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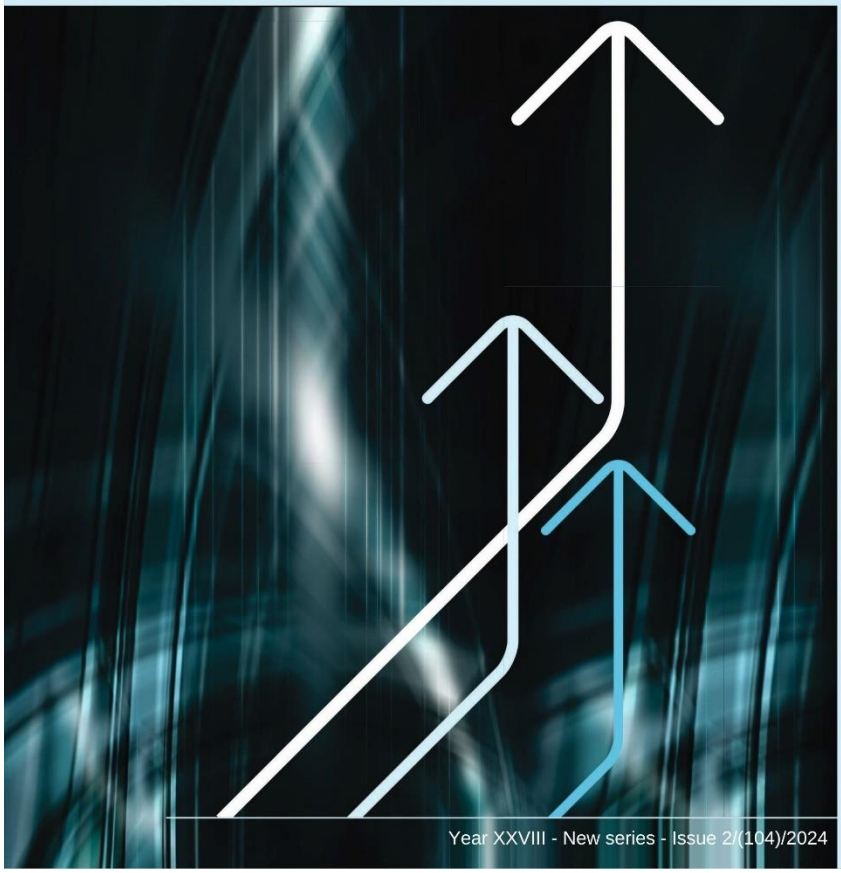

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“VICTOR SLĂVESCU” CENTRE FOR FINANCIAL
AND MONETARY RESEARCH

FINANCIAL STUDIES

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Contents

A NOTE ON THE EARLY WARNING SYSTEM OF CHANGE POINTS: COMBINATION OF REGIME SWITCHING AND THRESHOLD MODELS

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Abstract

Abrupt changes are a prevalent feature of financial data sets, such as prices of financial assets, returns of stocks, exchange rates, etc. An early warning system (EWS) can detect existing changes and predict possible future changes before they occur. Two important statistical models for change point detection and prediction are the regime-switching and threshold models. In the first model, the data set involves multiple structures that characterize the time series behaviours in different regimes. In a threshold model, change is detected as soon as a split variable passes a threshold. In this paper, by combining the two mentioned models, namely regime switching and threshold, an EWS for change point detection is designed. The underlying process for change detection obeys an AR(1) process. States are latent variables specifying whether a special time point is changed or not. They are realizations of the Markov chain. The predictive transition probabilities are determined by a threshold model based on adaptive recursive relations. This combination forms the mentioned EWS. Finally, two applications are given about change detection in stock returns and specifying business cycles.

Keywords: AR(1) process, abrupt changes, business cycles, Markov chain, regime-switching probabilities, split thresholds

JEL Classification: C53; C58; C63; G13; G17

1. Introduction

Many economic time series occasionally exhibit dramatic breaks in their behaviour, associated with events such as financial

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crises or abrupt changes in government policy. The time series of commodity prices, exchange rates, and macroeconomic indicators such as inflation and interest rates are always suspected that at some unknown points, their means or volatilities are changed rapidly or gradually. There are many statistical and econometric methods for modelling point-of-change problems. These methods include least squares, Bayesian, likelihood ratio, information criteria, non-parametric and parametric methods and quality control charts. The change point analysis in the univariate and multivariate time series, almost all types of econometric regression models, changes in the statistical distribution of variables such as mean, variance and covariance structure and even random graph models have been studied. Two main approaches for studying the change points are regime switching models and threshold analysis. For a comprehensive review of change point analysis, see Pons (2018) and references therein.

The Markov switching model of Hamilton (1994), also known as the regime-switching model, is one of the most popular nonlinear time series models considering the regime shift in economic models. Krolzig (1997) stated that a feature of the Markov switching model is that the switching equation is controlled by a latent state variable which obeys a first-order Markov chain. This model is perfect for describing dependent data showing dynamic patterns during different periods. Indeed, economists are interested in the behaviours of many economic variables, which are quite different during economic downturns.

The regime-switching model contains two components. First, x_t is observation at time t which satisfies in a time series model with an unknown parameter θ_{s_t} which depends on Markov chain s_t (a latent variable) with state space $\{0,1\}$ and transition probabilities

$$p_{ij} = P(s_{t+1} = j | s_t = i), i, j = 0,1.$$

Assuming, $[s_t = 1]$ stands for a bad event in the economy, such as a financial crisis or bankruptcy of important companies, then the posterior predictive probability

$$P(s_{t+h} = 1 | x_t, x_{t-1}, \dots, x_1),$$

plays the role of the early warning system.

Quantities

$$P(s_t = 1 | x_t, x_{t-1}, \dots, x_1),\ P(s_t = 1 | x_T, x_{T-1}, \dots, x_1),$$

for some $T > t \geq 1$ are filtered and smoothed probabilities. For example, the event $[s_t = 1]$ says about the possible existence of an

economic crisis at t −th year whereas x_t can be the level of inflation in a country, for example, represented by an RS-auto-regressive model. The x_t itself may be binary variable 0,1 related to hyperinflation or regular economic situations governed by a logit or probit regression. Hamilton filter (see Hamilton, 1994) proposes a recursive relation to make Bayesian inference about s_t given information $x_t, x_{t-1}, \dots, x_1$.

Similarly, some recursive relations are derived for smoothed and forecasting probabilities (see Kim, 1994). Basically, these recursive relations use the expectation maximisation (EM) algorithm to make inferences about s_t. These situations are studied by many authors in the early warning system literature, see Kole (2019). However, the novelty of this paper is that s_t is characterised by a threshold time series analysis.

The rest of the paper is organised as follows. In Section 2, literature reviews about the regime-switching model, threshold analysis techniques, as well as change point analysis are given. EWS models are also reviewed. Section 3 contains the methodologies applied in the current paper. Required notations and propositions are proposed. There first, the threshold states are defined. Then, the filtered, predictive and transition probabilities are given by using regime-switching estimates of the AR(1) coefficient as a state equation. Section 4 contains the data and data analysis in two data sets, that is, the change point detection in stock returns and the diagnosis of the business cycles. Section 4 concludes.

2. Literature review

The literature review covers three topics, including regime-switching models, early warning systems and threshold analysis.

The regime-switching models capture changes in the economic system that generates the data. Asako and Liu (2013) studied the potential ability of the regime-switching model to study the dynamic of inflation. They concluded that a regime-switching model with an independent shift in the mean and variance is best fitted to data and has minimum variance forecast with respect to other models. Pons (2018) specified that the Markov switching model also differs from the models of structural changes. The structural change models allow for frequent changes at random time points, but the latter admits only occasional and exogenous changes. Kapetanios (2003) stated that papers in the literature use time series techniques with two regimes

and apply their models to their different economic time series, such as exchange rates. Krolzig (1997) showed that using the Markovian property, which regulates the current position of the state variable, a time series mechanism may prevail for a random period of time. The mentioned structure will be replaced by another structure when a switch takes place. Hamilton (1994) employed the Markov switching model to capture macroeconomic models of financial crises. They concluded that the Markov shifting model is found to successfully capture the timing of regime shifts in the financial/credit shocks. Recently, the regime-switching model has also been a popular choice in the study of business cycles. A highly successful attempt is incorporating a switching mechanism into the conditional variance of ARCH and GARCH models.

The regime-switching model, together with threshold analysis, is used to construct the early warning systems, which are referred to as early warning systems (EWS). There are many methods for making early warning systems. Sanchez-Espigares and Lopez-Moreno (2021) stated that the two well-known approaches for making the EWSs are signalling and logit and probit regressions methods. Gao *et al*. (2015) studied how EWS helps system managers to make correct and suitable decisions before faults occur.

Nonlinear time series such as threshold models have been studied by many papers in the literature for a comprehensive review of threshold analysis. An example is Asako and Liu (2013), who studied the effect of speculative bubbles on prices in the stock market of the United States, Japan and China using the threshold analysis at which the probability of breaking the bubbles related to the splitting variable. z_t and threshold $\mathfrak{k}$. Throughout the TA model, the time series x_t has a structural break as soon as the splitting variable z_t goes beyond (or comes below) the threshold $\mathfrak{k}$, see do-Dios Tena and Tremayne (2009), Kapetanios (2003) and references therein.

In the current paper, it is assumed that the least square estimate of the coefficient of regime shift first-order autoregressive AR(1) plays the role of splitting variable z_t which, as soon as it passes the specified threshold, then a change point occurs in the parameters of the time series x_t which is equivalent to the state $[s_t = 1]$. Otherwise, event $[s_t = 0]$ happens.

3. Methodologies

Here, using the threshold analysis technique, states of regime-switching models are defined. To this end, let x_t be the mean corrected first-order autoregressive AR(1) process x_t defined by

$$x_t = \beta_t x_{t-1} + \varepsilon_t; t \geq 1,$$

where x_0 is the initial value of the process, $|\beta_t| < 1$ for all t's,

$$\varepsilon_t = \sigma_t z_t,$$

at which z_t is white noise $WN(0,1)$ time series.

Indeed,

$$x_t = \beta_{s_t} x_{t-1} + \sigma_{s_t} z_t$$

Here, $\beta_t = \beta_{s_t}$ and $\sigma_t = \sigma_{s_t}$ represent the regime-switching process where s_t is a 0-1 valued Markov chain with transition probabilities

$$p_{ij} = P(s_t = j | s_{t-1} = i);\ i, j = 0,1.$$

Indeed, the regime-switched processes are

$$A_{s_t} = A_0 1(s_t = 0) + A_1 1(s_t = 1),$$

for $A = \beta, \sigma$ at which $1(s_t = i)$ is zero if $s_t = i$ and zero otherwise, for $i = 0,1$.

As previously mentioned, using the threshold analysis technique, the least square estimate of the coefficient β determines the state of the world.

Indeed, for example, if $\hat{\beta}_t > threshold$ (for some fixed but unknown constant $threshold$), then the time series data x_t comes from state $s_t = 1$, and as soon as $\hat{\beta}_t \leq threshold$, then $s_t = 0$ governs on process x_t. Since $\hat{\beta}_t$ depends on $\hat{\beta}_{t-1}$, then s_t is a first-order Markov chain with a transition matrix $P = (p_{ij})_{i,j=0,1}$. For example, $p_{10} = P(\hat{\beta}_t \leq threshold | \hat{\beta}_{t-1} > threshold)$. Since $threshold$ is unknown, then s_t is a hidden Markov chain.

Similar to most regime-switching processes, the x_t is an observable process that its parameters depend on s_t. In the simplest form, it constitutes a first-order regime.

3.1. Regime switching coefficients

Suppose that the initial value of β_{s_t} is $\beta_0 = \beta$. Based on the first t observations, and if there is no change in initial value throughout t observations, the least square estimate of β is given by

$$\hat{\beta}_t = \frac{\sum_{i=2}^{t} x_i x_{i-1}}{\sum_{i=2}^{t} x_{i-1}^2},$$

The exponentially weighted least square estimate is given by

$$\hat{\beta}_{wt} = \frac{\sum_{i=2}^{t} \gamma^{t-i} x_i x_{i-1}}{\sum_{i=2}^{t} \gamma^{t-i} x_{i-1}^2},$$

for some suitable forgetting factor $\gamma \in (0,1)$. For practical applications, usually $\gamma = 0.95$ is chosen. This estimate gives higher weights to recent observations, which ensures that successive observations in the same state block are applied to calculate the time-varying (state-to-state) coefficients of the AR(1) process.

Define weights of recursive estimates of the coefficient of AR(1) by

$$\lambda_t = \frac{x_{t-1}^2}{\sum_{i=2}^{t} x_{i-1}^2},\ \lambda_{wt} = \frac{x_{t-1}^2}{\sum_{i=2}^{t} \gamma^{t-i} x_{i-1}^2},$$

and deviation of the least square estimate $\hat{\beta}_t$ (when there is no regime shift) of initial value β_0 denoted by $\hat{\theta}_{0t} = \hat{\beta}_t - \beta_0$.

Also, in the case of time-varying β's, let

$$\hat{\theta}_t^{tv} = = \hat{\beta}_t - \beta_t.$$

Under the regime-switching model, let $\hat{\theta}_t = \hat{\beta}_t - \beta_0$.

Proposition 1. Relations (*a*) - (*e*) are correct.

(*a*) $\hat{\beta}_t = (1-\lambda_t)\hat{\beta}_{t-1} + \lambda_t \frac{x_t}{x_{t-1}}$,

(*b*) $\hat{\beta}_{wt} = (1-\lambda_{wt})\hat{\beta}_{wt-1} + \lambda_{wt} \frac{x_t}{x_{t-1}}$,

(*c*) $\hat{\theta}_{0t} = (1-\lambda_t)\hat{\theta}_{0t-1} + \lambda_t \frac{\varepsilon_t}{x_{t-1}}$,

(*d*) $\hat{\theta}_t = (1-\lambda_t)\hat{\theta}_{t-1} + \lambda_t \frac{\varepsilon_t}{x_{t-1}} + \lambda_t s_t(\beta_1 - \beta_0)$,

(*e*) $\hat{\theta}_t^{tv} = (1-\lambda_t)\hat{\theta}_{t-1}^{tv} + \lambda_t \frac{\varepsilon_t}{x_{t-1}} - (1-\lambda_t)(\beta_t - \beta_{t-1}) =$

$$(1-\lambda_t)\hat{\theta}_{t-1}^{tv} + \lambda_t \frac{\varepsilon_t}{x_{t-1}} - (1-\lambda_t)(s_t - s_{t-1})(\beta_1 - \beta_0).$$

Proof. Parts (a)-(d) are easy to prove and they are omitted. For part (e), it is enough to see that

$$\beta_t - \beta_{t-1} = \beta_{s_t} - \beta_{s_{t-1}} = (s_t - s_{t-1})(\beta_1 - \beta_0)$$

3.2. Required probabilities

In this sub-section, transition, filtered and predictive probabilities are proposed.

(a) Transition probabilities.

Let ζ be a small positive number. Then,

$$\mathrm{p}_{01}^{\mathrm{t}} = P\big(\hat{\theta}_{\mathrm{t}} > \zeta \big| \hat{\theta}_{\mathrm{t-1}} = \zeta\big) = P\left(\frac{\varepsilon_{\mathrm{t}}}{\mathrm{x}_{\mathrm{t-1}}} > \zeta - \delta\right),$$

where $\delta = \beta_1 - \beta_0$.

Therefore, one can see that

$$\mathrm{p}_{00}^{\mathrm{t}} = 1 - p_{01} = 1 - P\left(\frac{\varepsilon_{\mathrm{t}}}{\mathrm{x}_{\mathrm{t-1}}} > \zeta - \delta\right)$$

$$\mathrm{p}_{10}^{\mathrm{t}} = P\big(\hat{\theta}_{\mathrm{t}} = \zeta \big| \hat{\theta}_{\mathrm{t-1}} > \zeta\big) = P\left(\frac{\varepsilon_{\mathrm{t}}}{\mathrm{x}_{\mathrm{t-1}}} > \zeta\right),$$

and $\mathrm{p}_{11}^{\mathrm{t}} = 1 - \mathrm{p}_{10}^{\mathrm{t}}$. Here, $\varepsilon_{\mathrm{t}} = \sigma_{\mathrm{t}} z_{\mathrm{t}}$. It is assumed that z_{t} has a standard normal distribution.

(b) Filtered probabilities.

Consider the filtered probability

$$\pi_t(1) = P(s_t = 1 | x_t, \dots, x_1),$$

which can be written as

$$\begin{aligned}\pi_t(1) = P(s_t = 1 | s_{t-1} = 1, x_t, \dots, x_1) P(s_{t-1} = 1 | x_{t-1}, \dots, x_1) \\ + P(s_t = 1 | s_{t-1} = 0, x_t, \dots, x_1) P(s_{t-1} = 0 | x_{t-1}, \dots, x_1) \\ = p_{01}\pi_{t-1}(0) + p_{11}\pi_{t-1}(1)\end{aligned}$$

Also, $\pi_t(0)$ can be written $p_{00}\pi_{t-1}(0) + p_{10}\pi_{t-1}(1)$. Thus, assuming $\boldsymbol{\pi}_t = (\pi_t(0), \pi_t(1))^T$, it is seen that $\boldsymbol{\pi}_t = P_t^T \boldsymbol{\pi}_{t-1}$.

Notice that $\pi_t(1) = P(s_1 = 1 | x_1)$. Since, $x_1 = \beta_{s_1} x_0 + \varepsilon_1$, it is seen that

$$\frac{x_1}{x_0} - \beta_0 = \beta_{s_1} - \beta_0 + \frac{\varepsilon_1}{x_0} = \beta_1 - \beta_0 + \frac{\varepsilon_1}{x_0} = \delta + \frac{\varepsilon_1}{x_0}$$

Hence, replacing the current relation in the last above equation, one can see that

$$\pi_t(1) = P\left(\frac{\varepsilon_1}{x_0} > \zeta - \delta\right),$$

$$\pi_t(0) = 1 - \pi_t(1).$$

It is easy to see that

$$\boldsymbol{\pi}_t = \{\prod_{i=2}^{t} P_i\}^T \boldsymbol{\pi}_1$$

Assuming $\boldsymbol{\pi}_t$ converges to $\boldsymbol{\pi}_\infty$, as $t \to \infty$, then $\boldsymbol{\pi}_\infty = P_\infty \boldsymbol{\pi}_\infty$.

The distribution $\boldsymbol{\pi}_\infty$ is referred to stationary distribution and its existing, uniqueness, and finding it, is too important.

(c) Predictive probabilities.

The predictive probability

$$f_{t+1}(i) = P(s_{t+1} = i|x_t, \dots, x_1), i = 0,1$$

are written as

$$f_{t+1}(0) = p_{00}\pi_t(0) + p_{10}\pi_t(1)$$

$$f_{t+1}(1) = p_{01}\pi_t(0) + p_{11}\pi_t(1)$$

Letting $\mathbf{f}_{t+1} = (f_{t+1}(0), f_{t+1}(1))^T$, it is seen that $\mathbf{f}_{t+1} = P_t^T\pi_t$. The h-step ahead prediction probabilities vector is given by

$$f_{t+h} = P_t^T \times \dots \times P_{t+h-1}^T \times \pi_t$$

3.3. AMOC model

Here, the famous structural break model is studied using the above-mentioned results. Suppose that s_0 and configuration

$$(s_1, \dots, s_{k_0}, s_{k_0+1}, \dots, s_t) = (0,0, \dots,0,1,1, \dots,1)$$

is observed. Here, the lengths of zeros and ones are k_0, $t - k_0$, respectively.

This model is the at most one change (AMOC) model in change point analysis literature and k_0 is an unknown change point. The likelihood function is given by

$$L = p_{00}^1 \times \dots \times p_{00}^{k_0} \times p_{01}^{k_0+1} \times p_{11}^{k_0+2} \times \dots \times p_{11}^t$$

Suppose that $\sigma_{s_t} = \sigma$ is known and ε_t's are iid normal $N(0, \sigma^2)$ distribution. Then, p_{00}^t, p_{01}^t and p_{11}^t are given as in the following Table.

Table 1

Transition probabilities

Probability	Equation
$\mathbf{p_{00}^t}$	$\Phi\left(\frac{\zeta - \delta}{\sigma}\lvert x_{t-1}\rvert\right)$,
$\mathbf{p_{01}^t}$	$\Phi\left(\frac{\delta - \zeta}{\sigma}\lvert x_{t-1}\rvert\right)$,
$\mathbf{p_{11}^t}$	$\Phi\left(\frac{-\zeta}{\sigma}\lvert x_{t-1}\rvert\right)$.

Source: Author's

It is interesting to propose the maximum likelihood estimate of threshold parameter ζ. To this end, the likelihood function is given by

$$\mathrm{L}=\prod_{\mathrm{i}=1}^{\mathrm{k}_0}\Phi\left(\frac{\zeta-\delta}{\sigma}|\mathrm{x}_{\mathrm{i}-1}|\right)\times\Phi\left(\frac{\delta-\zeta}{\sigma}|\mathrm{x}_{\mathrm{k}_0}|\right)\times\prod_{\mathrm{i}=\mathrm{k}_0+2}^{\mathrm{t}}\Phi\left(\frac{-\zeta}{\sigma}|\mathrm{x}_{\mathrm{i}-1}|\right)$$

The following proposition summarizes the above discussion.

Proposition 2. Relations (*a*)-(*d*) are correct.

(*a*) The time-varying transition probabilities are given by $\mathrm{p}_{00}^{\mathrm{t}}$, $\mathrm{p}_{01}^{\mathrm{t}}$ and $\mathrm{p}_{10}^{\mathrm{t}}$, as defined in Table 1.
(*b*) Let P_i be i-th probability transition matrix, then filtered probability $\boldsymbol{\pi}_t$ is $\boldsymbol{\pi}_t=\{\prod_{i=2}^{t}P_i\}^T\boldsymbol{\pi}_1$. This probability vector plays the role of EWS.
(*c*) Predictive probability is $\mathbf{f}_{\mathrm{t}+1}=\mathrm{P}_{\mathrm{t}}^{\mathrm{T}}\pi_{\mathrm{t}}$,
(*d*) The likelihood function L, under the AMOC model, is

$$\mathrm{L}=\prod_{\mathrm{i}=1}^{\mathrm{k}_0}\Phi\left(\frac{\zeta-\delta}{\sigma}|\mathrm{x}_{\mathrm{i}-1}|\right)\times\Phi\left(\frac{\delta-\zeta}{\sigma}|\mathrm{x}_{\mathrm{k}_0}|\right)\times\prod_{\mathrm{i}=\mathrm{k}_0+2}^{\mathrm{t}}\Phi\left(\frac{-\zeta}{\sigma}|\mathrm{x}_{\mathrm{i}-1}|\right),$$

the MLE estimate of parameters such as ζ are obtained by numerical optimisation methods.

Table 2 below shows various values of the maximum likelihood estimate (MLE) of ζ, for $n=525, k_0=273, \beta_0=0.25$.

Table 2

MLE of ζ

$\boldsymbol{\beta_1\backslash\sigma}$	**0.1**	**0.2**	**0.3**	**0.4**
0.35	0.203	0.101	0.075	0.041
0.45	0.221	0.151	0.111	0.205
0.55	0.251	0.188	0.158	0.215
0.65	0.296	0.197	0.182	0.255
0.75	0.304	0.204	0.195	0.286
0.85	0.321	0.213	0.201	0.304

Source: Author's

4. Data analysis

This paper combines regime-switching models with threshold analysis to obtain better results in change point analysis, a type of early warning system frequently used in financial fields. This manuscript proposes useful propositions to find heading warning probabilities. Here, two applications of the above-mentioned theoretical results are given in stock returns and business cycles.

(a) Stock returns.

Returns of any stock may be positive or negative, which are states of the fitted Markov chain in this sub-section. Local trends are successive short-length sequences of positive or negative returns. Finding these local trends, in the short run, is too important for traders and scalpers to take long or short positions. Here, a regime-switching model with fixed transition probabilities is fitted to the daily return of *Amazon Co*.

This series is defined as follows

$$x_t = \log(\mathrm{S}_t) - \log(\mathrm{S}_{t-1}),$$

for a period of 25 May 2021 to 23 May 2023, including 505 observations. Here, S_t denotes the price of the stock of *Amazon Co*. at $t\text{-}th$ day. The one-step transition probabilities matrix is

$$\begin{bmatrix} 0.53 & 0.47 \\ 0.45 & 0.55 \end{bmatrix}$$

The slopes of AR(1) for negative and positive returns are -0.00164, and 0.03489, respectively. The volatility seems to be fixed by examining the rolling estimates of standard deviation and checking its stability during the time, and it is 0.026. Here, using the Monte Carlo simulation, the distribution of maximum M of $x_t, t = 1, \ldots, 505$ is approximated. It is seen that. $M^{0.5}$ has zero skew and three kurtosis. That is, the normal distribution with a mean of 0.284 and standard deviation of 0.0153 is proposed for this random variable. Let τ be the upper bound for M with a 0.95 confidence level. Then, $\tau = 0.3091$.

(b) Business cycles.

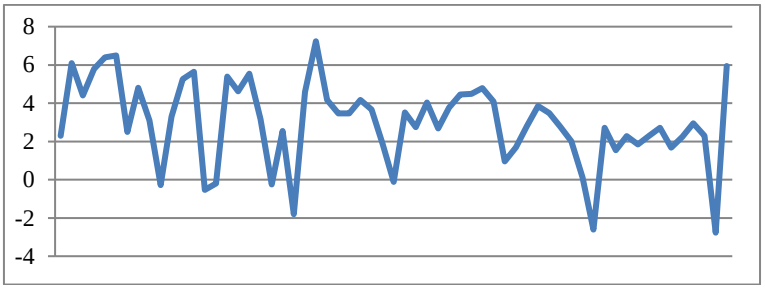
In economics, the business cycles are distinguished by the growth rate of macroeconomic variables such as unemployment and GDP. To this end, compute

$$x_t = \log(\mathrm{GDP}_t) - \log(\mathrm{GDP}_{t-1}),$$

where GDP_t is the GDP of $t\text{-}th$ year. The data set is the growth rate of the US GDP from 1960 to 2020 (62 observations), taken from https://data.worldbank.org/. A time series plot indicating three cycles is proposed.

Figure 1

Time series plot of GDP-GR of US

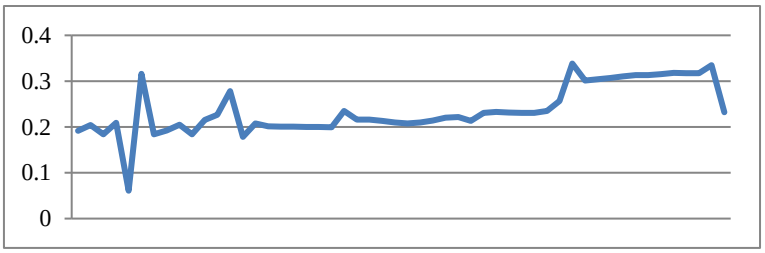


Source: Author's contribution

The first-order AR is fitted, and the time series plot of $\hat{\beta}_t$ is given as follows, which clearly indicates a change.

Figure 2

Slope of AR(1) model

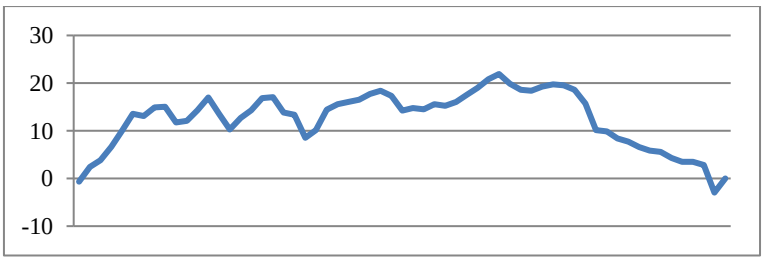


Source: Author's contribution

The logarithm of the likelihood function indicates the inverse V-shaped figure. With a high probability, there is a possible change point at $t = 40$ where the log-likelihood has been received to its maximum.

Figure 3

Log-likelihood plot

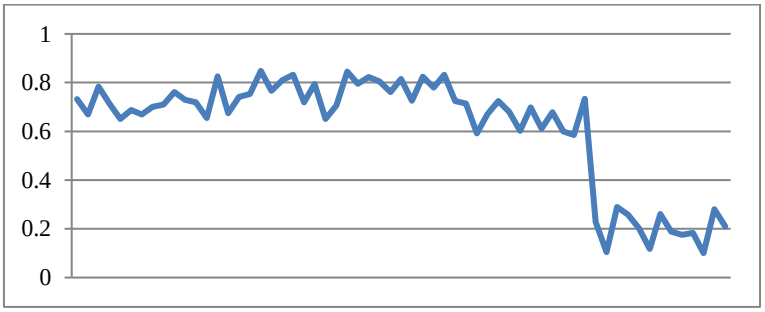


Source: Author's contribution

To make sure about the existence of the change point and its location, the probabilities p_{00}^{t} are plotted as follows. From this plot, it is seen that after t = 40, the probability of moving to state zero from state zero is negligible. Therefore, it is suspected there exists a change point at $t = 40$.

Figure 4

Plot of p_{00}^{t}



Source: Author's contribution

5. Concluding remarks

This paper studies the relationship between regime switching and threshold models and designs EWS using this relationship. The underlying process is AR(1). Some theoretical perspectives of EWS are proposed. Finally, it uses this EWS to study trading patterns and identify turning points in the stock market. This article has the following differences and advantages compared to similar articles.

a) Although Asako and Liu's (2013) paper deals with the identification of price bubbles from the point of view of change, it does not look at the issue from the perspective of regime change, a structure that mainly occurs in the stock market.
b) The paper by Gao, Cecati, and Ding (2015) is mainly used to identify change and fault points in mechanical systems. Although these methods are conventional, since they mainly consider deterministic methods, they cannot analyse the system's random states.
c) Do-Dios Tena and Tremayne (2009) did not use threshold models in the analysis, which are mostly necessary in stock data analysis.

d) Although Hamilton's book (1994) is very good at describing all the variables of financial time series, it does not provide combined methods.
e) Kapetanios (2003) considers only regime-switching models for change point analysis, which requires early warning algorithms, which are not found in that paper.

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INNOVATIVE TECHNOLOGIES FOR THE INSURANCE SECTOR IN THE REPUBLIC OF MOLDOVA

Cristina UNGUR, PhD*

Abstract

The trend of sustainable development implies, among other things, a process of digitization of economic processes to ensure transparency, reduce costs, increase the user experience, and make the time used more efficient. The COVID-19 pandemic has accentuated the need for digitization, the trend being supported by the level of the insurance industry as well. The purpose of this article is to analyse opportunities for the implementation of digital technologies in the insurance market in the Republic of Moldova and to identify the potential for development through digitalization. It requires research for this date on the aspirations of the Republic of Moldova to join the EU, which implies the alignment of European trends in financial innovation and digitalization. The objectives pursued in the study were to determine what are the possibilities and the challenges of insurance companies in the Republic of Moldova in the implementation of digital technologies and how this process is supported by the government. As a result of the research, directions for the digital development of the insurance industry in the Republic of Moldova were established, problems faced by insurance companies in this process were identified, and recommendations were developed regarding the consolidation of the insurance market.

Keywords: insurance market, digitalization, European Union accession

JEL Classification: G18; G22; G4; O33

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1. Introduction

Digitization of economic processes has multiple advantages, including reducing the time required for processes, their transparency, data security, improving user experience and reducing costs. However, the effective implementation of digital technologies also involves significant costs for software development, integration of new processes in the operational activity of insurance companies, and technological equipment. At the same time, there is also the issue of financial and digital training and education of consumers who must develop the necessary skills to access these services through digital channels.

In this study, we aimed to analyse the opportunities for implementing digital technologies in the insurance market in the Republic of Moldova and find innovative solutions that can be used by both insurance service providers and consumers. We also analysed the efforts of the authorities of the Republic of Moldova to digitalize the financial sector, including the insurance sector.

The research question that started this study was: How can digital technologies be implemented in the insurance market in the Republic of Moldova? An important aspect is the simplification of the digital experience for customers, which would mean offering services in an accessible and tailored manner to the needs of consumers. In this sense, we have determined what are the possibilities of accessing digital services for the population, taking into account the technological endowment, but also digital and financial education. At the same time, it is important that the digitization of processes provides professionals with all the necessary resources for ascertainment, including relevant documents and information.

The topicality of the research problem is given by the tendency to accelerate financial innovations at the European level, which was accentuated by the signing in 2022 of the European Declaration on digital rights and principles for the digital decade (2023/C 23/01) (EU, 2023).

The declaration proposed by the Commission in January 2022 expresses the European Union's commitment to a safe, secure and sustainable digital transformation, with a focus on protecting citizens' fundamental rights and respecting EU values. This declaration complements previous digital initiatives of Member States, such as the Tallinn Declaration on e-Government (European Commission, 2017),

the Berlin Declaration on the Digital Society and Value-Based Digital Governance (European Commission, 2020) and the Lisbon Declaration – Digital Democracy with a purpose (EU, 2021).

Efforts to digitize all sectors, including the financial sector, have been accelerated by the COVID-19 pandemic, and the insurance industry was no exception. Considering the aspirations of the Republic of Moldova to become a member of the European Union, alignment actions with the EU directives are necessary. On the other hand, consumers increasingly demand the implementation of technologies in all spheres of life. Thus, there are all the necessary prerequisites to increase efforts to digitize the insurance sector in the Republic of Moldova in order to strengthen the insurance market and to offer quality, fast and sustainable services to consumers.

2. Literature review

In the specialized literature, we find studies on the opportunities of digitizing the financial sector by Susanto (2022), Bartik et al. (2020), Manta (2023), Eling (2018), and Pauch and Bera (2022). This issue is also widely discussed in various forums and meetings of insurance practitioners, such as OECD (2020), NBM (2024), and Deloitte (2021).

The studies analysed show the major importance of implementing innovative solutions in all economic fields, including insurance. Understanding the contribution of digital technology to the development of business operations is one of the main research areas of information systems. Studies show that implementing technologies is always a high-cost exercise. However, authors Lu and Ramamurthy (2011) argue that digital technology should be viewed not only as a cost measure but also as an investment in revenue growth.

Based on the research analysed, we consider that the implementation of innovative technologies is all the more important in small financial markets, such as that of the Republic of Moldova. Here digital channels for distribution and information analysis could boost sales of insurance products, which would contribute to the development of the financial sector. The importance of insurance digitalization in the Republic of Moldova and trends in this field were analyzed by the author of this study in 2017 (Cuciureanu and Ungur, 2017) and in other later scientific work, what denotes the contribution of the author to the development of knowledge in this field.

Special attention in this research was given to the regulations, strategies, and statements of the European Commission to identify the European Union's direction towards the digitization of all processes. Additionally, the legislative acts and strategies developed by the Government of the Republic of Moldova were analyzed to determine the country's digital development priorities.

3. Methodology and data

To carry out this study, available data from international and national reports, including OECD statistics, European Commission reports, statistics of the National Bank of Moldova, the Electronic Government Agency, etc., were used.

The research covered the last 10 years, 2014-2023. The data were selected, grouped, and analysed dynamically, which allowed the achievement of the research objectives and the solution of the research problem from which the study started.

To reflect the current situation in the insurance market in the Republic of Moldova, the main aggregated financial indicators of the market were used, such as the solvency rate, the liquidity ratio, the volume of insurance premiums and compensations, and the profit of insurance companies. At the same time, market penetration and density indicators were calculated in US dollars using the average exchange rate for each year, and their dynamics were analysed. Insurance density was calculated by relating the volume of written premiums converted into US dollars to the total number of inhabitants of the country. The degree of penetration was calculated by reporting the volume of gross written premiums reflected in US dollars to the GDP in current prices calculated in US dollars. To establish the accessibility of digitalization of insurance services for consumers, the degree of coverage of the population with computers and Internet access was analysed.

4. Results and discussion

4.1 The current situation in the insurance market in the Republic of Moldova

Insurance markets worldwide are oriented towards development, which involves improving the insurance product portfolio in terms of diversity and quality.

The costs of these products for the population and businesses play a central role, as affordable prices can attract a larger number of customers. Accessibility refers not only to costs but also to the ease with which customers can purchase and use insurance products. In this aspect, digitization is the most important. Simplicity and transparency of procedures are essential to avoid confusion and facilitate the processes of purchasing and managing insurance. Additionally, the complexity of the information provided about products and the methods of promotion must be managed so that customers can clearly understand what they are purchasing and what benefits they receive.

From July 1, 2023, the Supervisory Authority of the non-banking financial market in the Republic of Moldova, of which the insurance sector is a part, became the National Bank of Moldova (BNM), thus replacing the National Financial Market Commission (CNPF). This transfer of responsibilities involved the NBM taking over the licensing, regulation and supervision of the activity of insurers, reinsurers, intermediaries, and the National Bureau of Motor Vehicle Insurers (BNAA). The goal pursued by the state authorities regarding this change was to strengthen the financial market and create a more integrated and resilient structure within the financial system of the Republic of Moldova.

With the transfer of insurance supervision responsibility to the National Bank of Moldova, a series of regulatory changes were implemented in the insurance industry of the Republic of Moldova. Thus, the fundamental laws in this sector were amended: Law No. 92 of 07.04.2022 on insurance or reinsurance activity (Parliament RM, 2022a); Law No. 106 of 21.04.2022 on mandatory motor third-party liability insurance for damages caused by vehicles (Parliament RM, 2022b). These legislative measures are aimed primarily at strengthening the country's insurance market by protecting the rights and interests of financial services beneficiaries and ensuring the stability of the insurance system.

The key indicators reflecting the situation in the insurance market of the Republic of Moldova are presented in Table 1.

Table 1

Indicators of the insurance companies in the Republic of Moldova (situation on 31.12.2023)[1]

	Name of the insurance company	Solvency ratio (%)	Liquidity coefficient	Gross premiums	Claims paid	Premiums ceded to reinsurance	Net profit
				millions USD			
1	ACORD GRUP SA	173.9	4.3	13.69	2.64	2.71	2.26
2	ASTERRA GRUP SA	126.8	3.7	29.08	9.87	3.84	3.81
3	DONARIS VIENNA INSURANCE GROUP SA	140.2	2.3	20.75	8.07	4.59	1.94
4	GENERAL ASIGURARI SA	133.3	4.9	24.04	8.45	3.87	2.18
5	GRAWE CARAT ASIGURARI SA	140.3	4.9	24.73	11.92	1.68	2.98
6	INTACT ASIGURARI GENERALE SA	155.5	6.5	17.45	4.81	9.47	3.88
7	MOLDASIG SA	183.6	3.1	25.64	6.67	4.80	1.53
8	MOLDCARGO SA	130.5	2.7	5.54	2.36	2.58	-1.14
9	TRANSELIT SA	137.0	4.2	7.82	3.06	5.42	0.60
	TOTAL	X	X	168.73	168.73	57.85	38.97

Source: developed by the author based on NBM data

From the data presented in Table 1, it can be seen that 9 insurance companies operate on the insurance market in the Republic of Moldova, of which only one, Grawe Carat Asigurări, provides life insurance services. The share of life insurance on the market is 3.66% in 2023, constantly decreasing during the last 5 years. Of the total gross premiums subscribed for general insurance, the classes with the largest shares were held by Mandatory Motor Third-Party Liability Insurance (54.3%) and Comprehensive Motor Vehicle Insurance

[1] *The exchange rate according to NBM data on 31.12.2023 was 1 Moldovan leu = 17.4 US Dollars.*

(CASCO), other than railway, with a share of 19.6%. Thus, car insurance in the Republic of Moldova has a share of 74 per cent of the market (NBM, 2024).

During 2023, insurance companies subscribed gross premiums worth 168,73 million US dollars, 18.8% more than the gross premiums subscribed in the previous year, which indicates a significant growth trend in this sector.

According to the normative requirements (NCFM, 2011), the solvency rate of the insurer (reinsurer) must be equal to at least 100%. The statistical data presented by the NBM for the year 2023 (Table 1) show that all insurance companies operating on the financial market in the Republic of Moldova have a level that exceeds the established norms, which reflects a high solvency of the insurers. Regarding the liquidity of insurance companies, the NCFM Regulation (NCFM, 2011) provides that the insurer is obliged to guarantee liquidity by permanently maintaining unencumbered and liquid assets and to maintain a liquidity ratio of at least 1,0 permanently. Thus, we find that all analysed insurance companies exceed at least twice the established limit, which indicates that the insurers will be able to pay their debts from the liquid assets held.

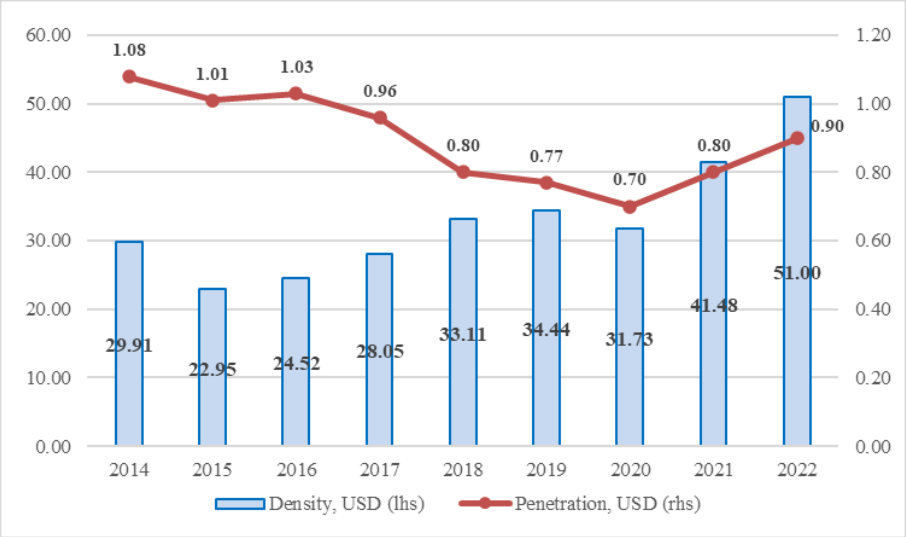
One of the particularities of the Moldovan insurance sector is the low level of reinsurance premium transmission. Only 23% of the insurance premiums are passed on to reinsurance, which is much less than in other countries. The basic indicator of the insurance business remains the net profit, which is 18,04 million US Dollars at the aggregate level of the market. Most insurance companies recorded net profits for 2023 from 0,6 million US Dollars at Transelit SA to 3,88 million US Dollars at Intact Asigurări Generale SA. Only the Moldcargo SA insurance company recorded losses of 1,14 million US Dollars in 2023.

Over the past 10 years, the number of market participants has undergone changes, largely due to legislative changes regarding capital requirements, solvency and insurance reserves. The main trends regarding the professional market participants are oriented towards the significant increase in the number of insurance and bancassurance agencies and the decrease in the number of insurance companies. From 16 companies active on the market in 2016, today we have reached 9 companies. The same downward trend is followed in the ranks of insurance brokers. However, we believe that the measures to change the legislative and normative requirements have

nevertheless contributed to the filtering of professional participants in the insurance market, leaving only those who can ensure the provision of quality services that comply with market and consumer requirements.

Regarding the general diagnostic indicators of the insurance sector, we observe an insurance penetration rate of only 0.9%, which is significantly lower than in countries with a developed economy. We can mention here that the average penetration rate of the insurance market in the European Union is around 8%. However, there is a constant increase in this indicator at the domestic level, which indicates that the insurance industry in the Republic of Moldova is developing. The same situation applies to the insurance density indicator. We find that the population is still reserved in accessing private insurance services, with the insurance density reaching only 51 US dollars in 2022.

Figure 1
The insurance market development indicators in the Republic of Moldova



Source: developed by the author on the basis of NCFM, NBM, NBS

From the analysis, we can see that the insurance market in the Republic of Moldova is going through a period of transformation and adaptation to global and European trends. These changes are driven

by factors such as digitization, increased risk awareness and international regulatory compliance requirements. Modernization and education efforts, along with adaptation to new technologies and demographic changes, will contribute to the growth and consolidation of this essential sector which is essential for the national economy.

4.2. Technologies with potential for implementation in insurance

Over 80% of insurers believe that the future of the insurance market belongs to those organizations that will make significant investments in innovation and digitization (Pauch and Bera, 2022).

Based on our research, we have identified the following digital technologies that could be implemented in the insurance sector (see Table 2).

Table 2

Digital technologies suitable for implementation in the insurance sector

Technology	Utility	Impact
Big Data	Identification of the appropriate type of products for customers in certain regions or belonging to specific demographic groups	Increasing sales productivity and reducing the volume of company losses, especially losses caused by fraudulent claims
Advanced analysis (AA)	- can identify which distribution channels (including agents and brokers) are best suited for certain types of potential customers; - can assess risks, for example, by analysing data posted in social channels (social media), but within the limits of the legal provisions regarding the use of personal data	
Blockchain	The use of smart contracts in which all insurance conditions and information regarding the payment of compensation can be seen in real and transparent mode	Increases public confidence in companies and reduces the likelihood of mistakes
Internet of Things (IoT)	Sensors embedded in vehicles, homes and other equipment provide insights into customer behaviour and can deliver early warnings	Networked digital devices that can be used in cars, buildings or on land can protect people and property and thus reduce risks and claims

Technology	Utility	Impact
IoT wearables devices	Smart accessories monitor the health status of customers (heart rate, sleep quality, distance travelled per day), and within a health insurance contract, the data of these devices are considered and offer customers the possibility of obtaining discounts	Increase in the number of health insurance policies due to customers becoming more aware and responsible about their health
Telematics	Telematic data flows are used in the usage-based insurance (UBI) system, which is also called "pay-as-you-drive" or "pay-as-you-live". For example, due to a safer driving style, a car insurance customer can get a discount or priority insurance package	It increases customer security and road safety, contributes to the innovation of the sector, accelerates the pace of decision-making
Machine learning (ML)	- rapid adaptation to new data of insurers' information systems, without the need for reprogramming - calculation of the volume of premiums and management of compensations - voice biometrics that can be used to identify customers when they call contact centers, saving them the inconvenience of entering policy numbers and passwords, information that they don't always have at hand.	Improving the quality of insurance services and increasing customer satisfaction
IT Infrastructure	Cloud technology has brought insurers new options for processing, computing and storing information in virtual space, and co-authoring and video calling allow connecting with customers without additional travel costs	Reducing costs of accessing services and increasing consumer satisfaction
Virtual reality (VR)	- risk assessment; - employee training An insurer could use VR to create a three-dimensional image of a room or reconstruct an accident in detail	It transforms the way information for subscription is collected, as well as how complaints are resolved

Source: developed by the author

4.3. Digitalization efforts of the insurance sector in the Republic of Moldova

Digitization is an essential component of the modernization of the national economy and alignment with European standards. Digitization efforts focus both on improving the technological infrastructure and increasing the level of digital and financial education of the population. Recently, the greatest efforts have been made to implement online sales systems. Insurers in the Republic of Moldova

have started to develop online platforms that allow customers to compare insurance offers, purchase policies directly from companies' websites, manage policies and make online payments.

At the same time, insurance companies implemented the use of chatbots and virtual assistants, which contributed to improving the user experience. These technologies provide instant customer support by answering frequently asked questions and assisting them in the policy purchase process.

Significant efforts are made in the field of digital and financial education of the population by initiating information campaigns and education programs that include workshops and training seminars, online educational materials such as video tutorials, guides and informative articles available on the websites of insurance companies and on social media platforms.

It's important to mention the efforts of the Government of the Republic of Moldova, which, in collaboration with international development partners, plays a vital role in supporting the digitization process. Regulations have been established, and favourable policies implemented to encourage innovation and the adoption of digital technologies in the insurance sector. For example, amendments to the Law on Compulsory Motor Third Party Liability Insurance (MTPL), the Contravention Code, and the Law on Preventing and Combating Money Laundering and Terrorism Financing have been passed. This has enabled the MTPL policy to be issued and perfected online in the Republic of Moldova. The amendments aimed to digitize the process of issuing MTPL policies. Thus, the conclusion of MTPL contracts electronically and online payment of the insurance premium has facilitated the process of purchasing MTPL policies for drivers, reduced the duration of contracting the service, and developed online distribution channels for insurance services. Due to these legislative changes, the obligation to issue documents (MTPL insurance policy, contract) on paper support has been eliminated.

As the Republic of Moldova pursues its aspirations for EU membership, alignment with European standards in digitization becomes a priority. This involves adopting the best practices and technologies used in EU member states, as well as participating in European initiatives for financial innovation. In this regard, it is worth mentioning that the European Union aims to prepare its businesses and citizens for a more sustainable and prosperous digital future, centred around human factors. To achieve this goal, the Digital Decade

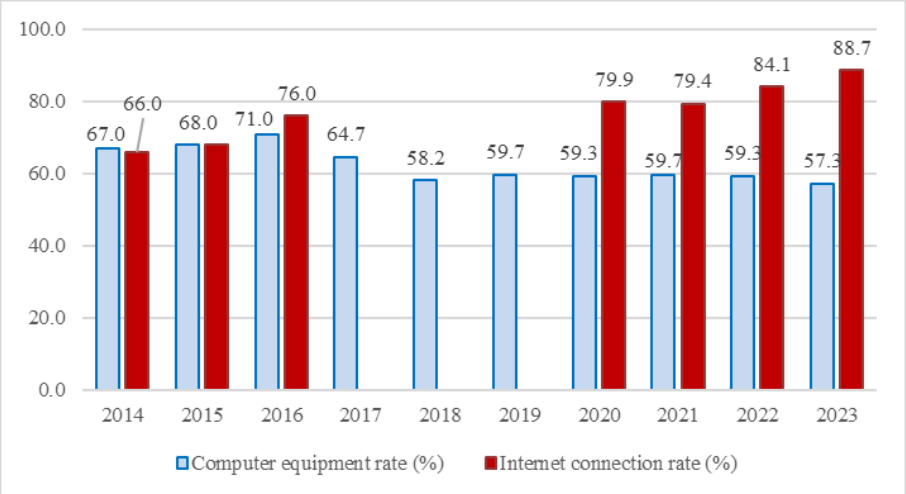
Policy Program has been created with specific targets and objectives for 2030. Among the central objectives are the digitization of all government and private enterprises, as well as the development of digital skills in at least 80% of the population by 2030 (European Commission, 2024).

The Republic of Moldova has initiated the Digital Transformation Strategy for the years 2023-2030 in support of the digitization idea promoted by the EU.

The analyses carried out within the research show a high potential for the implementation of innovative technologies in the insurance market in the Republic of Moldova due to the increased level of internet connection and the increased penetration of electronic connection devices. Approximately six out of ten households (57.3%) in the Republic of Moldova have a computer at home (EGARM, 2023). This indicator has been decreasing in recent years, the maximum being 71% in 2016. The decrease is explained by the fact that consumers are changing their preferences by choosing other, more accessible and convenient devices to use the Internet. The general internet connection rate in the Republic of Moldova in 2023 was 88.1% (Figure 2).

Figure 2

Population access to the Internet in the Republic of Moldova



Source: developed by the author based on the Electronic Government Agency of the Republic of Moldova

Besides having electronic devices and internet access, the Republic of Moldova's population has a financial literacy level of 59.5%, which is nearly equal to the average level for OECD countries (Ciumara, 2020). Financial literacy is a crucial element without which the population would not access insurance services through any distribution channels. Considering that both technical equipment and financial education levels are sufficient, we can conclude that the digitization of insurance services has a high development potential in the Republic of Moldova.

The efforts to digitize the insurance sector in the Republic of Moldova are essential for modernizing and streamlining this sector. By adopting modern technologies, promoting online sales, utilizing chatbots, digital and financial education, governmental support, and alignment with European standards, the insurance sector can become more accessible, transparent, and efficient. These measures will contribute to strengthening the insurance market and providing high-quality services to consumers, thereby supporting the sustainable development of the national economy.

5. Conclusions

The digitization of insurance brings multiple benefits to the industry, including process efficiency, improved customer experience, and reduced costs.

For insurance companies in the Republic of Moldova, it is a priority to offer suitable and affordable insurance products and services at competitive prices so that they are understood and accepted by all interested parties. This involves developing insurance products that meet the diverse needs of customers, from life and health insurance to property and liability insurance. Flexibility in customizing insurance products can also increase their attractiveness, adapting to the specific situations of each client.

In this sense, collaboration between the authorities and insurance companies is necessary to promote financial education and increase awareness of insurance's benefits. Authorities can play an important role in regulating and overseeing the sector, ensuring that standards of quality and transparency are met. In parallel, insurance companies must invest in public information and education campaigns, clearly explaining the advantages and importance of insurance in protecting assets and health.

In the insurance market of the Republic of Moldova, there is a potential for the implementation of digital technologies due to the following factors: the high level of profit of insurance companies, easy access to the Internet, equipping consumers with electronic devices, but also an average level of financial education. All of this can contribute to the development of digital insurance services for consumers but also to the implementation of innovative software for the efficiency and modernization of operational processes within insurance companies.

Promoting technological innovations in the insurance sector can significantly contribute to improving accessibility and transparency. Using digital platforms for selling and managing insurance policies, implementing mobile applications and developing interactive online tools can greatly simplify the customer experience, giving them quick access to information and services.

In conclusion, the development of the insurance sector largely depends on the ability to offer diversified, affordable and understandable products to the general public. Through effective collaboration between authorities and insurance companies and through the promotion of financial education and technological innovation, the objectives of growth and consolidation of the insurance market can be achieved, thus contributing to overall economic stability and prosperity.

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ENHANCING ENERGY POLICY ADOPTION WITHIN THE SOUTH AFRICAN FINANCIAL SERVICES SECTOR

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Abstract

In the wake of increasing global emphasis on sustainable environmental practices, South African organisations strive to integrate green business principles into their strategies. The paper's objective was to evaluate the importance and implementation of an energy policy within the financial services sector in line with ISO50001. The paper presents findings from a quantitative non-experimental study within the South African financial services sector through a structured questionnaire. The findings showed that although the implementation of an energy policy is important, there is still a gap in the adoption of an energy policy within the financial services sector. The study further found that a notable percentage (29.5%) of respondents indicated that the energy policy did not provide sufficient guidance on energy targets and objectives. Setting an energy policy is the starting point and driving force for implementing energy management. It should be the priority of managers who have not yet done so. Further research on how energy policies are structured through content analysis could add value to organisations that have not yet implemented such policies.

Keywords: ISO50001, energy management, management responsibilities

JEL Classification: Q48; Q58; M14

1. Introduction

Over the past decade, sustainable practices have gained momentum, including in South Africa. Energy is a crucial factor in

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South African organisations' economic and social development (Winkler, 2005; Esty & Simmons, 2011). There are various international and domestic requirements for energy. Firstly, organisations must follow government-established policies and procedures to control and oversee energy efficiency and renewable energy initiatives. The Conference of the Parties (COP) is the United Nations Framework Convention on Climate Change (UNFCCC) decision-making body (UNFCCC, 2014). The UNFCCC (2014) established targets for carbon emissions and energy concerns, the first of which was the Kyoto Protocol, which has since been modified to consider the changing climate environment. Organisations must not only follow international requirements but also the national requirements of their respective countries. South Africa has various policies and regulatory requirements regarding energy, including the 1998 White Paper on Energy Policy, the 2003 White Paper on Renewable Energy Policy, the National Energy Act (No. 34 of 2008), the 2005 Integrated Energy Plan (IEP), and the 2005 National Energy Efficiency Strategy (NEES). According to the White Paper on Energy Policy, South Africa's energy strategy should balance the nation's supply and demand with short-, medium-, and long-term objectives that utilise the country's natural resources while considering the sustainability of the environment (DME, 1998). Increasing access to reasonably priced energy sources, enhancing energy sector governance, promoting economic growth, controlling the effects of energy on health and the environment, and securing an energy supply through diversification are the primary goals of energy policy (Davidson & Winkler, 2003; DME, 1998; Winkler, 2005:28). These five goals remain applicable and serve as the cornerstone for all energy-related policies and practices in South Africa (Department of Energy, 2013).

To guarantee the diversification of energy sources and sustainable energy use in South Africa, the National Energy Act (No. 34 of 2008) was introduced in 2008. This legislation intended to supply the South African economy with a range of energy supplies to guarantee affordable and sustainable quantities. This is necessary to promote economic expansion and poverty reduction. Creating a sustainable energy sector entails integrating environmental management regulations and encouraging collaboration between economic sectors, providing energy planning and supply through sufficient funding to track energy demand, supply, and data generation and establishing an organisation tasked with advancing effective

energy generation, consumption and research (Department of Energy, 2008).

Two of the most significant papers that influence the South African energy industry are the Integrated Energy Plan (IEP) and the Integrated Resource Plan (IRP). The IEP set out to achieve eight main goals, including energy supply, minimising energy costs, expanding energy access, diversifying primary energy carriers and supply sources, minimising emissions from the energy sector, enhancing energy efficiency; encouraging localisation, technology transfer and job creation; and guaranteeing water conservation (Department of Energy, 2013). The IEP and IRP are energy planning frameworks that are used to create capacity development on the supply side, and the government uses them as the main tool to determine the future action of the electricity supply in South Africa (WWF International, 2014). The National Energy Efficiency Strategy (NEES) objectives were to respond to the demand for energy and to increase the commitment to reducing the national environmental footprint (Department of Energy, 2016). By facilitating the increased availability, affordability, and quality of technologies, encouraging the creation of jobs, supporting investments in energy efficiency, encouraging the sharing of knowledge and best practices and cultivating a thriving and competent energy services sector, the government hopes to support organisations in utilising the opportunities presented for energy efficiency through NEES.

According to Zimon, Jurgilewicz and Ruszel (2020), standardised management systems such as the quality management system (ISO9001) and environmental management system (ISO14001) are very popular with organisations that want to improve their internal process. They further add that these systems can be supplemented with the ISO50001, which focuses more on a rational energy management system. Owing to the scarcity of energy sources and associated increase in energy prices, there is an increased focus on energy management within organisations. Moreover, organisations need to adhere to the sustainable development goals related to energy. One of the methods to achieve these goals is for organisations to implement energy policies and procedures to manage and enhance their energy performance. One of these methods is the implementation of the ISO50001 guidelines. ISO50001 is not a statutory requirement but can provide sustainable energy management within organisations. As it is not required by law, there is still a reluctance for implementation.

Setting policies and procedures for managing energy within the organisation is imperative. Management, therefore, needs to understand the importance of energy policy and its adoption, appoint dedicated teams to set goals, monitor, communicate, and train employees. This paper outlines the importance and implementation of energy policy within the financial services sector, emphasising the need for management involvement and the adoption of strategies to improve energy performance.

The specific objectives of the study are as follows:

1. To determine whether organisations see the implementation of an energy policy as important for overall energy performance.
2. To determine whether an energy policy has been adopted within the organisation.
3. To investigate whether the energy policy served as a guideline to set the energy targets and objectives.
4. To determine whether the ISO50001 is used to give guidance on how to implement energy plans.
5. To investigate whether an energy manager and team have been appointed within the organisations.
6. To determine the use of energy data to improve energy performance.

The objective of the paper is to establish how financial services firms implement energy policies and procedures to manage and improve their energy performance. The paper is organized as follows: after the Introduction, in the second section, the literature analysis is carried out regarding the organizational requirements for energy in terms of ISO50001, which is based on the continuous improvement framework - "Plan-Perform-Check-Act." In the next two sections, the research design and data analysis are presented. The last section of the paper covers the conclusions and recommendations.

2. Literature review

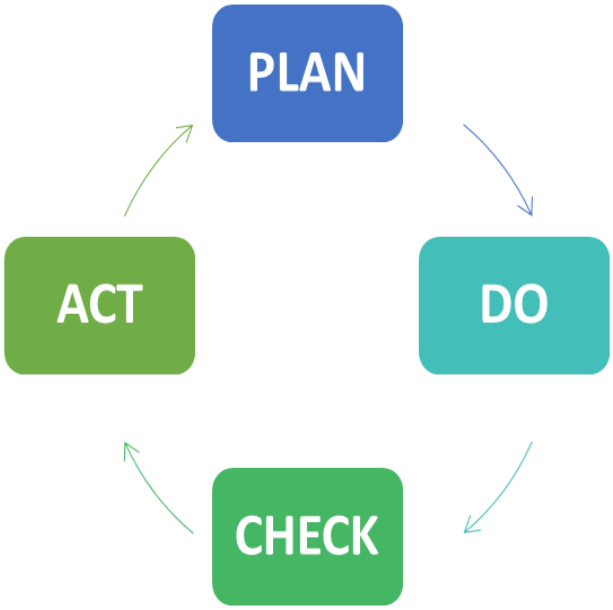
The literature review will look at the organisational requirements for energy in terms of ISO50001, which is based on the continuous improvement framework - ‘Plan-Do-Check-Act’, and how they relate to the implementation within organisations.

Organisational Energy Requirements

ISO50001 provides basic guidelines for the implementation of sustainable energy within organisations. Piñero (2011) argues that the development of an energy management standard was strongly prompted by the need to reduce greenhouse gas emissions, enhance energy efficiency and expand the use of renewable energy sources. He maintains that these guidelines aim to give managers and organisations strategies to lower their energy expenses, boost energy efficiency, and enhance their environmental performance. ISO50001 was introduced in 2011 and updated in 2018 to help public and private organisations implement management strategies to reduce energy costs, increase energy efficiency and improve overall energy performance through a systematic process (Chiu, Lo & Tsai, 2012; ISO, 2018; Fuchs, Adhajanzadeh & Therkelsen, 2020, Kurniawan & Feinnudin, 2021). Over 22,000 facilities worldwide have implemented ISO50001 by the end of 2017 (ISO, 2018). All the procedures needed for an energy management system are included in ISO50001, which offers businesses and organisations a global, uniform framework for energy management (Chiu et al., 2012; Gopalakrishnan & Ramamoorthy, 2014; Naden, 2018). The standard only applies to actions that an organisation controls, allowing them to control energy performance, meet targets and implement suitable plans if targets are not met.

Since the start of the 21st century, organisations have faced challenges related to energy savings and aims to reduce GHG emissions (Rizzon & Clivillé, 2015). Organisations face economic costs related to energy and environmental and social costs because of the depletion of resources and the increasing contribution to climate change. However, organisations cannot control energy costs, government policies, or the global economy but can implement energy management strategies to improve energy management within their respective organisations (ISO, 2018). The defined framework known as the energy management system (EnMS) outlines the objectives, guidelines, rules, and procedures that must be followed to preserve and enhance energy management within organisations (Gopalakrishnan & Ramamoorthy, 2014). ISO50001 is based on a continuous improvement framework, 'Plan-Do-Check-Act' (PDCA), which incorporates energy management into the organisation's daily activities (Figure 1).

Figure 1
Plan-Do-Check-Act structure of the ISO50001 EnMS



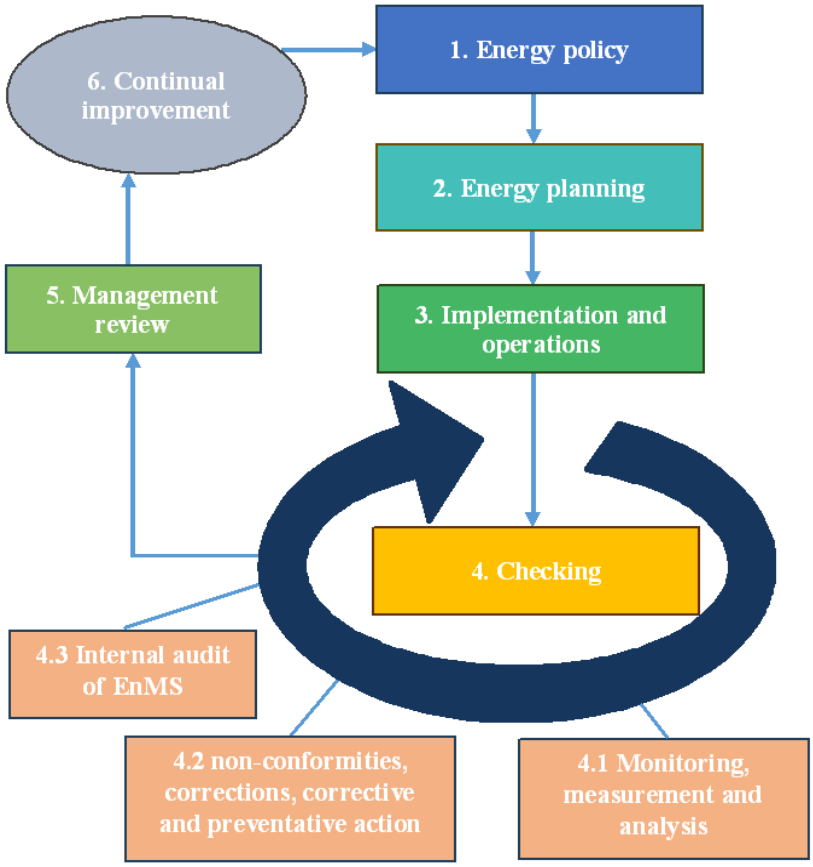
Source: Stapleton, Glover & Davis, 2001

In evaluating the steps within the EnMS and how this relates to the PDCA structure, the first step in the EnMS is to establish an energy policy. According to Kurniawan and Feinnudin (2021), an organisation needs to have an energy policy describing the adopted general strategies in order to implement an energy management system. The establishment of an energy policy is a critical step for the successful implementation of an energy system, which must involve all organisational stakeholders (Gopalakrishnan & Ramamoorthy, 2014). The organisation's commitment to enhancing energy performance is expressed in the formal energy policy, which is issued by top management and should be appropriate for the scale of the organisation's energy use (Gopalakrishnan & Ramamoorthy, 2014).

Figure 2 shows the energy management system according to ISO50001. This process consists of energy policy and planning, implementation, monitoring, review, and continuous improvement of this process within an organisation.

Figure 2

Energy Management System for ISO50001



Source: Stapleton, Glover & Davis, 2001

The energy policy within organisations is the driving force for the implementation and improvement of the organisation's energy performance in accordance with the targets and objectives (Martinez-Sanchez et al., 2023). Top management is responsible for developing and implementing an energy management statement and communicating this to all stakeholders and should show their commitment towards establishing energy goals and targets (Lawrence et al., 2019; Martinez-Sanchez et al., 2023).

Energy planning, which is associated with the plan phase of the PDCA, is the subsequent step in the EnMS. The first phase in the

PDCA procedure, shown in Figure 1, is planning. In this phase, the company needs to (1) examine all statutory and regulatory requirements; (2) examine energy data and find areas for major improvements; (3) provide a baseline year for comparison; (4) create metrics of energy performance to assess energy efficiency; (5) determine the goals and objectives; and (6) outline the action plans. Kurniawan and Feinnudin (2021) further state that in this stage, energy consumption is evaluated through an energy audit, which will indicate the consumption profile, baseline for key performance areas, and areas for improvement.

This action plan outlines the steps that must be followed, along with the roles and strategies used to accomplish these goals (Stapleton et al., 2001). Therefore, establishing an energy baseline is necessary for organisations to calculate savings on energy when the plan is put into action (Jin et al., 2020). This baseline year can be determined through an energy review and will rely on the availability of pertinent data (Chiu et al., 2012; Gopalakrishnan & Ramamoorthy, 2014; Jin et al., 2020). Analysing energy use and consumption, identifying regions of significant use, and spotting possibilities to improve energy performance are all part of the energy assessment (Gopalakrishnan & Ramamoorthy, 2014). Plans for communication with all internal stakeholders, document management and upkeep, the creation, acquisition, and application of operational controls, and staff training and awareness are also included (Stapleton et al., 2001). Martinez-Sanchez et al. (2023) further emphasise that energy awareness needs to be created within organisations to show the importance and benefits of the EnMs for efficient energy use.

The Do phase in the PDCA structure relates to the third step in the EnMS, "implementation", where the organisation is required to implement the plans they made. In this phase, the organisation needs to train employees to be aware of the various energy targets and objectives, as they need to monitor these within their business units (Martinez-Sanchez et al 2023). To determine whether the EnMS is functioning, the third phase of the PDCA structure is utilised (Figure 1). This relates to the fourth EnMS step, "checking", and entails the following: conducting internal audits; identifying noncompliance; determining the need for corrections and preventative actions; monitoring, measuring and analysing the various activities within the energy plan; assessing compliance with all requirements; and controlling the data and records of the process outcomes (Stapleton et

al., 2001). In addition, organisations must periodically monitor, measure and analyse their energy performance in accordance with the EnMS (Gopalakrishnan & Ramamoorthy, 2014). Furthermore, Gopalakrishnan and Ramamoorthy (2014) argue that internal audits of the EnMS process are also necessary to ensure that the organisation has met the standard's requirements, achieved its energy targets and objectives, and successfully implemented and maintained the plan. These audits can assist organisations to improve their energy performance.

The final step in the EnMS process is to identify current and future non-conformities. These variations can be used to identify areas where the standard's requirements are not currently being met or where there is potential for improvement. The organisation must then identify corrective and preventative actions to rectify the non-conformities (Gopalakrishnan & Ramamoorthy, 2014). The final section of the PDCA structure outlines the management's plan for process review-based continuous improvement. This is in line with the management review step five of the EnMS process. After reviewing all the EnMS activity findings, management will decide how best to improve the organisation's operations and energy performance (Stapleton et al., 2001). According to Antunes, Carreira and Da Silva (2014), a system review is required to assess how resources are allocated within the energy management system and to make any necessary changes to the energy policy, objectives and targets. Management responsibility, roles, responsibilities, authority, and energy policy form part of the underlying foundation of the PDCA.

Management Responsibility

According to Kurniawan and Feinnudin (2021), top management plays a significant role in the implementation of the ISO standard by:

- ensuring a suitable energy policy is in place;
- showing commitment to complying with regulations;
- implementing continuous improvements in energy performance;
- determining and assessing energy targets;
- providing the necessary resources and information;
- doing regular assessments of progress;
- documenting and communicating the strategies to all stakeholders.

Top management's dedication to the EnMS and the ongoing development of their energy management plans are an essential component of their organisational approach to energy management, which top management must acknowledge (Martinez-Sanchez et al., 2023).

Roles, Responsibility, and Authority

Management is responsible for appointing an energy team and an energy manager. This group sets the organisation's energy expectations and goals, keeps an eye on energy performance and works to enhance the system and employee behaviour related to energy consumption (Martinez-Sanchez et al., 2023). The team's duties include setting energy targets, organising energy projects, creating cost estimates, putting benchmark energy projects into action, and keeping track of energy savings through monitoring and assessment. The integration of the energy team's activities is displayed in Table 1, reflecting several organisational divisions the energy team represents.

Table 1

Energy management activities within the energy team

Integration of energy management activities	Energy management team	Engineering department	Financial management department	Building, design, and maintenance department
Establish energy goals	√			
Plan energy projects	√	√		√
Develop cost estimates for the projects	√	√	√	√
Implement energy projects	√	√		√
Track energy savings	√			

Source: Energy Star (2005)

Energy policy

Creating, implementing and disseminating an energy management policy to the organisation's stakeholders is the responsibility of management and will enhance the improvement of the organisation's overall management strategy. Organisations can set up their energy management process using ISO50001, which includes planning, implementing, monitoring, and reviewing the process for

ongoing improvement and setting an energy policy and targets. The energy policy should be a short statement that all stakeholders within the organisation can understand and implement within their work activities (Martinez-Sanchez et al., 2023). Risk management ought to be a component of the organisation's energy strategy to identify and assess the different risks that impact energy initiatives. The plan must be communicated using training and awareness efforts as the last task.

3. Research design

According to the IEA (2021), industry (37.55%), residential (26.31%) and transport (16.46%) is the three major contributors to the final energy consumption in South Africa. Followed by commerce (7.36%), agriculture (2.97%), fishing (0.11%), non-specified (1.62%) and non-energy use (7.61%). There are currently 275 companies listed on the JSE, with 34.91% within the financial industry, 16.36% in the industrial industry, 16.36% in basic materials, 13.82% in consumer services, 7.64% in consumer goods, 5.09% in technologies, 2.55% in health care, 2.18% in telecommunications and 1.09% in oil and gas (Listcorp, 2024). Although the Department of Energy (2015) prioritised the mitigation actions on climate change within the energy, transport, mining and industrial sectors, there is still great potential for implementing energy management strategies and reducing costs within the other sectors. Although energy consumption within the commerce sector is still low, there are many opportunities for improvement in energy usage and management within this sector, especially the financial services sector, which plays an important part in the economy.

The research employed a quantitative non-experimental design, utilising a questionnaire, to evaluate the importance and adoption of energy policy within the South African financial services industry. The questionnaire was developed after an extensive literature review on the international, domestic and organisational requirements. The study focused on managers within the financial services industry involved in operations and strategic decision-making. Managers are involved in the implementation of policy and regulatory requirements, and they were selected for the study. The study involved 142 participants, and 77 responses were obtained, achieving a response rate of 54%, ensuring that the findings and conclusions can be regarded as reliable and representative. The survey included closed-

ended questions and covered aspects of whether an energy policy is important, whether the organisations adopted an energy policy if the energy policy serves as a guideline for setting their targets and objectives, whether the energy data were used to identify opportunities for improvement, the adoption of ISO50001 within the organisations and whether they appointed an energy manager and energy team within the organisation. The questionnaire made use of a five-point Likert scale and was pre-tested by an industry expert, two academics, and a statistician to improve the questionnaire and ensure its validity and reliability. The reliability of the questionnaire was checked using Cronbach's alpha with a value of 0.97, showing a relatively high standard of internal consistency. The data was analysed using descriptive statistics in the form of distributions and percentages.

This study has received ethical clearance from the Research Ethics Review Committee of the Unisa College of Economic and Management Sciences. Research participation was voluntary and anonymous.

4. Analysis and results

This section reflects the results of examining management issues involved in energy strategy, namely energy policies, the level of energy policy adoption within the financial services sector and the effectiveness of the policy in helping to set energy targets and objectives. The study reported in this paper investigated whether energy data was reviewed to identify opportunities for improvement and whether organisations implemented ISO50001.The energy policy is a formal statement made by management indicating their commitment to improving the organisation's overall energy performance. The energy policy is a crucial step in the EnMS and should include all stakeholders. Therefore, management is responsible for developing and implementing the energy strategy within the organisation to improve the overall management strategy. Martinex-Sanchez et al. (2023) indicated that the energy policy is the driving force for the implementation and improvement of energy performance within organisations. Although most of the respondent recognises the importance of energy policy (68.83%), a significant portion (38.96%) indicated that their organisations had not yet adopted an energy policy (Table 2). Ensuring a suitable energy policy is in place is a function of top management (Kurniawan & Feinnudin, 2021), and it is, therefore,

imperative for top management within these organisations to play a significant role in setting their organisational energy policy in place.

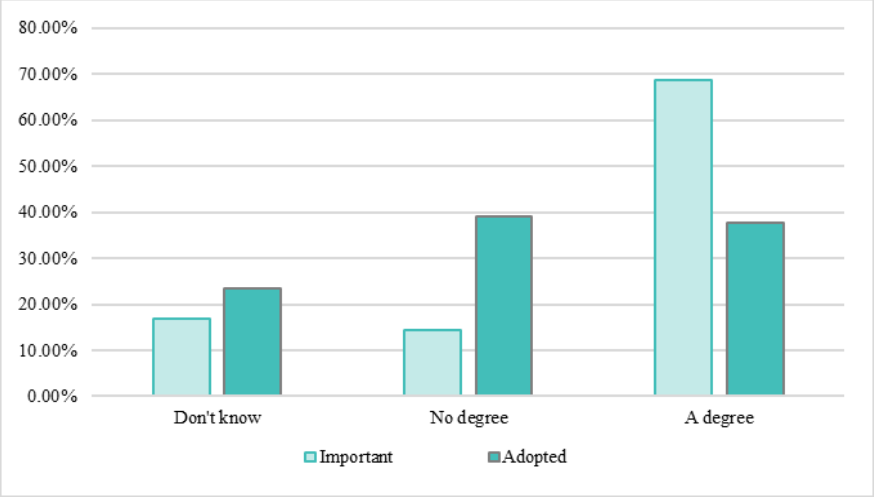
Table 2
Importance and adoption of energy policy in the organisation

	Importance of energy policy	Adoption of energy policy
Don't know	16.88%	23.38%
No degree	14.29%	38.96%
A degree	68.83%	37.66%

Source: Author's compilation

Figure 3 shows that there are still some respondents who were not aware of whether there is an energy policy within their organisations (23.38%), and almost 40% indicated that their organisations have not yet adopted an energy policy. Top management is responsible for documenting and communicating the energy strategies to all stakeholders (Kurniawan & Feinnudin, 2021). With the respondents indicating that this is an important aspect within the organisation, the level of communication and training with regards to the energy policy might assist the organisation in creating a holistic view of their energy objectives throughout the organisation.

Figure 3
Importance and adoption of energy policy in organisation



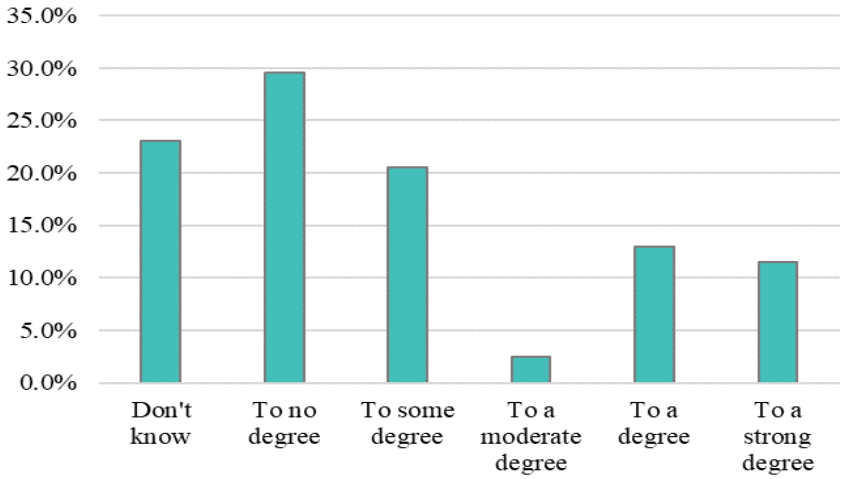
Source: Author's compilation

According to the literature, energy policy sets the framework for action and assists the organisation in setting its targets and objectives (Lawrence et al., 2019; Martinez-Sanchez et al., 2023). The energy policy, targets, and objectives are created to improve the organisation's processes and procedures. The question related to whether the energy policy served as a guideline within the organisation to set energy targets and objectives. As depicted in Figure 3, 23.1 per cent of respondents said they were unsure, with 29.5 per cent indicating the energy policy did not act as a guide to provide direction for determining energy targets and objectives.

Figure 4 illustrates that of the 47.4 per cent of respondents who said the energy policy affected the determination of energy targets and objectives, 20.5 per cent said it has some influence and only 11.5 per cent said it has a strong influence.

Figure 4

Energy policy as a guide for energy target and objective setting



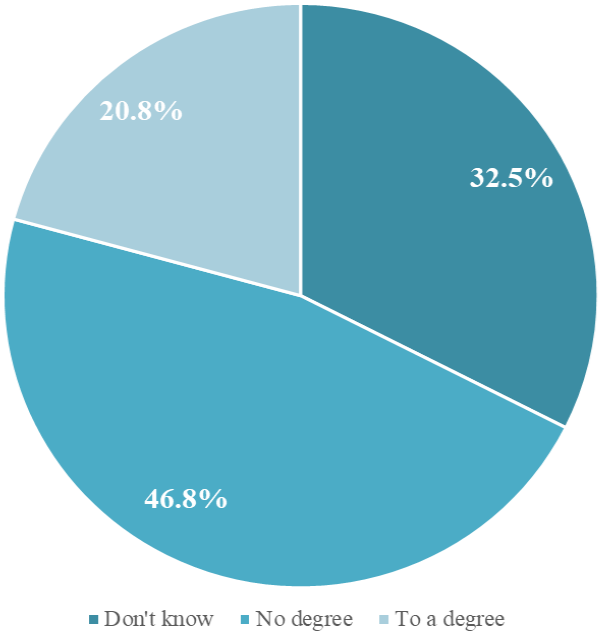
Source: Author's compilation

The need to reduce greenhouse gas emissions, promotion of energy efficiency and increase the use of renewable energy gave rise to the introduction of ISO50001 (Piñero, 2011). The standard was designed to develop systems and processes for improving energy performance, use and consumption. A majority of the respondents (46.8%) reported that ISO50001 was not applied in their organisation, although 32.5% said they were unsure if the organisation had done so.

As Figure 5 illustrates, just 20.8 per cent of respondents said they had applied ISO50001. The standard applies only to activities under the organisation's control, where it can set targets and objectives and control energy use. If the goals are not met, ISO50001 gives guidance on how to implement plans.

Figure 5

Implementation of ISO50001



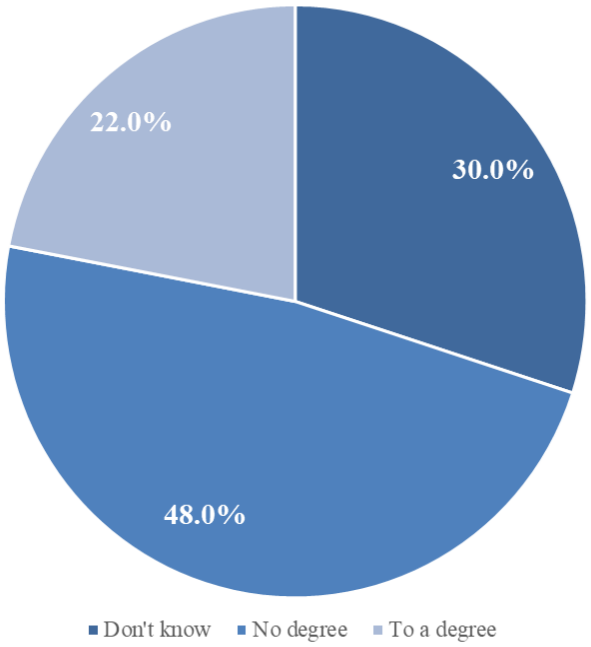
Source: Author's compilation

The issue of roles, duties, and authority surrounding energy strategies within the organisation is one of the fundamental views of PDCA. Within any organisation, the management is in charge of appointing an energy manager and an energy team. This energy team's duties include setting the organisation's energy goals and expectations, keeping an eye on energy performance, and, where necessary, enhancing energy-use systems and behaviour. The energy team also creates cost estimates, plans pertinent energy initiatives, establishes energy targets, and executes and oversees various energy projects, as indicated in Table 1. Training and educating everyone in

the organisation about the various energy solutions is the last task. Thirty per cent of the respondents said they were unsure if their organisations had an energy manager and team, while most respondents (48%) said that their organisations lacked an energy manager and an energy management team in charge of setting goals and targets. Figure 6 shows that only 22 per cent of respondents said their company had an energy manager and energy team. This could be because, at the time of the investigation, the majority of organisations had not yet implemented ISO50001 (20.4%) or a formal energy policy (38.96%). Therefore, organisations must conduct more research in this area to develop and execute appropriate energy management measures inside their own organisations.

Figure 6

Appointment of energy manager and energy team



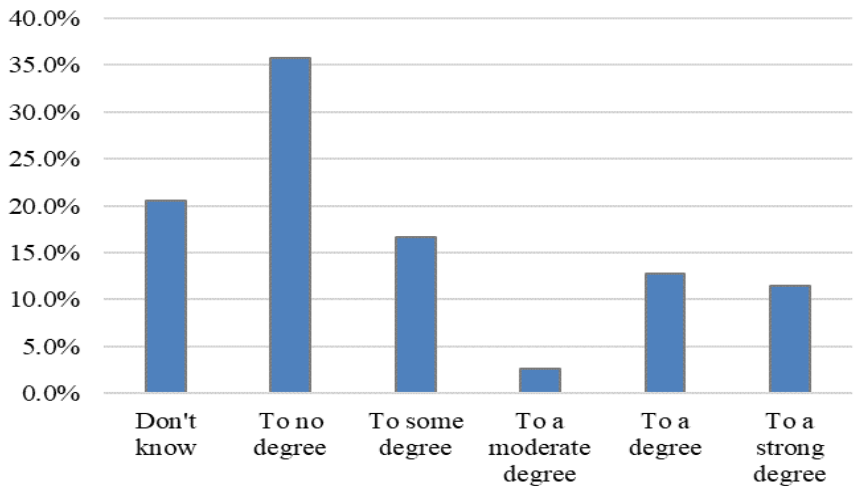
Source: Author's compilation

The energy review comprises an analysis of energy consumed, overall consumption, areas of major use, and potential for improvement in relation to the baseline year (Gopalakrishnan & Ramamoorthy,

2014). A review of energy data is essential to improve energy policy and evaluate the allocation of resources used in the energy management system (Antunes et al., 2014; Kurniawan & Feinnudin, 2021). The data made it evident that 56.4 per cent of the respondents said their organisations either did not review the energy data to find possibilities for continuous improvement or did not know. Figure 7 shows that of the 43.6 per cent of respondents who said their company assessed its energy use, 16.7 per cent said the review was done to some degree, 2.6 per cent to a moderate degree, 12.8 per cent to a degree, and just 11.5 per cent said it was done to a strong degree.

Figure 7

Identify opportunities for improvement from energy data



Source: Author's compilation

Within their own organisations, over half (62.34%) either did not have a formal energy policy in place or were unaware of one. Energy policies serve as the official foundation for action; therefore, it is critical for organisations to create them to demonstrate their dedication to raising overall energy performance. Energy policy also helps organisations in setting energy targets and objectives. The energy policy, according to over half of the respondents (52.6%), did not act as a guide for targets and objectives, which might be owing to the fact that they have not adopted a formal energy policy, which is an area where management within the organisation could improve. Another management aspect that was identified was the review of energy data.

Reviewing energy data is an important management function to change energy policy, adapt energy goals and objectives and evaluate the resources used in the energy management system (Antunes et al., 2014; Gopalakrishnan & Ramamoorthy, 2014). Fewer than half of the respondents (43.6%) indicated that energy data was reviewed and used to identify opportunities for improvement. This is an area in which organisations can improve when implementing strategies. ISO 50001 assists to encourage energy efficiency and reduce greenhouse gas emissions. While not required, this standard may benefit organisations in managing their energy plans. According to data obtained during the present investigation, it was evident that, at the time of the investigation, only 20 per cent of organisations had adopted ISO50001. This might be an area for organisations to consider improving their energy management.

5. Conclusion and recommendations

This paper underscores the critical importance of integrating energy policies and management systems within organisations, particularly in the context of South Africa's evolving energy landscape. The international shift towards sustainable practices has increased the focus on aligning business strategies within international and domestic energy policies. The South African energy-related policies, including the White Paper on Energy Policy and the White Paper on Renewable Energy Policy, highlight the intricate goals of energy supply diversification, energy growth and environmental responsibilities. ISO50001 is a guideline framework for the implementation of sustainable energy practices within organisations and highlights the importance of a comprehensive approach to energy management. The PDCA structure, in conjunction with the EnMS provides organisations with a roadmap for establishing their energy policy, setting targets and continuously monitoring and improving energy performance. The adoption of energy policies and energy management is of paramount importance for South African organisations aiming to reduce costs and greenhouse gas emissions. Furthermore, organisations should appoint a dedicated energy manager and team to oversee energy-related tasks and responsibilities. The study showed the importance of setting an energy policy within the financial services sector. An energy policy is the starting point and driving force for the implementation of energy management systems and should be the first priority for managers who

have not yet implemented such a policy. The findings showed a gap in the adoption of energy policies, with a significant proportion of respondents indicating a lack of implementation. The findings further showed challenges in using energy policies to effectively set energy targets and objectives. Once the energy policy is in place, it will serve as a guideline for setting energy targets and objectives. Using the ISO50001 framework can guide organisations in the implementation of energy management as well as the utilisation of their energy data for continuous improvements. Management should show commitment to energy policy and plans within the organisation and facilitate the awareness, communication and training initiatives to staff to assist in improving the action plan.

As the study focuses only on the financial services sector, the findings might not be relevant to all industries. The industrial sector, which has more regulation in terms of energy, might have a higher implementation of the requirements than those within the financial services sector. A broader study incorporating all industries could add value to how different industries implement the ISO 50001 and the effect on their overall energy cost. As the study only made use of descriptive statistics, a more comprehensive study on the implementation and impact on energy cost could add value to the importance of implementing a sound energy management strategy.

The holistic approach advocated emphasises the need for organisations to embrace ISO50001, evaluate their energy performance, and align their business strategies with the sustainability goals. As organisations navigate the ever-changing global landscape, the integration of robust energy policies emerges not just as a regulatory necessity but also as a strategic imperative for long-term success and corporate social responsibility.

As energy policy is the driving force for implementing and improving organisational performance, further research could be conducted through content analysis to evaluate the various energy policies of organisations to see what is included and how they structure these policies within the organisation.

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