on two forecast revisions are reported. The results are generally similar when the number of revisions is changed.

between revenue and outlays, these results suggest that the lower p-values in deficit projections are primarily driven by the inefficiency in the revenue projections. For the economic projections, the efficiency of nominal GDP, unemployment, ten-year and three-month treasury yields projections are strongly rejected, especially at the longer horizons.

Figures 1 and 2 show the plots of actual values and forecasts for budgetary and economic projections. As evident from the figure, the CBO's projections are heavily influenced by the recent observations prior to their projections and fail to predict the changes in trends. In addition, CBO's economic projections tend to assume a smooth transition to the long-run levels of variables, though these long-run levels are hardly revised and the transition dynamics are more unpredictable than they assume. Both tendencies create persistence in the forecast errors, which leads to the rejections in the efficiency.

Table 3 shows the results of MZ test regressing CBO's budgetary projections on the differences in the economic assumptions between CBO and SPF's forecasts. The efficiency is rejected in most series, which implies there is a systematic relationship between CBO's projections and its deviation from the SPF's forecasts about underlying economic conditions.

This table also shows the Diebold-Mariano statistics comparing the accuracy of the CBO's projections and the projections adjusted by SPF's economic forecasts. Since I subtract CBO's forecast errors from SPF-adjusted forecast errors, negative figures imply that CBO's projections are more accurate. The results are mixed in the sense that the evidence against forecast inefficiency helps to improve the accuracy of the CBO's projections, though it is not always the case. For deficit and revenue, the efficiency for one-year ahead projections are rejected, but the adjusted forecasts based on the evaluation are less accurate. On the other hand, the results of the efficiency evaluation help to improve the accuracy of outlay projections. This is because the cost of estimating parameters in the MZ test is too costly to improve the accuracy of original forecasts.

The results corresponding a part of Subsection 3.2 and Subsection 3.5 are incomplete.

5 Conclusion

This paper evaluates the efficiency of the CBO's budgetary and economic projections, and investigate the possible sources of inefficiency in its forecasts. The efficiency is rejected for both projections, especially for the forecasts for revenue and treasury yields. Using the method of the conditional forecast evaluation, I propose the method to adjust the difference in the underlying economic forecasts between CBO and SPF, and show that this adjustment can significantly improve the accuracy of the projections in some cases. These results suggests that the efficiency in the budgetary projections is due to the inefficiency in the economic projections.

References

Arai, Natsuki, "Using Forecast Evaluation to Improve the Accuracy of the Greenbook Forecast," *Journal International Forecasting*, January 2014, *30* (1), 12–19.

Auerbach, Alan J., "On the Performance and Use of Government Revenue Forecasts," *National Tax Journal*, December 1999, *52* (n. 4), 765–82.

Booth, Mark, Logan Timmerhoff, and David Weiner, "CBO's Economic Forecasting Record: Forecast Errors for CBO's and the Administration's Two-Year Revenue Projections," Congressional Budget Office 2015.

Clark, Todd E. and Kenneth D. West, "Approximately Normal Tests for Equal Predictive Accuracy in Nested Models," *Journal of Econometrics*, May 2007, *138* (1), 291–311.

_ and Michael W. McCracken, "Nested Forecast Model Comparisons: A New Approach to Testing Equal Accuracy," 2009. Working Paper.

_ and _ , "Advances in Forecast Evaluation," 2011. Working Paper.

_ and _ , "Evaluating Conditional Forecasts from Vector Autoregressions," Federal Reserve Bank of St. Louis 2014-025B 2015.

Coibion, Olivier and Yuriy Gorodnichenko, "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts," NBER Working Papers 16537 November 2010.

_ and _ , "What Can Survey Forecasts Tell Us about Information Rigidities?," *Journal of Political Economy*, 2012, *120* (1), 116 – 159.

Croushore, Dean and Simon van Norden, "Fiscal Forecasts at the FOMC," *Review of Economics and Statistics*, 2016. forthcoming.

Diebold, Francis X. and Roberto S. Mariano, "Comparing Predictive Accuracy," *Journal of Business and Economic Statistics*, July 1995, *13* (3), 253–63.

Ehrbeck, Tilman and Robert Waldmann, "Why are Professional Forecasters Biased? Agency Versus Behavioral Explanations," *The Quarterly Journal of Economics*, 1996, *111* (1), pp. 21–40.

Elliott, Graham, Allan Timmermann, and Ivana Komunjer, "Estimation and testing of forecast rationality under flexible loss," *The Review of Economic Studies*, 2005, *72* (4), 1107–1125.

Elmendorf, Douglas W., ""Dynamic Scoring": Why and How to Include Macroeconomic Effects in Budget Estimates for Legislative Proposals," *Brookings Papers on Economic Activity*, Fall 2015.

Faust, Jon and Jonathan H. Wright, "Efficient forecast tests for conditional policy forecasts," *Journal of Econometrics*, October 2008, *146* (2), 293–303.

_ and _ , "Comparing Greenbook and Reduced Form Forecasts using a Large Realtime Dataset," *Journal of Business and Economic Statistics*, October 2009, *27* (4), 468–479.

_ and _ , "Forecasting Inflation," in G. Elliott, C. Granger, and A. Timmermann, eds., *Handbook of Economic Forecasting*, Vol. 2, Elsevier, 2013, chapter 3, pp. 2–56.

Kliesen, Kevin L. and Daniel L. Thornton, "The Expected Federal Budget Surplus: How Much Confidence Should the Public and Policymakers Place in the Projections?," *Federal Reserve Bank of St. Louis Review*, 2001.

_ and _ , "How Good Are the Government's Deficit and Debt Projections and Should We Care?," *Federal Reserve Bank of St. Louis Review*, 2012.

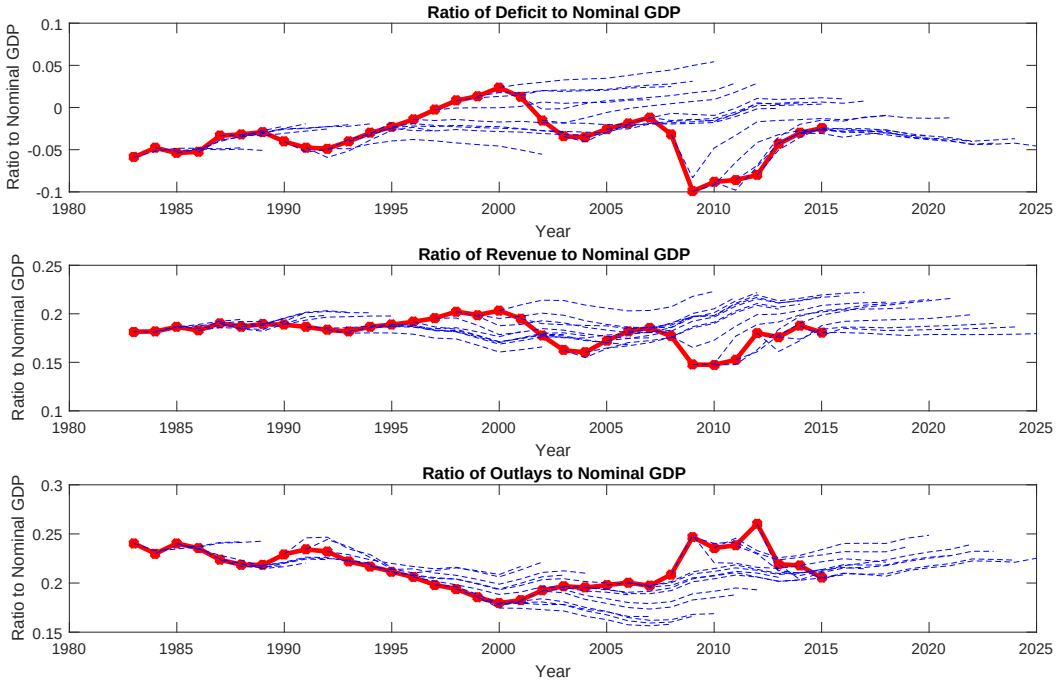
Laubach, Thomas, "New Evidence on the Interest Rate Effects of Budget Deficits and Debt," *Journal of the European Economic Association*, June 2009, *7* (4).

Patton, Andrew J. and Allan Timmermann, "Forecast Rationality Tests Based on Multi-Horizon Bounds," *Journal of Business and Economic Statistics*, 2012, *30* (1).

Rossi, Barbara and Tatevik Sekhposyan, "Forecast Rationality Tests in the Presence of Instabilities, with Applications to Federal Reserve and Survey Forecasts," *Journal of Applied Econometrics*, 2015.

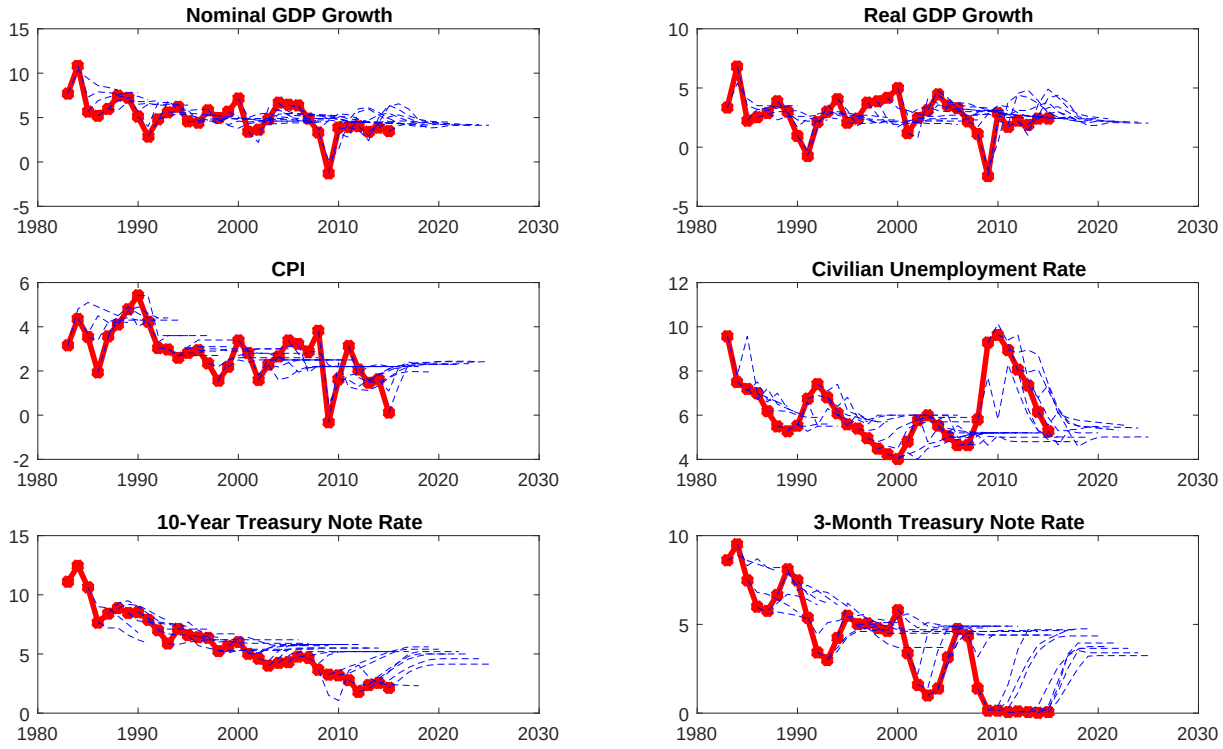
Tulip, Peter, "Has the Economy Become More Predictable? Changes in Greenbook Forecast Accuracy," *Journal of Money, Credit and Banking*, 2009, *41* (6), 1217–1231.

West, Kenneth D., "Forecast Evaluation," in G. Elliott, C. Granger, and A. Timmermann, eds., *G. Elliott, C. Granger, and A. Timmermann, eds.*, Vol. 1 of *Handbook of Economic Forecasting*, Elsevier, 2006, chapter 3, pp. 99–134.



Note: The red solid line shows the actuals and the blue dotted lines show the forecasts.

Figure 1: CBO's Budget Projections



Note: Same as Figure 1.

Figure 2: CBO's Economic Projections

Series	Average	Standard Deviation
Panel A: Budgetary Projections		
Deficit	-3.39	2.83
Revenue	18.14	1.37
Outlays	21.53	2.00
Panel B: Economic Projections		
Nominal GDP	5.03	2.01
Real GDP	2.63	1.61
CPI	2.72	1.22
Unemployment Rate	6.21	1.54
10-Year Treasury Note Rate	5.75	2.73
3-Month Treasury Bill Rate	3.78	2.85

a. This table shows the average and standard deviation of the series from 1984 to 2016. Budgetary projections are normalized by nominal GDP of the corresponding year.

Table 1: Descriptive Statistics

Series	MZ Test						PT Test				
	h=1	h=2	h=3	h=4	h=5	h=6	h=1	h=2	h=3	h=4	h=5
Panel A: Budgetary Projections											
Deficit	0.32	1.17	3.08^{**}	$6.17^{**}_{\dagger}$	$9.23^{**}_{\ddagger}$	$10.09^{**}_{\ddagger}$	1.85	1.87	3.29^{**}	$4.84^{**}_{\ddagger}$	$7.34^{**}_{\ddagger}$
Revenue	1.41	4.09^{**}	$15.25^{**}_{\ddagger}$	$28.60^{**}_{\ddagger}$	$21.45^{**}_{\ddagger}$	$16.41^{**}_{\ddagger}$	$8.36^{**}_{\ddagger}$	$5.70^{**}_{\ddagger}$	$11.64^{**}_{\ddagger}$	$18.75^{**}_{\ddagger}$	$12.99^{**}_{\ddagger}$
Outlays	0.73	1.34	1.92	3.06^{**}	4.40^{**}	$6.07^{**}_{\ddagger}$	0.97	1.00	$4.04^{**}_{\dagger}$	$4.74^{**}_{\ddagger}$	3.59^{**}
Panel B: Economic Projections											
Nominal GDP	0.06	$5.01^{**}_{\ddagger}$	$4.34^{**}_{\ddagger}$	$4.73^{**}_{\ddagger}$	$3.95^{**}_{\ddagger}$	$3.76^{**}_{\ddagger}$	1.06	2.16^{*}	1.83	$2.34^{*}_{\ddagger}$	$3.05^{**}_{\ddagger}$
Real GDP	0.23	3.46^{**}	$3.91^{**}_{\ddagger}$	$5.99^{**}_{\ddagger}$	$4.72^{**}_{\ddagger}$	$4.48^{**}_{\ddagger}$	0.85	1.67	$2.30^{*}_{\ddagger}$	$3.48^{**}_{\ddagger}$	$4.02^{**}_{\ddagger}$
CPI	0.25	2.15	1.86	1.13	1.44	2.11	0.65	0.92	0.88	0.56	1.19
Unemployment Rate	1.76	3.86^{**}	2.14	$4.13^{**}_{\dagger}$	$5.99^{**}_{\ddagger}$	$3.99^{**}_{\dagger}$	4.84^{**}	3.44^{**}	2.98^{**}	$4.73^{**}_{\ddagger}$	$3.69^{**}_{\ddagger}$
10-Year Treasury Note	1.21	4.79^{**}	$9.54^{**}_{\dagger}$	$11.47^{**}_{\ddagger}$	$11.48^{**}_{\dagger}$	$13.42^{**}_{\dagger}$	3.05^{*}	$7.04^{**}_{\ddagger}$	$8.72^{**}_{\ddagger}$	$10.60^{**}_{\ddagger}$	$10.98^{**}_{\ddagger}$
3-Month Treasury Bill	1.18	3.90^{*}	5.26^{**}	7.01^{**}	9.80^{**}	$15.96^{**}_{\ddagger}$	$3.51^{**}_{\dagger}$	2.41^{*}	3.28^{**}	4.83^{**}	$9.13^{**}_{\ddagger}$

a. This table shows the F-statistics of the forecast efficiency evaluation, based on Mincer-Zarnowitz (MZ) and Patton-Timmermann (PT) regressions. The PT regression includes two forecast revisions.

b. The forecast horizons are from nowcast ($h = 1$) to the forecasts five years ahead ($h = 6$).

c. Superscripts, $*$ and $**$, and subscripts, † and ‡, denote the significance at the level of 10% and 5% based on the asymptotic critical values and bootstrap with 10,000 replications, respectively.

Table 2: Forecast Efficiency Evaluations for CBO's Projections

Series	MZ Test		DM Statistic	
	h=1	h=2	h=1	h=2
Deficit	1.31	**16.67**	-1.30	**-2.76**
Revenue	0.23	**3.02**	**14.61**	**-3.84**
Outlays	**2.61**	**16.36**	**2.73**	**2.27**

a. The first two columns show the F-statistics of Mincer-Zarnowitz (MZ) regression of CBO's budgetary forecasts on the differences in economic forecasts between CBO and SPF's forecasts. The second two columns show the Diebold-Mariano (DM) statistic to compare the accuracy of the original CBO's forecasts and the estimate of budgetary projections based on SPF's forecasts.

b. The numbers in bold letters denote the significance at the level of 5%.

c. The forecast horizons are from nowcast ($h = 1$) to the forecasts one year ahead ($h = 2$).

Table 3: Comparison of CBO's Forecast and SPF's Forecasts

9/17/2016

Conference Report to National Chengchi University

1. Name and Position

- Name: Natsuki Arai (荒井　夏來)
- Position: Assistant Professor
- Department: International Business Department
- College: College of Commerce

2. Details of the Presentations

- Institution: Chinese University of Hong Kong (CUHK), Department of Economics
- Dates: September 12, 2016
- Venue: CUHK, Hong Kong

3. Paper presented at the conference

(Title)

The Effects of Monetary Policy Announcements at the Zero Lower Bound

(Abstract)

This paper investigates the effects of monetary policy announcements at the zero lower bound using Japanese data from 1998 to 2013. I find that the effect of expansionary monetary policy shocks is directly passed on to corporate bond yields, notably for high-grade corporate bond yields. However, the magnitude of estimated pass-through to stock prices and the exchange rate is substantially smaller than in the U.S., and not statistically significant in most cases. Such differences may reflect a higher degree of market segmentation or smaller scope to achieve further accommodation in Japan.

4. Comments and questions received during the presentations

- Interpretation of estimated coefficients (pass-through from long-term interest rate to asset prices) is not entirely clear due to identification problem. Is it possible to use intra-daily data to confirm your results?

  - Unfortunately intraday data is not available.

- The idea how identification through heteroscedasticity can identify the coefficient is not clear. Can you elaborate this point more?

  - Essentially, I use the difference of the variances as an instrument for the identification. Since the variance of monetary policy shock is the only thing that is different between announcement and non-announcement days, we can regard that

such difference is only related to monetary policy shock. Since it is only related to monetary policy shock, we can use it as an instrument.

- How can you pick the important announcement days? Does identification depend on the selection of the announcements?

  - Yes, identification depends on the selection of announcement days. In fact, if you select too many trivial announcement days, it will dampen identification. Therefore, I select important announcement days, and pick the dates when BoJ officially changed its monetary policy. (They are mix of forward guidance and asset purchases) I have 41 announcement days from 1998 to 2013.

- Can you look at the changes on the real variables, using the technique such as VAR, instead of indirectly measuring the financial variables?

  - It is a very good question, and our focus is of course on the effects of monetary policy on real variables. Unfortunately, under this framework, the availability of high-frequency data is essential, and I cannot directly look at real variables since they can only be observed monthly or quarterly.

2017/07/18

Conference Report to National Chengchi University

1. Name and Position

- Name: Natsuki Arai (荒井　夏來)
- Position: Assistant Professor
- Department: International Business Department
- College: College of Commerce

2. Details of the Conference

- Name: International Association for Applied Econometrics (IAAE 2017)
- Dates: June 26-30, 2017
- Venue: Hotel Emisia (Sapporo, Japan)

3. The paper presented at the conference

- Title: "Investigating the Inefficiency of CBO's Budgetary Projections"
- Abstract: This paper evaluates the efficiency of the Congressional Budget Office's (CBO) budgetary and economic projections, and investigates the causes of the inefficiency in its projections. While the efficiency is accepted for the CBO's projections for outlays, it is strongly rejected for its revenue and economic projections. The inefficiency in the budgetary projections is partially due to the inefficiency in the underlying economic projections. By adjusting the CBO's budgetary projections using the Survey of Professional Forecasters' (SPF) economic forecast, I find that the accuracy CBO's budgetary projections is significantly improved in some cases.

4. Comments and questions received during the presentation

- Is the accuracy of CBO and SPF comparable?
- Are there any difference between nowcasts and forecasts?
- Why do they make inefficient forecasts?

5. Interesting Presentations at the Conference

- "The Macroeconomic Effects of Monetary Policy in a Small-Open Economy: Narrative Evidence from Canada" by Julien Champagne and Rodrigo Sekkel (Bank of Canada)

  (Abstract)

  We use narrative evidence along with a novel database of real-time data and forecasts from the Bank of Canada's staff economic projections from 1974 to 2015 to construct a new measure of monetary policy innovations and estimate the effects of monetary policy in Canada. We find that a one percentage point increase in our new shock series leads to a 0.7 per cent decrease in real GDP and a 0.4 per cent fall in the price level. We show that it is

crucial for these results to take into account the structural break in the conduct of monetary policy caused by the introduction of inflation targeting in 1992. Moreover, we provide evidence that spillovers from U.S. monetary policy shocks lead to a very similar drop in Canadian GDP and a rise in the short run of the price level.

- "Expected Inflation Regimes in Japan" by Tatsuyoshi Okimoto (Australian National University)

  (abstract)

  This paper examines the dynamics of expected inflation regimes in Japan over the last three decades based on the smooth transition Phillips curve model. We find that there is a strong connection between the expected inflation and monetary policy regimes. The results also suggest that the introduction of the inflation targeting policy, and quantitative and qualitative easing in the beginning of 2013 successfully escaped from the deflationary regime, but was not enough to achieve the 2% inflation target. Finally, our results indicate the significance of exchange rates in explaining the recent fluctuations of inflation, and the importance of oil and stock prices in maintaining the positive expected inflation regime.

- "The Effects of Government Spending on Real Exchange Rates: Evidence from Military Spending Panel" by Wataru Miyamoto (Bank of Canada), Thuy Lan Nguyen (Santa Clara University), and Viacheslav Sheremirov (Boston Fed)

  (abstract)

  Using panel data on military spending for 125 countries, we document new facts about the effects of changes in government purchases on the real exchange rate, consumption, and current accounts in both advanced and developing countries. While an increase in government purchases causes real exchange rates to appreciate and increases consumption significantly in developing countries, it causes real exchange rates to depreciate and decreases consumption in advanced countries. The current account deteriorates in both groups of countries. These findings are not consistent with standard international business-cycle models. We propose potential sources of the differences between advanced and developing countries in the responses to spending shocks

105年度專題研究計畫成果彙整表

計畫主持人：荒井夏來	**計畫編號：**105-2410-H-004-016-
計畫名稱：有限樣本下預測合理性檢定的性質評估	

成果項目					量化	單位	質化 （說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文			0	篇	
		研討會論文			0		
		專書			0	本	
		專書論文			0	章	
		技術報告			0	篇	
		其他			0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件	
				已獲得	0		
			新型/設計專利		0		
		商標權			0		
		營業秘密			0		
		積體電路電路布局權			0		
		著作權			0		
		品種權			0		
		其他			0		
	技術移轉	件數			0	件	
		收入			0	千元	
國外	學術性論文	期刊論文			1	篇	"The Effects of Monetary Policy Announcements at the Zero Lower Bound," International Journal of Central Banking, 13 (2) (2017) pp. 159-196
		研討會論文			0		
		專書			0	本	
		專書論文			0	章	
		技術報告			0	篇	
		其他			0	篇	
	智慧財產權及成果	專利權	發明專利	申請中	0	件	
				已獲得	0		
			新型/設計專利		0		
		商標權			0		
		營業秘密			0		
		積體電路電路布局權			0		

		著作權	0		
		品種權	0		
		其他	0		
	技術移轉	件數	0	件	
		收入	0	千元	
參與計畫人力	本國籍	大專生	1	人次	學習型兼任助理
		碩士生	1		學習型兼任助理
		博士生	0		
		博士後研究員	0		
		專任助理	1		專任助理
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士後研究員	0		
		專任助理	0		
其他成果 （無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）					

科技部補助專題研究計畫成果自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現（簡要敘述成果是否具有政策應用參考價值及具影響公共利益之重大發現）或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估
   ■達成目標
   □未達成目標（請說明，以100字為限）
   　□實驗失敗
   　□因故實驗中斷
   　□其他原因
   說明：

2. 研究成果在學術期刊發表或申請專利等情形（請於其他欄註明專利及技轉之證號、合約、申請及洽談等詳細資訊）
   論文：■已發表　□未發表之文稿　□撰寫中　□無
   專利：□已獲得　□申請中　■無
   技轉：□已技轉　□洽談中　■無
   其他：（以200字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性，以500字為限）
   Improve the accuracy of the forecasts made by policy institutions by correcting systematic errors.

4. 主要發現
   本研究具有政策應用參考價值：□否　■是，建議提供機關財政部,經濟部,中央銀行,
   （勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
   本研究具影響公共利益之重大發現：■否　□是
   說明：（以150字為限）