

## Audit Techniques by using the Kalman Filter

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### Abstract

*More importance is allocated to financial budgetary of a country, since the recent economic crisis, which certainly depend on the financial performance of its institutions, not only from public sector, but also from private one. On the other hand, the fundamental of financial budgetary can be influence by the auditors' opinions. Their activity is mainly based on expressing an opinion about the evolution of an economic entity. Mathematical approach is needed in order to reveal detailed perspective of them as the classical methods can point out statistical uncertainly. This article tries to emphasize the importance of performance audit techniques by using the Kalman filter when the budgetary balancing process of a public institution is analyzed, taking the INTOSAI standards into consideration.*

**Keywords:** *Kalman filter, Management performance audit, public institutions, budgetary balance, INTOSAI audit standards*

**JEL Classification:** M40, M41, M42, M10

### Introduction

The auditor opinion about financial distress can influence the attitude of several stakeholders, and moreover can affect the budgetary process at a macroeconomic level. The INTOSAI audit standards focus on the fact that auditors should present and develop adequate information, control and proper evaluation within the government process and moreover performance audit should be the main issue of them. Actually, their opinion should reveal not only the past situation, but also the present and the perspective of it. In order to apply the ISSAI 400 standards to public budgetary, the Kalman test can be used as new areas of developing the auditors' activity is looked for.

### Literature review

In the main literature there are two studies that are considered the Kalman filter's implementation. As a fact, Kalman, R.E (1960) and Kalman, R.E and Bucy, R,S (1961) developed a mathematical model, generally applied in engineering. The Kalman filter is actually a system of mathematical equations which reveals an efficient way in estimating a

particular process. The importance of this filter is based on the fact that it can likelihood estimate the form of the present, past and future process even though its nature is unknown. Wegman, E.J. (1982), Meinhold, R.J., Singpurwalla, D, N (1983) tried to explain the model as it could be applied using the Bayesian linear one. The idea was to apply it in other areas where past, present, and future development is all essential. As a fact, the audit process is a fundamental area where this element can be used.

Welch, G and Bishop, G (2006) revealed that Kalman test's use offers better results than other techniques as its measurements considerably smoother the noisy effects., while Taylor, G. and Brookes R. (2007) demonstrated that Kalman filter displaying higher variability than the moving average, but they illustrated that the Kalman estimates would improve in time.

In Romanian literature it has been recently presented by Dobre, F, Loghin, R.D, Gornea, M. A (2012) who point out the advantages and the mathematical perspective is emphasized.

The connection between the need of applying the Kalman test and the audit profession can be revealed by analyzing the international audit standards. At a global level, the performance audit is considered a new tool; more open to judgment and interpretation that contains more discussion and reasonable arguments. Moreover, the INTOSAI standards consider that the audit opinion should be in a strong relationship with the financial statements, but on the other hand it could be proper justify by past, present and future evolution. The importance that is conferred to audit is not recent as Bagnall R., Derow P. (2004) point out. They demonstrate that the audit opinions influence the flexibility of the budgetary process even when Prometheus lived.

As the public sector is still essential for present economies, it is necessary that a proper balancing budgetary process should be realized. When ISSAI 100 is also looked at, the full government auditing refers to performance audit and regularity, performance that could be obtained by efficiently evaluating the situation of the process discussed.

### **Research methodology**

As there is a permanent concern about the harmonization of accounting and auditing principles, Dumitru and Ristea (2005) realise that the way through which the objectives, the rules, the terms and the situation through which these could be applied changes as new techniques and methods are used.

Taking these elements into consideration, the present research is focusing in explaining the role that audit, accounting and financial governmental statistic has in a public institution where the Kalman filter has been applied.

In order to realize the analysis, a combination of classical methods with new ones was realized. As a fact, both experimental and historical data have been used in order to reveal the importance of budgetary equilibrium.

The wages for one year, 2011, were analyzed for a public institution for extracting the importance of Kalman filter upon the audit principles. The budgetary process was completed by using the revenues obtained from taxes and carry out services. The revenues are presented in net values, as the budgetary revenues can influence other financial indicators.

Moreover, the period analyzed is from one financial reporting period, as a fact, the difference between one value and another is for one month.

Values for operating income structure and the degree of implementation of budget payments of current expenses have been calculated, and moreover the operating expenses structure and the degree of current budgetary revenue collection were also estimated. After that, a constant has been revealed as expenses elements were multiply between them.

The observations were calculated and adjusted considering the budgetary revenues and expenses of a Kalman Filter. The missing values were estimated by using the average mobile techniques. As a fact, missing values for the accounting type information took the value of previous existing one, while, the discount measurement new values took into consideration also the residual information. The data updated, was firstly taking the form of process into consideration, and secondly, by using the discounted measurements.

Table 1.

**Calculating the Kalman filter**

The form of process	Discount measurement
$\widehat{y}_t = \widehat{y}_{t-1}$ , profit estimation	$\widehat{y}_t = \widehat{y}_t + Y_t * (z_t - \widehat{y}_t)$ ,  $Y_t$ - profit, $z_t$ -value obtained
$\bar{P}_t = \bar{P}_{t-1}$ , The form of process	$p_t = (1 - Y_t) * \bar{P}_t$

(Source: Dobre, F., Loghin, R.D., Gornea, A.M., 2012)

The data obtained, debt burden was presented. A classical regression model between the debt burden as the dependent variable and the ratio of paying the wages was realized. The regression elements provided by econometrical soft were analyzed in order to validate the model proposed.

**Finding and discussion**

The model presented was realized by estimating and calculating discounting values for expenses with wages for each month. The table number 2 explained summary statistic for analyzed values.

Table 2.

**Summary statistics for Kalman filter variables**

Element	Minimum	Maximum
$z_t$	0.57 - December	0.84- February
$y_{t-1}$	0.68 - June	0.78- March
$y_t$	0.68 December	0.78- February
$P_t$	0.01 December	0.08 - January

(Source: Dobre, F., Loghin, R.D., Gornea, A.M., 2012)

As it can be seen, the importance values that affect the profitability of the company are situated when the audit terms for evaluating the company evolution is meant to be done. Taking the INTOSAI standards into consideration, it was observed that this

data could have influence the attitude of auditors as it could be used as audit evidence. It is considered that in an audit process, development of adequate information and reliable evaluation will facilitate the accounting process and moreover it can influence the auditor opinion as a real evaluation of the company budgetary process can determine its financial performance.

Moreover, a filtering method helps the evaluator to reveal the real values of the analyzed indicators, which could be incorrect illustrated in the financial statements of the company.

As data are analyzed, the conclusion is that the budgetary pays are superior to the real expenses with salaries and moreover, the revenues and the debt burden obtained maximum values in the middle year of the period (May –June) when the intermediary audit process is realized.

When the second elements are look at, the regression has the following characteristics.

Table 3.

**Summary statistics for classical regression model**

<b>Element</b>	<b>Value</b>	<b>Interpretation</b>
Ratio of multiple correlation	0.2286	There is a small correlation between the debt burden and the values of wages (the proper ratio)
R squared	0.0523	Only 5.22% from the debt value it can be explained by the wages of the company
Ajusted R squared	-0.0425	The unreliable evaluation of the wages can influence the profitability of the company
Standard error deviation	0.0019	The error has a small deviation, which mean that the estimation of real wages is done correctly
DW	2.012	No autocorrelation can be detected
F	0.5515	The p value of rejecting the null hypothesis is 0.15, but because of the small number of observation, the model is considered proper

(Source: Dobre, F., Loghin, R.D., Gornea, A.M., 2012)

As it can be seen, the connection between the debt burden and the wages is reliable, but on the other hand other elements can influence dependent variable. As the connection is around 5%, the auditors should pay higher attention when the data are analyzed, as it can be seen that applying the Kalman test only upon wages is not enough for a proper predictable audit opinion.

Moreover, it has to be considered that using the Kalman techniques, the audit can conclude opinions about the past companies' management and can indicate several ways through which the inadequate elements are decreasing the profitability of the company, and moreover the elements that affect its credibility.

As a fact, the Kalman filter would improve the credibility of auditors as they have lost it due to the macroeconomic circumstances from the last financial years.

## Conclusions

The Kalman test was used in the present research study as a way of improving the financial performance of a public company and moreover in order to emphasize the importance of reliable information for audit opinion.

As a fact, the auditor opinion could be more credible as mathematical approach can be realized by the usage of this technique. Due to this, the audit opinion could be more reliable as proper information is evaluated by the auditor team. That means that professional attitude is revealed and moreover, the subjectivism of the audit activity is partially eliminated.

The results obtained in the present research prove that about 1% of the average of debt burden was due to the expenses and revenues from the operational activity of the institution. In order not to influence badly the debt burden, same values should be kept for the following years (2012). Moreover, a correlation between debt burden and the expenses of the company when wages are analyzed was obtained.

These elements could definitely influence the auditor activity in order to found that the auditor profession is still sustainable. The Kalman filter would improve the auditor credibility as mathematical justification of their verdict could be implemented.

The problems of the study are focused on the fact that the model could be applied using forecasting values for budgetary elements and generally companies do not present detailed analyze of their expenses and revenues.

Orțan T., Otgon C. (2011) obtained reliable data information by using the Matlab program and by concluding that calculating partial elements that can determine the debt burden can influence the attitude of the company.

Further research would be realized by using the Kalman Filter to other categories of revenues and expenses, which in the end can influence the decisions, took at macroeconomic level, when the economic growth is calculated.

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