Revisiting the linkage between internal audit function characteristics and internal control quality

Abstract

This paper revisits the linkage between internal audit function (IAF) characteristics and internal control quality (ICQ). Using the responses of 48 chief auditing executivesfrom Greek listed companies, we consider a random polynomial-kernel, metabolized regression model leveraging fromthe approach of Oussi and Taktak (2018) in MATLAB environment. Our results demonstrate that the proposed random polynomial model is valid, reliable, and appropriate to assess ICQ; presenting over 3 times better estimation performance when compared to the linear regression case. Our findings suggest that the proposed model can serve as a starting point for companies and practitioners to improve ICQ level, through the assessment of certain independent variables. On that basis, our study offers insights to regulatory bodies, auditors, and scholars in perceiving the contribution of the IAF'S constituents on ICQ. Finally, our approach is expected to inspire conclusive follow-on research on the ICQ assessmentin other countries with similar settings.

Keywords - Internal Control Quality Estimation; Random Polynomial Regression; Internal Audit Function, Greek Listed Companies.

Paper type–Research paper

Key messages

- Our results demonstrate that the proposed polynomial model is valid, reliable, and appropriate to evaluate ICQ
- This polynomial model presents over 3 times better estimation performance when compared to the linear regression case
- Our study offers insights to regulatory bodies, auditors, and scholars in perceiving the contribution of the IAF'S constituents on ICQ

1. Introduction

Studies regarding internal audit (IA) and self-assessment in organizations have been rigorously conducted for several decades now (Gramling *et al.*, 2004; Ramamoorti, 2003). Although auditors play a significant role in the smooth corporate operational strategy execution, they have not often been consideredas a part of the corrective factors within companies, especiallywithin thesmall and medium-sizedenterprises, which would usually avoid both,complying even with the basic financial legislation andpaying the imposed charges, putting their own viability at undue risk. PCAOB (2007) contends that effective IA is vital to ensure high-quality financial reporting.

Previous research has demonstrated that Corporate Governance (CG) plays a crucial role in preventing corporate collapses and financial scandals (Baydoun et al., 2013; Endaya and Hanefah, 2016; Hazami-Ammar, 2019; Park et al., 2019). In this vein, IAeffectiveness may constitute an essential factor toenhancefinancial reporting reliability and restore investor confidence (Lin et al., 2014; Prawitt et al., 2009; Rubino and Vitolla, 2014; Tang and Karim, 2019). However, on this occasion, many issues need to be addressed since corporate environment is affected by complex and unpredictable dynamics (i.e., unpredictable market and human behavior, political and economic conditions, employees, and employers perceived relationship, etc.) (see, McConnell, 2017). On that basis, a new fruitful research area is emerging on this landscape that challenges the existing methodologies of measuring ICQ (Thompson, 2018). This in practice means, that scholars and auditing community must overcome all recording problems with increased transaction volumes, scale and complexity and engage all real-life systems among different corporal-functioning factors.

Within this context, what is preferred is a holistic enterprise resource planning (ERP), which would combine all operational processes to attain centralized performance and profit optimization by taking into consideration digital records and logs (Spraakman *et al.*, 2018). Thus, auditors are expected to implement the capabilities of modern ERPs, which function as providers oflarge amounts of recorded data received from well-monitored and widely used channels (e.g., e-commerce, online payments, etc.) and, to identify either explicitly or implicitly as well as recognize valuable insights and informationpertaining accounting (Madami, 2009).Hence,it isauditors' responsibility toaudit enough recorded data so that their audit judgment is justified objectively and impartially. In other words, auditors should assess and prioritize potential key risks against the potential negative impact on enterprise goals (Dzuranin and Mălăescu, 2016; Curti, Migueis and Stewart, 2019; Lois et al. 2020). To conclude, IA is required to be flexible enough to cope with a dynamic andat the same time cumbersome business model, and to tackle a highly stochastic problem, within a reasonable amount of time to respond.

The flexibility and updatability of IA, can ensure an adaptive and robust IA execution, capable of integratingmultiple corporal key performance indicators: value-chain symbiosis, resource use optimization, regulatory and legislation framework compliance, employees' satisfaction, executive governance revenues, accounting transparency, and so on (Mihret andv Woldeyohannis, 2008).Thanks to the rapid technological advances in micro-processing sector, the traditional manual audit process has been enriched by more tedious and computationally demanding software tools that are steadily becoming part of the auditing procedures (Shin *et al.*, 2013). Data examination via common database query, data-requesting or data-visualizing commands, which may provide the framework for analysis and extraction of intuitive insights but lacks in information mining[1] and patterns profiling/recognition, is usually enabled by ERP and software auditing tools (Kuhn and Sutton, 2010).

On the other hand, over the last centuries, considerable research has been devoted to extracting information from recorded data manually (Nasar *et al.*, 2018). Due to the recent advancements in computer technology with regard to storing, handling, and processing capacity, the emergence of the automated data analyzing software methodologies and tools was inevitable, which in turn led to the development of well-established computer science methods: neural networks, cluster analysis, genetic algorithms, decision trees and decision rules, and support vector machines (Han *et al.*, 2011; Witten *et al.*, 2011).It is apparent that auditors' situation analysis can be facilitated with the use of Information-Mining as the latter provides auditing powerful automated tools which offer a systematic approach for corporate decision-support and strategic planning. Hence, enterprises could achieve their sustainability goals with the aid of formal and informal management control (Crutzen*et al.*, 2017).This suggests that in order to devise a new tool (i.e., measurement system) that would encompass all dimensions for long term value creation process, a multidimensional perspective is required (Bonacchi and Rinaldi, 2007).

The aforementioned techniques focus on computation efficiency by implementing possible solutions to transcend any limitations sprung from the scale and complexity of the dynamics entailed within operational malfunctions and fraudulent acts. Normally, in IAF execution, the cutting-edgestrategies employed, use visual analytics to assist human decision makers and auditors, to draw conclusions and assess the present state of the enterprise (Whitehouse, 2014). The internal audit function (IAF) strategy is generally considered to be a factor of ensuring high quality in the internal control system.

Yet, little research attention has been given to what extent and how the IAF specifications affect the internal control quality. The number of studies about the internal control weaknesses related to the IAF practices (Fadzil *et al.*, 2005; Lin *et al.*, 2011), is generallyrather limited.

[1]"Information-Mining" term is considered to represent better the exact same scientific topic as the much more widely used buzzword "Data-Mining". Both terms are equivalently used herein.

To continue, they are limited in two ways. On the one hand, the analyzed IAF practices do not usually consider the impact that a shared workplace has onIA and the audit committee (AC), having available only limited literature (Barroso-Castro *et al.*, 2016; De Silva Lokuwaduge and Armstrong, 2015; Pugliese *et al.*, 2009). On the other hand,due to the low modeling complexity,the model versions are simplistic and they can neither yield reliable results nor generalize with acceptable error variance (IIA, 2016; Johl *et al.*, 2013; Oussii and Taktak, 2018; Pizzini *et al.*, 2015).Also, thanks to the fact that data is highly available and easily accessible, this research revolves around the US enterprises' case, thus,its conclusions "replicability" is limited, when it comes to particular cases found in other specific countries (Becker *et al.*, 1998; Hope *et al.*, 2013; Khlif and Samaha, 2014; Kinney *et al.*, 2004).Finally, the increased application complexity does not allow pertinent scientific studies to fill the existing gap between accounting / auditing and information mining topics (Al-Khaddash *et al.*, 2013; Rezaee *et al.*, 2002).To conclude,in the Greek paradigm, there is lack of scientific interest and substantial evidence to overcome the limitations mentioned above.

The recent financial turbulence affected various Eurozone countries (Cohen and Karatzimas, 2018). In Greece, the financial crisis sparked considerable interest in the internal control systems (Repousis *et al.*, 2019). Greece is located in Southeast Europe and at that time, its gross domestic product per capita was $20,311while its unemployment rate reached about 19.85%, based on the data that had been gathered since October 2018 (IMF, 2018). Greece's main economic problem is structural,and it reveals the need for new measures that stem from the concept of management control systems (Katharaki and Tsakas, 2010; Malmi and Brown, 2008). The financial crisis has pushed to the top of the agenda the importance of CG and IA (Drogalas et al., 2018). The two main goals of this study are to detect the level of ICQ dependence and then, justify the significance of the assessment of internal control regarding the performance of the Greek enterprises while the country's economy is in a recession.

The contribution of our study is twofold. First, we contribute to the current literature by examiningthe application of a random polynomial regression model-training methodology on a real-life data sample which is evaluated using extended verification tests in the Greek context. In particular, we draw attention to the order (denoted with N) as well as the number of the monomials (denoted with M) to demonstrate the total estimation error of the trained model, using an automated abstract exploration strategy considering exhaustive tests of all possible different [M,N] combinations. Secondly, we advance an emerging branch of IA literature which seeks to resolve problems with high complexity. In this vein, we indicate the efficiency levels of the polynomial regression against the linear case. In this sense, we bridge the gap between theory and practice.

Our empirical findings, concerning the Greek enterprises application case, are generally in agreement with the expected ones since the extensive exploration of the best polynomial regression model, considering M=31 monomials and N=12 maximum order, presented over 3 times better estimation performance (3 times smaller total approximation error) both for the training (known) and validation (unknown) dataset cases, in comparison with the most commonly simplified case of a linear regression model.Consequently, an automatized multi-polynomial regression method may reduce the modeling and training effort to a considerable degree while presenting higher estimation efficiency compared with simplified classic linear regression.

The rest of the paper is organized as follows: Section 2 focuses on the specified research hypotheses. Section 3 presents the variables and indexes considered for formulating the independent as well as the regression variables. Section 4 presents the main ideas behind the proposed statistical methodology. In the fifth section the proposed methodology's extensive tests are presented briefly. In the sixth and final section we summarize the findings, and we present the implications and limitations of the study.

2. Literature review
2.1. The Greek Corporate Context

The Athens Stock Exchange (ASE) is small in terms of market capitalization and the number of listed firms (Dasilas and Leventis, 2011). In particular, the financial system is characterized as an insider since the main sources of funding are internal (Sikalidis and Leventis, 2017) and it is dominated by the presence of family firms (Nerantzidis and Filos, 2014). Indeed, the Greek institutional structure has been influenced by the French (La Porta et al, 1998) and offers a weak regulatory quality, a weak legal enforcement, and poor shareholders' protection (La Porta et al, 1998; Karampinis and Chevas, 2009). This reflects the strong involvement of the family in Corporate Governance and may explain why Type II agency problems have arisen between controlling families and minority members (La Porta et al., 1999). Thus, the CG environment in Greece has been criticizedfor being of low quality (Lazarides and Drimpetas, 2011).

The Greek financial reporting environment has been influenced by the adoption of International Financial Reporting Standards (IFRS) on January 1, 2005. However, Greece has the lowest score of legal enforcement regarding IFRS implementation (Li, 2010). This may be explained by the extraordinary characteristics of the economic and institutional environment (Tsipouridou and Spathis, 2012).

The Greek CG framework has been reformed the last decades by a series of laws incorporating the guidelines and directives of the European Union (EU). The Law 3016/2002 is the most important law for CG and internal auditing in Greece, since it has imposed several compulsory and organizational regulations for the first time in Greek listed firms (Koutoupis, 2012). For instance, it mandates the establishment of an internal control function. The Law 3693/2008 (incorporates the European Directive 2006/43/EC) introduces the establishment of Audit Committees (AC's) on listed firms and imposes important obligations regarding notifications (Drogalas et al. 2020, Drogalas et al. 2021). The recent Law 4449/2017reinforces the composition and the duties of AC's. For example, Article 44 states that AC's committees must be composed by at least three members, most of whom must be independentof the audited entity. It also mentions that the AC is directly responsible for the appointment, compensation, retention, and supervision of external auditors (Drogalas et. al. 2021). Today, the AC monitors the efficacy of internal audit procedures and supervises the operation of the internal audit department while it also oversees the quality of financial statements and risk management practices (Grose et al. 2020).

2.2. Research hypotheses

The effectiveness of the Internal Auditing is highly correlated with the CG environment; despite that, no deterministic and statistical tools have ever been used to calculate this relationship by using analytical procedures (Lenz *et al.*, 2014). There is a number of diverse studies on the composite measure (index) that is regarded as representative for the IAF effectiveness, available in literature (Alhajri, 2017; Alzeban and Sawan, 2015; Johl *et al.*, 2013; Lenz and Hahn, 2015; Pizzini *et al.*, 2015; Prawitt *et al.*, 2009; Sarens *et al.*, 2009; Soh and Martinov-Bennie, 2011).Similarly, the current study seeks to create the problem of quantifying the effect of IAF features on ICQ. According to the theoretical framework, IAF is a vital reporting mechanism for effective corporate governance that aims to decrease the situation awareness inadequacies (Goodwin-Stewart and Kent, 2006; Sarens and Abdolmohammadi, 2011).

This study is driven by recently published studies (IIA, 2016; Johl *et al.*, 2013; Oussii and Taktak, 2018; Pizzini *et al.*, 2015) which have revealed the strong positive relationship between the IAF attributes and the quality of the internal control system and by the fact that the problem is not explored extensively in literature. Hence, the current study explores the relationship between ICQ and key IAF characteristics such as *a) IAF organizational status; b) working relationship between the IAr and the AC; c) IA staff* *competence; d) IAF investment; e) quality assurance program and; f) the follow-up on internal control deficiencies.*

The statistical hypotheses-of-study in relation to the connection between IAF attributes and ICQ, as elicited from the attributes mentioned above, are explained in the subsequent paragraphs.

2.2.1. Internal audit function organizational status

As maintained by IA attribute standard 1100 "*IA activity must be independent, and IArs must be objective in performing their work*" (Alzeban and Gwilliam, 2014; IIA, 2016, p. 3; Oussii and Taktak, 2018). According to prior studies, the IAF organizational status is one of the most important factors that affects in a positive way the dependency of external auditors' decision-making on internal control programs (Bame-Aldred *et al.*, 2013; Cohen and Sayag, 2010; Lin *et al.*, 2011). If the above is taken into consideration, a hypothesis could be formulated as follows:

H1. There is a positive relationship between IAF organizational status and ICQ.

2.2.2. The relationship between the chief audit executives and the committee

Based on previous research, in order to achieve a more concrete and objective IArs' judgment opinion, highlighting its improved execution/implementation, an efficient relationship between chief audit executives (CAEs) and IAF (positively affect) is essential (Alzeban and Sawan, 2015; Arena and Azzone, 2009; Dal Mas and Barac, 2018; Drogalas *et al.*, 2019).For instance, Sarens, Abdolmohammadi and Lenz (2012) support the view that IAF's interactions with the AC, influence positively the IAF's role. This is the reason whywe anticipate the AC's engagement in IAF to have an effect on ICQ. Thus, the following hypothesis is formed:

H2. There is a positive relationship between the AC's involvement in reviewing the IAFexecution and ICQ.

2.2.3. Internal audit function competence

IArsshould have the required capabilities and obtain other competencies to rise to their challenges (Farkas *et al.*, 2019).Similarly, the IAF program must make the most of auditors' human capital to accomplish its mission. The technical competence of the IArs should be considered by the level of adequacy of the IAF execution when assessed by external auditors (Arena and Azzone, 2009; IIA, 2016, p. 6; Mihret *et al.*, 2010; Soh and Martinov-Bennie, 2011). IAF execution effectiveness will be improved if IArs are technically competent. This will also contribute to the elimination of internal control deficiencies. As a result, the following hypothesis is considered:

H3. There is a positive relationship between IAF competence and ICQ.

2.2.4. Internal audit function investment

Previous research has revealed that the distribution of greater resources for IAF could lead to higher ICQ with better-skilled IArs and more effective risk assessment and mitigation mechanisms utilized (Alhajri, 2017; Bedard and Graham, 2011; Gramling and Myers, 2006). For this reason, IAF execution effectiveness is more likely to affect positively the available tools and resources to the IA staff. Therefore, the following hypothesis is proposed:

H4. Allocating greater resources for IAF leads to less severe internal control weaknesses.

2.2.5. Quality assurance and improvement program

Apart from the suggested constant monitoring and regular external independent evaluation, one of the key responsibilities of the CAEs is the development and maintenance of the ICQ assurance program that would cover all the featuresof the IA activity i.e., ethics, standards (IIA, 2016, p. 7). A number of studies demonstrate a positive relationship between the quality assurance techniques and ICQ reporting (Johl *et al.*, 2013; Lin *et al.*, 2011; Pizzini *et al.*, 2015). The above leads to the assumption that there is a positive association between the use of quality assurance practices and the ICQ. Therefore, we hypothesize that:

H5. There is a positive relationship between internal audit quality (IAQ) assurance and ICQ.

2.2.6 Follow-up on internal control deficiencies

The knowledge acquired from past events and abnormal deficient situations could serve as a concrete basis for the design and adaptation of the IAF execution by responsible chief executives, as it could contribute to the achievement of a coherent and sound ICQ management. This would also encourage the creation of a follow-up process to monitor and recognize past-observed internal control inadequacies in due time (Lin *et al.*, 2014). Thus, there is a positive connection between the availability of such strategies and procedures with the ICQ, giving rise to the following hypothesis of the study:

H6. There is a positive relationship between the existence of follow-up process and ICQ.

3. Research method

In this section, the indexes as well as the analytic formulations used for the preparation of the data for the model training process will be briefly presented. In total, six independent variables along with four control variableswere used for the formulation of the polynomial regression model under investigation, in line with the approach implementedby Oussii and Taktak (2018).

3.1. Test Case Sample

For thecollection, study and analysis of the attributes and hypotheses regarding IAF execution and ICQ, described in section 4, a survey method was adopted. More specifically, a targeted questionnaire was distributed among CAEs from companies listed on the Greek Stock Exchange (GSE) during the last quarter of 2018. In total, 78 questionnaires were successfully distributed electronically. This yielded 48 (61.5% completion rate) exploitable responses received from the 78 companies, however, 2 out of the 78 responses were inadequately filled out and as a result, neglected and 28 invitations remained unanswered. The size of the usable sample i.e., 48, represents the 26% of all 185 listed companies on the GSE. A more representative and concise conclusion could be inferred for the overall population as the sample size received is large enough. Table 1contains a brief description of the sample studied herein.

Table 1. Sample profiling.

	Percentage W.R.T. the total population	Absolute Number
Total Number of firms listed on GSE at 12/2018	100%	185
Exclusions	57.8%	107
Firms deleted because of non-responses to the survey	15.1%	28
Firms deleted because of missing data	1.1%	2
Final useable sample	26%	48

3.2. The dependent variable

Based on prior research conducted by Bedard and Graham (2011) and Oussii and Taktak (2018), the dependent variable (response of the modeled system), denoted as ICQ, whichis defined as *the number of internal control deficiencies detected annually by chief executive auditors,* is a representative index for the quality of internal control. The ICQ values have become available from a corresponding single item of the questionnaire contributed. IAF features are expected to elaborate on the IAQ and therefore, contribute to the reduction of the occurrence of ICQ inadequacies and shortcomings.

3.3. The independent variables

As already discussed, six independent variables are used for the considered statistical and relational analysis: IAF organizational status, working relationship between the internal auditor and the AC, IA staff competence, IAF investment, quality assurance program, and the follow-up on internal control deficiencies.

The variable *IAF organizational status* (IAF_OS) is a dummy post-designed variable to test H1 and it is designed to take the value one when the IAF reports functionally to the AC.

In relation toworking relationship between the internal auditor and the AC, the variable WKREL is used to test H2 and denotes whether the auditing committee reviews internal IAF program executed by IArs. It is derived by implementing a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

The variable *IA staff competence* (STF_COMP), is used to test H3 obtained by standardized and averaged fusion of five questionnaire items as follows:

$$STF_{COMP} = STF_{COMP,P} + min\left(STF_{COMP,P}\right) \quad (1)$$

Where:

$$STF_{COMP,P} = \frac{z_{EXP} + z_{EDU} + z_{CERT} + z_{TRN}}{4} \quad (2)$$

experience (denoted with EXP): company's IArs' average experience standardized number of years, available as a single questionnaire item;

$$z_{EXP} = \frac{EXP - \mu_{EXP}}{\sigma_{EXP}} \quad (3)$$

education (denoted with EDU): company's IArs' average higher education standardized number of years (after high school), available as a single questionnaire item;

$$z_{EDU} = \frac{EDU - \mu_{EDU}}{\sigma_{EDU}} \quad (4)$$

certification (denoted with CERT, i.e., Percentage of Certified IArs [over the total IArs number]): the standardized fraction of the number of company's IArs who are certified with at least one audit certification (available as a single questionnaire item) over the total number of IArs of the company, also available as a single questionnaire item;

$$z_{CERT} = \frac{CERT - \mu_{CERT}}{\sigma_{CERT}}, CERT = \frac{NoCertified}{NoTotal} \quad (5)$$

training (denoted with TRN): company's IArs' average standardized number of training hours per year, available as a single questionnaire item.

$$z_{TRN} = \frac{TRN - \mu_{TRN}}{\sigma_{TRN}} \quad (6)$$

To test H4, *the variable IAF investment* (IAF_INV) is used. It has been formulated as the fraction of a single questionnaire item (Zain *et al.*, 2006): the natural logarithm of the total number of human resources (denoted as IAF_HMR) participating in the IAF execution:

$$IAF_{INV} = ln(IAF_{HMR}) \quad (7)$$

The variable *quality assurance program*, denoted as QAS, is a variable to test H5. It has been formulated as a single composite obtained by linearly and evenly (using the sample global averages) fusing six questionnaire items as follows (Johl *et al.*, 2013):

$$QAS = QAPX + NT\_ASS + XT\_ASS \quad (8)$$

A program existence (denoted with QAPX): scalar Boolean variable, available as a single questionnaire item, indicating if (value 1) a quality assurance program/plan is being formally implemented or not (value 0);

$$QAPX = H\left(QAPX_p - \widetilde{QAPX_p}\right) \quad (9)$$

internal assessment (denoted with NT_ASS): measured as the normalized average of two five-point Likert scale questionnaire items (from: 1 – none at all; Up to: 5 - always):

i. the utilization of internal continuous monitoring tools (UT_MON);

ii. the reporting tendency of periodic auditing reviews (R_TEND).

$$NT_{ASS} = H\left(NT_{ASS,P} - \widetilde{NT_{ASS,P}}\right)\left(\frac{UT_{MON} + R_{TEND}}{\max\left(UT_{MON} + R_{TEND}\right)}\right) \quad (10)$$

External assessment (denoted with XT_ASS): formulated as the average of three questionnaire items:

$$XT_{ASS} = H\left(XT_{ASS,P} - \widetilde{XT_{ASS,P}}\right)\left(\frac{EXQA + EXASS + PREX}{3}\right) \quad (11)$$

denoted as EXQA, the existence of an external quality assessment (Yes=1/No=0);

denoted as EXASS, the implementation of a fully external assessment or self-assessment assisted by external validation (Yes=1/No=0), and;

denoted as PREX, the periodic implementation of an internal auditing external evaluation every five years (Yes=1/No=0).

Note that for all the aforementioned cases, the tilde symbol is used for denoting the median value of the respective questionnaire item sampled, while $H(x_0)$ function denotes a diversified version of the identity Heaviside step function formulated as follows:

$$H(x - x_0) = \begin{cases} 1, & x > x_0 \\ 0, & x \leq x_0 \end{cases}$$

Finally, the variable*the follow-up on internal control deficiencies* (FUP_DEF), is a post-designed dummy variable to test H6. The variable is designed to take the value of one if the IAF builds upon the knowledge acquired from previously observed internal control deficiencies.

3.4. The control variables

Moreover, several firm attributes and features are considered as independent control variables, associated with ICQ (Bedard and Graham, 2011; Khlif and Samaha, 2016; Lin *et al.*, 2011). The 4 control variables used in the model, deriving from respectively designed single questionnaire items, are: the percentage of financial experts in the AC (FC_XP); the natural logarithm of the entity's sales size (LN_SLS); the return on assets ratio financial index (ROA) and; the boolean variable that equals one only if the firm belongs to any financial industry sector (FIN_IND).

4. Regression methodology description

A random polynomial statistical regression model is used in the general case (as shown below), for the analysis of the dependencies and correlations of the considered independent and control variables with the dependent ICQ.

$$ICQ \approx \widetilde{ICQ} = \beta_0 + \sum_{i=1}^{M} \beta_i \begin{pmatrix} (IAF_{OS})^{n1}(WKREL)^{n2}(STF_{COMP})^{n3}(IAF_{INV})^{n4}(QAS)^{n5} \\ (FUP_{DEF})^{n6}(FC_{XP})^{n7}(LN_{SLS})^{n8}(ROA)^{n9}(FIN_{IND})^{n10} \end{pmatrix} \quad (12)$$

Where "n1, n2, …, n10" are positive integer numbers, denoting the order of each independent variable contributing to the total order of the monomial as follows:

$$n1 + n2 + n3 + n4 + n5 + n6 + n7 + n8 + n9 + n10 \leq N$$

A reduced version of an N-th order polynomial regression, where M is the number of monomials, and thus, the number of the unknown beta coefficients are real scalar values, is employed by the model. The linear regression model can be written again in the following concise form:

$$\widetilde{ICQ} = \theta \cdot \varphi$$

$$\theta = [\beta_0 \quad \beta_1 \quad \beta_2 \quad \cdots \quad \beta_M]$$

$$\varphi_i = \begin{matrix} (IAF_{OS})^{n1,i} \cdot (WKREL)^{n2,i} \cdot (STF_{COMP})^{n3,i} \cdot (IAF_{INV})^{n4,i} \cdot (QAS)^{n5,i} \cdot \\ (FUP_{DEF})^{n6,i} \cdot (FC_{XP})^{n7,i} \cdot (LN_{SLS})^{n8,i} \cdot (ROA)^{n9,i} \cdot (FIN_{IND})^{n10,i} \end{matrix}$$

$$\varphi = \begin{bmatrix} 1 \\ \varphi_1 \\ \varphi_2 \\ \vdots \\ \varphi_M \end{bmatrix}$$

The regression analysis strategies utilized in the results section try to descriptively or analytically estimate their values, using the surveyed dataset sample. The methodology applied considered exhaustive tests with differently parameterized tests (different combinations of N and M parameters) to explore the most efficient one, in terms of the calculated estimation error (see Section 4.2) and compare it with the benchmark case (see Section 4.1).

4.1. Base Case for Benchmarking

The following linear statistical regression model is employed to do both, test the validity of the designed problem and have a widely accepted metric for performance comparison purposes:

$$ICQ \approx \widetilde{ICQ} = \beta_0 + \beta_1 IAF_{OS} + \beta_2 WKREL + \beta_3 STF_{COMP} + \beta_4 IAF_{INV} + \beta_5 QAS + \beta_6 FUP_{DEF} + \beta_7 FC_{XP} + \beta_8 LN_{SLS} + \beta_9 ROA + \beta_{10} FIN_{IND} \quad (13)$$

A reduced version of a first order polynomial regression where the unknown beta coefficients are scalar real values is used by the model. The regression analysis strategies employed in the results section attempt to estimate their values in a descriptive or an analytical way, by usingthe surveyed dataset sample.The order of each constituent independent variable in each monomial is defined in a random way each time. The respective regression analysis for different maximum orders (N-values) is discussed along with the respective training and validation errors, in the subsection that follows.

4.2. Error Function

The squared (L2) normalized formula below, where M is the total number of monomials, was used to average the total error for each corresponding case:

$$e_{cost} = \frac{1}{M}\sum_{i=1}^{M}\left(\frac{ICQ-\widehat{ICQ}}{ICQ}\right)^2 (14)$$

A sampling method was used to divide the items randomly into two groups, where the 75% of the items are regarded as a training dataset for the regression model while the remaining 25% are the validation dataset, where the accuracy and performance of the trained model is being evaluated on a practically different/unknown dataset in comparison with the training one. Additionally, to avoid misguidance concerning the training process due to the assumed sampled data noise and falling into local minima, all independent variables were normalized to vary between [0, 10] and have the exact same scale of measure.

5. Regressionresults & evaluation

5.1. Descriptive statistics results

In the Table 2 below, the questionnaire variables are used in the exact same order andthe indicative descriptive statistical attributes are listed for each corresponding variable. For the statistical and relational analysis for the single scalar dependent variable, the independent variables and four (4) control variables are used.

Table 2. Sampled Variables Descriptive Statistics

		Frequency	**Percentage (%)**	**Mean**	**R correlation**	**P matrix**
IAF_OS	0	11	22.92	0.771	0.001	0.993
	1	37	77.08			
WKREL	1	3	6.25	2.646	0.08	0.587
	2	18	37.50			
	3	21	43.75			
	4	5	10.42			
	5	1	2.08			
STF_COMP	0-1	2	4.17	2.025	-0.338	0.019
	1-2	22	45.83			
	2-3	22	45.83			
	Over 3	2	4.17			
EDU	0-3	6	12.5	6.583	0.058	0.693
	4-7	24	50			
	8-10	14	29.16			
	Over 11	4	8.33			
EXP	0-5	6	12.5	14.06 2	-0.331	0.022
	6-10	8	16.67			
	11-15	15	31.25			
	16-20	11	22.91			

	Over 21	8	16.67			
NO_CERTIFIEDAUDITORS	0-5	44	91.67	3.25	0.06	0.686
	6-10	4	8.33			
	Over 11	0	0			
NO_TOTALAUDITORS	0-10	27	56.25	10.729	0.223	0.127
	11-20	21	43.75			
	21-30	0	0			
	Over 31	0	0			
TRN	0-5	10	20.83	8.875	-0.37	0.009
	6-10	20	41.67			
	11-15	18	37.50			
	16-20	0	0			
	Over 21	0	0			
Natural logarithm of IAF_HMR	0-1	7	14.58	1.515	0.052	0.727
	1-2	35	72.92			
	Over 2	6	12.50			
IAF_HMR	0-3	13	27.08	5.042	0.055	0.713
	4-7	29	60.42			
	8-11	6	12.50			
	Over 12	0	0			
QAS	0	5	10.41	1.625	0.031	0.832
	1	17	35.42			
	2	17	35.42			
	3	9	18.75			
QAPX	0	24	50.00	0.5	0.006	0.968
	1	24	50.00			
UT_MON	1	5	10.41	2.979	0.064	0.665
	2	13	27.08			
	3	11	22.92			
	4	16	33.34			
	5	3	6.25			
R_TEND	1	6	12.5	3.021	0.071	0.629
	2	9	18.75			
	3	15	31.25			
	4	14	29.17			
	5	4	8.33			
EXQA	0	24	50.00	0.5	-0.148	0.315
	1	24	50.00			
EXASS	0	18	37.5	0.625	-0.036	0.81
	1	30	62.5			
PREX	0	28	58.33	0.417	0.18	0.22
	1	20	41.67			
FUP_DEF	0	31	64.58	0.354	0.065	0.659
	1	17	35.42			
FC_XP	0-3	28	58.33	2.828	0.065	0.658
	4-7	20	41.67			
	8-11	0	0			
	Over 12	0	0			
SLS_SIZE	0<x<3e+7	11	22.92	5.727M	0.097	0.513
	4e+7<x<7e+7	19	39.58			
	8e+7<x<11e+7	15	31.25			
	Over 11e+7	3	6.25			
ROA	x<-0.5	5	10.41	-0.123	0.848	2.83E-14
	-0.5<x<0	24	50			
	0<x<0.5	19	39.58			
	0.5<x	0	0			

FIN_IND	0	38	79.17	0.208	0.128	0.385
	1	10	20.83			
ICQ	Below 40	16	33.34	45.769	1	0
	40-50	15	31.25			
	50-60	10	20.83			
	Over 60	7	14.58			

Table 2 presents that over 77% of the collected usable questionnaires consider a functional reporting within the applied IAF to the internal auditing committee (IAF_OS). To continue, the regression coefficient (R correlation) of this variable has a positive value, showing that H1 hypothesis is true with a confidence level much smaller than 95% since the p-value = 0.99>0.05 corresponds to a non-significant correlation in R = 0.0012 and a high probability of observing the respective null hypothesis.

Also, over 80% of the auditors contacted, provided a neutral reply aboutthe assessment of the work relationship (WKREL), meaning that the auditing committee reviews internal IAF program conducted by IArs. Moreover, the regression coefficient (R correlation) of this variable has a positive value, revealing that H2 hypothesis is true with a confidence level smaller than 95% since the p-value = 0.58>0.05 corresponds to a non-significant correlation in R = 0.08 and a high probability of observing the respective null hypothesis.

On the other hand, the evaluation of the IA staff competence and exploitable skills, denoted as STF_COMP, has revealed that the regression coefficient (R correlation) of this variable has a negative value, indicating that H3 hypothesis is not true with a confidence level greater than 95% since the p-value = 0.0187<0.05 corresponds to a significant correlation in R = -0.33821<0 signifying a negative association.

The HMR (mean=5, std=2.2) is used to represent the investment in IAF implementation, which concerns the available human resources employed for such a purpose within the company.The IAF_INV independent variable is then formed after collecting the values and parsing them through the natural logarithm function. Also, the fact that the regression coefficient (R correlation) of this variable has a negative value, indicates that the H4 hypothesis is true with a confidence level smaller than 95% since the p-value = 0.7268>0.05 corresponds to a non-significant correlation in R = 0.0518 and a high probability of observing the corresponding null hypothesis.

As regards the quality assurance program, referred to as QAS, it is measured with the use ofdichotomization (by the respective median value). Moreover, the regression coefficient (R correlation) of this variable has a negative value, indicating that H5 hypothesis is true with a confidence level smaller than 95% since the p-value = 0.8318>0.05 corresponds to a significant correlation in R = 0.0315 and a low probability of observing the respective null hypothesis.

The deficiencies in internal control, referred to as FUP_DEF variable, is a post-designed dummy variable which shows whether IAF depends on the knowledge obtained from previously observed internal control deficiencies or not (mean=0.35, std=0.48). Moreover, the regression coefficient (R correlation) of this variable acquires a positive value, signifying that the H6 hypothesis is true with a confidence level smaller than 95% since the p-value = 0.658>0 corresponds to a non-significant correlation in R = 0.065 and a high probability of observing the respective null hypothesis. Our main results are almost identical with the study of Oussi and Taktak (2018).

Finally, the dependent ICQ variable, regarded as a representative index for the quality of internal control, has been defined as the number of internal control weaknesses identified annually by chief executive auditors. Although this variable is independent, it was also calculated via the respective questionnaires completed by the committee members of the subject sample. The annual number of internal control deficiencies spotted in each company, is indicated by the ICQ variable. The ICQ results (mean= 45.768, std =11.6). Moreover, the regression coefficient (R correlation) of these variables has a positive value, with a confidence interval greater than 95% since the p-value = 0 corresponds to a non-significant correlation in R = 1.

5.2.Linear regression model results

This subsection focuses on the efficiency and effectiveness of the linear regression model version, by taking into considerate onthe maximum monomial order N=1 as well as the number of monomials equal to 11. The formula discussed in section 4.2, both for the training as well as the validation datasets, was used to estimate the total estimation error which is equal to: Total Training Error + Total Validation Error = 0.94. The respective values of the theta vector coefficients are presented in Table 3 below.

Table 3. Theta Coefficients Values (M=11, N=1).

Coefficients-θ	Values
β1	0.011
β2	0.063
β3	-0.039
β4	0.040
β5	0.037
β6	0.056
β7	0.087
β8	0.101
β9	0.091
β10	0.102
β0 (constant term)	0.021

The regression elements'randomly generated order for each respective first-order monomial term is shown in Table 4.

Table 4. Monomial Orders (M=11, N=1).

	IAF_OS	WKREL	STF_COMP	IAF_INV	QAS	FUP_DEF	FC_XP	LN_SLS	ROA	FIN_IND	Total Order
β1	1	0	0	0	0	0	0	0	0	0	1
β2	0	1	0	0	0	0	0	0	0	0	1
β3	0	0	1	0	0	0	0	0	0	0	1
β4	0	0	0	1	0	0	0	0	0	0	1
β5	0	0	0	0	1	0	0	0	0	0	1
β6	0	0	0	0	0	1	0	0	0	0	1
β7	0	0	0	0	0	0	1	0	0	0	1
β8	0	0	0	0	0	0	0	1	0	0	1
β9	0	0	0	0	0	0	0	0	1	0	1
β10	0	0	0	0	0	0	0	0	0	1	1
β0	0	0	0	0	0	0	0	0	0	0	0

Finally, Figure 1 displays the total training and validation error (e_{cost}) of the resulted linear regression model.When the maximum allowable order of monomials increases, the error term profiles follow the same overlapping profile both for training and validation datasets. In addition, this factsignifies a slight over-fitting (i.e., the regression coefficients resulted, force the overall model to determine in an accurate way the underlying system dynamics, significantly decreasing its tendency to generalize into unknown or abnormal data-point instances) since training loss is almost equal to validation loss.

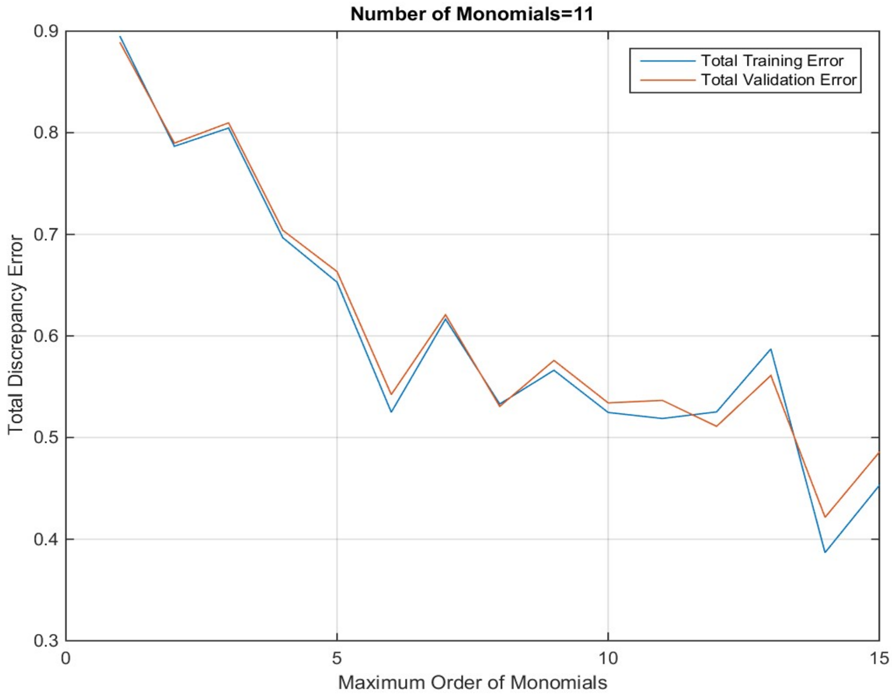

Figure 1. Training and Validation Dataset Error for number of monomials (M=10+1 constant term) and varying monomial orders (N=1:1:15).

5.3. Random polynomial regression model general results

As anticipated, the model trained on thetraining dataset has achieved similar or better performance than the one trained on the unknown validation dataset. Nevertheless, it could be generally concluded that the overall performance of the considered linear-in-the-parameters regression model is reasonably good, presenting total errors (both training and validation) close to zero. Moreover, for smaller sizes of the polynomial, the error of the trained model generates a decaying profile since the maximum order increases, in other words, the performance improves as the maximum order increases. Despite that, this dynamic ceases to exist after a critical point of the number of monomials, where, as portrayed in Figure 2, both for training and validation datasets, the fitting error presents a decaying behavior, for every selection of the maximum order from 1 to 15 of each monomial, up until the total number of monomials comprising the polynomial is around M=51 (see Figure 2). The performance of the trained linear (in the parameters) regression model for large values of the maximum monomial order is becoming poorer and poorer (see also Table 5) once the number of monomials exceeds M=51.

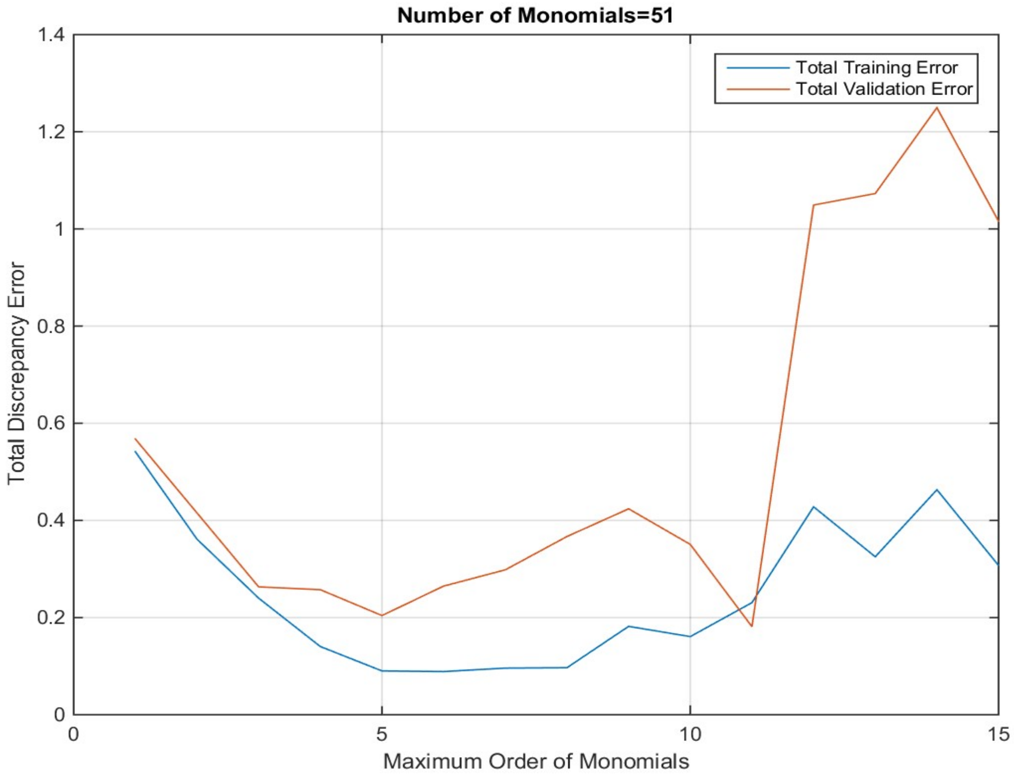

Figure 2. Training and Validation Dataset Error for number of monomials (M=50+1 constant term) and varying monomial orders (N=1:1:15).

In the case above, while the maximum allowed order of the monomials rises, the error term profiles reflect a similar trend in both training and validation datasets, denoting an adequately trained model where the respective validation error curve is slightly over/higher than the training error curve, showing that it can generalize adequately when the maximum order of the monomials considered is $N<5$.

Additionally, it can be clearly inferred, after comparing the corresponding curves for training and validation dataset error in Figure 1 and Figure 2, that the regression model considering M=51 displays almost always better performance (smaller error) regardless of the maximum order of monomials chosen.

Table 5. Total error indexes considering different M and N values.

	N=1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
M=2	1.943	1.956	1.924	1.912	1.981	1.941	1.880	1.904	1.871	1.838	1.859	1.828	1.924	1.920	1.862
11	1.783	1.576	1.614	1.401	1.316	1.067	1.237	1.064	1.142	1.059	1.055	1.036	1.148	0.808	0.938
21	1.809	1.494	1.300	1.136	1.109	0.697	1.037	0.674	0.523	0.835	0.493	0.391	0.569	0.376	1.294
31	1.511	1.349	0.925	0.473	0.577	0.505	0.352	0.508	0.315	0.362	0.409	**0.251**	0.448	0.411	0.259
41	1.392	1.026	0.811	0.476	0.387	0.428	0.372	0.297	0.294	0.394	0.603	0.598	0.323	0.964	0.761
51	1.109	0.777	0.503	0.398	0.294	0.354	0.394	0.464	0.606	0.512	0.412	1.477	1.398	1.713	1.323
61	1.359	0.922	0.581	0.278	0.397	0.824	0.843	0.696	1.485	0.931	1.779	2.194	2.584	3.444	3.647
71	1.140	0.711	0.408	0.654	0.681	0.950	1.361	0.955	2.259	3.008	2.465	3.280	3.057	3.173	3.783
81	1.174	0.630	0.426	0.636	0.902	1.056	1.296	2.562	4.673	2.550	3.329	4.415	5.757	5.925	6.623
91	1.029	0.569	0.344	0.642	1.449	1.803	2.866	3.047	3.146	5.401	7.148	7.752	7.953	9.474	9.710
101	0.941	0.420	0.597	1.934	1.956	2.807	3.539	4.233	6.684	7.205	9.743	8.744	11.95	14.959	10.750
111	0.953	0.891	1.135	1.940	3.110	3.932	3.926	7.002	5.564	10.41	11.503	13.227	12.58	14.045	16.205
121	0.966	0.659	0.612	2.154	3.867	4.756	4.177	6.251	7.207	10.12	13.152	15.980	17.489	20.856	17.873
131	1.210	0.980	1.141	2.304	5.582	6.869	5.967	6.245	10.445	18.17	16.264	19.014	20.871	23.068	21.859
141	0.985	0.604	1.557	3.402	7.384	9.165	10.274	11.229	13.200	21.166	19.344	18.525	24.893	24.738	29.323
151	1.143	1.300	3.462	4.886	5.768	9.142	10.585	12.823	18.394	19.245	22.224	28.685	28.463	29.154	31.273
161	1.015	0.921	2.870	4.260	6.772	13.221	12.946	14.836	20.737	21.920	23.620	24.626	31.286	36.952	42.022
171	1.215	1.148	2.990	7.617	10.249	15.527	11.968	14.352	26.865	27.107	28.284	38.650	42.142	40.185	41.961
181	1.713	1.365	3.662	9.106	11.117	11.894	16.200	20.041	23.707	24.182	39.197	37.421	49.988	51.165	48.753
191	2.264	1.649	6.033	7.534	12.249	19.540	19.193	22.712	24.386	29.818	48.029	54.751	51.740	60.557	56.288

5.4. The most effective regression model in terms of approximation error

This subsection contains the performance (Total Training Error + Total Validation Error = 0.25) of the most effective polynomial regression model based on the findings already presented, regarding M=31 (monomial number and a constant monomial scalar term) and N=12 (maximum monomial order), highlighted in yellow in Table 5.

The problem about the maximum order and monomial number choice in multiple polynomial regression modeling methods, arises in the discussed dataset as well. A linear-in-the-parameters low-order polynomial can sufficiently emulate the relationship of the single dependent variable ICQ and the independent variables since both validation and training dataset evaluation errors are low in lower monomial number and maximum order options. In these value ranges appear to have the ability to successfully address the problem of generalization in regression problems, where the trained model can generalize efficiently beyond its training set, presenting comparable performance estimation (Ostertagová, 2012).

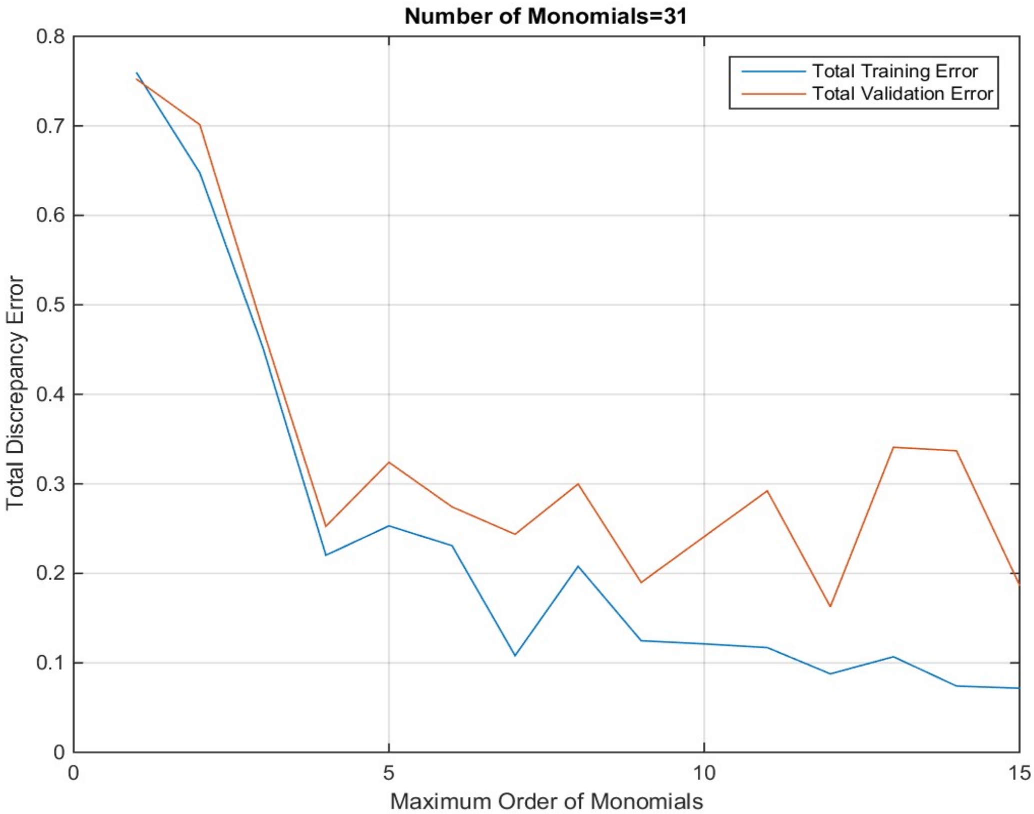

Figure 3. Training and Validation Dataset Error for number of monomials (M=30+1 constant term) and varying monomial orders (N=1:1:15).

In this case, as the maximum allowable monomial order increases, the error term profiles follow a similar trend for both training and validation datasets, showing a model adequately trained where the corresponding validation error curve is slightly over/higher than the training error curve, signifying its ability to effectively generalize when the maximum order of the monomials considered is N>5 (see Figure 3).

More specifically, the total estimation error, about the simplified linear case, displayed in subsection 5.2 above, is approximately: (0.94-0.25)/0.94=73.4% better; or equivalently 3-4 times better, depicting the simplifying strategy considered for the linearized model version, not adequately efficient, when there is need for precision and a more detailed estimation of the dependent ICQ variable. The respective values of the theta vector coefficients are presented in Table 6 below.

Table 6. Theta Coefficients Values (M=31, N=12).

Coefficients-θ	**Values**
β1	0.181
β2	0.196
β3	0.101
β4	0.130
β5	0.071
β6	0.196
β7	-0.175
β8	0.146
β9	0.157
β10	0.189
β11	0.199
β12	0.168
β13	0.198
β14	0.184
β15	0.188
β16	0.164
β17	0.063
β18	0.164
β19	0.186
β20	0.187
β21	-0.126
β22	0.140
β23	0.187
β24	0.194
β25	0.186
β26	-0.172
β27	-0.091
β28	0.001
β29	0.188
β30	0.047
β0 (constant term)	0.021

Being the same as in the linear case, the constant term value *β0* indicates the standard offset in the ICQ measured values while the regression elements' order, created at random, is depicted in Table 7 below for each respective monomial term.

Table 7. Monomial Orders (M=31, N=12).

	IAF_OS	WKREL	STF_COMP	IAF_INV	QAS	FUP_DEF	FC_XP	LN_SLS	ROA	FIN_IND	Total Order
β1	0	0	0	0	0	4	0	0	0	0	4
β2	6	0	0	0	0	0	0	1	0	2	9
β3	0	1	0	0	0	0	2	0	10	1	14
β4	2	0	0	0	10	0	0	0	0	1	13
β5	1	9	0	0	0	0	0	0	0	0	10
β6	0	0	0	0	0	0	1	0	0	13	14
β7	0	0	6	8	0	0	0	0	0	0	14
β8	0	2	0	10	0	0	0	0	2	0	14
β9	0	0	0	7	1	0	0	0	1	0	9
β10	0	0	0	0	0	2	0	0	0	0	2
β11	0	3	0	0	0	0	1	0	3	0	7
β12	3	0	0	0	4	0	1	0	0	0	8
β13	0	0	0	0	0	0	0	0	1	0	1
β14	11	1	0	0	0	0	0	0	0	0	12
β15	0	0	0	0	6	0	0	0	0	0	6
β16	0	0	0	0	0	0	4	1	4	0	9
β17	0	0	0	0	4	0	0	0	0	0	4
β18	0	0	0	0	0	2	8	0	0	0	10
β19	8	0	0	4	0	0	0	1	1	0	14
β20	0	9	0	0	0	0	0	2	0	0	11
β21	3	2	2	0	0	0	1	0	2	0	10
β22	13	0	0	0	0	0	1	0	0	0	14
β23	0	0	0	10	0	0	1	0	0	0	11
β24	0	1	11	0	0	1	0	0	1	0	14
β25	0	4	0	0	0	0	0	10	0	0	14
β26	3	1	1	1	0	0	0	2	4	1	13
β27	1	4	4	0	1	1	0	0	1	0	12
β28	0	0	0	0	0	0	0	0	0	13	13
β29	0	1	0	5	3	0	0	0	1	1	11
β30	0	0	0	7	0	0	0	0	1	0	8
β0	0	0	0	0	0	0	0	0	0	0	0

Unsurprisingly, the theta coefficient values (shown in Table 6 above), calculated with the use of a multiple polynomial regression model, indicate whether the relationship of each respective independent variable with the dependent one, is positive or negative. For simplicity reasons in terms of analysis, consider, the case of FUP_DEF independent variable as an indicative example; the monomial terms which comprised only of FUP_DEF are the monomial number M_1 and number M_{10}, where the order of the monomial is even (N_1=4 and N_{10}=2) while the corresponding values of the theta coefficients are both positive, showing that FUP_DEF exhibits a positive relationship to ICQ while H6 hypothesis is true, verifying the respective conclusion coming from the analysis in section 5.1.

6. Conclusions

We revisit the linkage between IAF characteristics and ICQ, in Greek listed companies, by adopting a random polynomial regression model. Our results support the notion that the IAF characteristics are positively associated with ICQ, as reflected by the independent variables "IAF organizational status", "working relationship between the IAr and the AC", "IAF investment", "quality assurance program" and "the follow-up on internal control deficiencies". The only hypothesis that is not supported is H3, meaning that "IA staff competence" does not positively affect the ICQ.

Further, we examine thebest (the most efficient one in terms of approximation error) option among different choices of monomial number and order. Moreover, we performed comparison between the best resulted polynomial regression model, considering M=31 monomials and N=12 maximum order. Our results illustrate that this polynomial model presents over 3 times better estimation performance when compared to the linear regression case. This suggests that companies could assess and potentially manage certain independent variables affecting the ICQ levels as a mean of presenting higher modeling performance.

The empirical findings of our study could be useful to regulatory bodies, auditors, and companies in perceiving the contribution of the IAF'S constituents on ICQ. The regulatory bodies should be aware thatIAF has a significant role in ICQ and on these terms, they should try to enhance the legislation of CG framework. Auditors should source additional information to evaluate the ICQ, since our analysis suggests that corporate environment is much more complex and is affected by unpredictable dynamics. Similarly, companies should invest on upgrading ERP systems to increase ICQ and achieve better performance in terms of profit maximization.

As is the case with every study, this one is also subject to a number of caveats. First, our main findings rely on 48 responses from chief auditing executives in Greek listed companies, which arguably could not be sufficiently enough to capture the different perspectives in auditing community. The allocation of larger periods of time as well as more dedicated personal interviews (instead of impersonal questionnaires) could assist on extracting much more concrete conclusions. Further, we note that our analysis uses a quite small number of proxies/variables to describe the dependent ICQ variable. The usage of different or additional variables such as demographic and professional attributes of CEO's, country culture and institutional environment and technological information systems could provide a more coherent picture of ICQ level. Finally, we acknowledge that a different range of exploring the maximum monomial order, or the number of monomials could also spark significant research interest in future studies.

Acknowledgements and Declaration of Interest section

The authors declare no conflicts of interest. The authors alone are responsible for the content and writing of the paper. This paper is an extension of dissertation submitted by one of the authors for acquiring the post-graduate diploma on Management and Business Administration.

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