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Original Scientific Paper

FINANCIAL SECTOR DEVELOPMENT AND REAL SECTOR GROWTH – ASSOCIATION, SPILLOVER AND CAUSALITY DURING PRE COVID AND COVID REGIMES

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Abstract. *In this paper, we propose an alternative approach to understanding the relationship between financial sector development and real sector growth in India. We use stock market sectoral indices available on National Stock Exchange (NSE) like Capital Goods Index, FMCG Index, Energy Index, Infra Index, Metal Index, Realty Index, and Auto Index to represent the real sector. To represent the financial sector, we consider Bank Index and Financial Services Index separately. The proposed framework examines the relationships at a granular level to understand the extent of association, spillover, and causality. We also analyze the relationship between the financial sector and the real sector in Pre COVID and COVID periods separately. Our research methodology includes the use of Detrended Cross-Correlation Analysis (DCCA), Wavelet Multiple Correlation (WMC), Wavelet Multiple Cross Correlation (WMCC), Diebold-Yilmaz spillover Framework, and Non-Linear Causality Test. Our granular approach has enabled us to examine the relationships in different periods and we observe that the results change. The intensity of the relationships also is different during the COVID period as compared to Pre COVID period.*

Key words: *Financial Sector, Real Sector, Detrended Cross-Correlation Analysis (DCCA), Wavelet Multiple Correlation (WMC), Wavelet Multiple Cross Correlation (WMCC), Diebold-Yilmaz spillover*

JEL Classification: C01, C22**.**

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1. INTRODUCTION

World Development Report (1989) dwells in great detail on the role of the financial sector in economic growth. The financial sector pools the savings of individuals and lends them for large investment projects which help in economic growth. Further, various financial instruments make it easier to trade and exchange goods and services and also make the cost of raising resources cheaper for firms. Self-financed investments have obvious limitations and profitable investment opportunities can be explored only in the presence of external finance. In today's world of globalization and with the growth of the internet, accessing finance has become easier, and the financial wealth of a nation is now no longer confined within its geographical boundaries.

The institutions in the financial sector, through their lending activities, also appraise projects for lending. This generates comfort to the savers that their savings are protected by people specializing in lending activities. Risk management and risk monitoring are done systematically and generate confidence in the savers, encouraging further savings with institutions. The financial sector, through its lending activities, also takes care of the agency problem thus encouraging shareholders to undertake projects, either for expansion or diversification. Some papers in this area include Jensen and Meckling (1976), Rozeff (1982), Easterbrook (1984), and Jensen (1986).

There is considerable literature on the relationship between financial sector growth and real sector growth. King and Levine (1993), Levine (1997), and Aghion et al. (2004) have laid the foundation of research in this area. In this context, different variables have been identified for understanding the relationship between financial sector growth and real sector growth. For financial sector development, variables like the ratio of liquid liabilities to GDP, the ratio of bank credit to total credit, the ratio of non-banking credit to total credit (except credit to the public sector), the ratio of bank credit divided by bank credit plus central bank domestic assets, the ratio of credit allocated to private enterprises to total domestic credit (excluding credit to banks), and credit to private enterprises divided by GDP have been considered. Growth in per capita output and growth in physical capital formation has been considered to represent real sector growth.

During the recent COVID-19 pandemic, the real sector came under pressure all over the world due to lockdowns, a standstill in world trade, closure of operations in factories, and shutdown in international and domestic travel (Özen and Özdemir, 2021; Jana et al., 2022; Babalola, 2022). In India, a few trains were running, airlines were running at low capacity, inter-state movement in the workforce went down significantly and factories were struggling to resume operations (Patil et al., 2022; Rajak et al., 2022). Loss of income and employment led to a fall in demand. The GDP growth rate has turned negative and there is little evidence of when things will get back to the pre-COVID stage. The banking sector and the non-banking financial services sector came under pressure as loan defaults had increased and fresh financial assistance was not being sought. The focus is on how to ease the financial burden of the borrowers. There was a huge requirement for liquidity and the Indian government used the banking sector to channel financial assistance to the needy. Mutual funds witnessed large redemptions as individuals faced liquidity constraints.

In this background, we propose an alternative approach to understanding the relationship between the financial sector and the real sector in India. We use stock market indices in India from the National Stock Exchange (NSE) for modeling and to represent the real sector, we consider Capital Goods Index, FMCG Index, Energy Index, Infra Index, Metal Index, and Auto

Index. To represent the financial sector, we consider Bank Index and Financial Services Index. We propose a framework where the relationship is examined at a granular level to understand the extent of association, spillover, and causality.

Although we will be using stock market indices which are financial sector indices, our contention is that company stock prices and consequently, sectoral indices, except for speculative waves, do reflect the state of the real sector. The sectoral indices that we have chosen, representing the real sector, reflect the fortunes of the companies within the sector, the state of that sector, and their growth prospects. Macroeconomic studies dealing with overall aggregative data fail to capture these sectoral characteristics.

The financial sector is represented by the banking sector index and the non-banking financial services sector index. In a similar vein, these reflect the state of the financial sector institutions and their future prospects. The bank index represents the health of the banking sector. It considers not only growth in assets and their profitability but also factors in the quality of assets and composition of assets. If banks are deploying more funds in government securities and government-sponsored directional lending, then the share of the private sector falls. This can impact the growth rate.

The Financial Services Index represents the state of the NBFC (Non-Banking Financial Services Companies) sector. Here again the growth in assets and the quality of assets step in. Also, such entities tend to be innovative in their asset allocation and more risk-taking as their cost of funds is higher. Their risk-taking can fund innovative ventures through different instruments. For our study, we have focused on the Indian economy predominantly due to two reasons. First, it has a strong and varied industrial structure with highly profitable and renowned companies, along with thriving micro, small and medium enterprises. This makes its requirements from the financial sector quite varied. Second, the COVID pandemic revealed the existence of a large migrant labor force who contribute to the supply chain and also constitute a significant part of the market for goods and services. The pandemic affected economic activities and, in turn, affected demand for financial services and products. Our framework can be applied to other economies and would reveal the structure of their real and financial sectors and the nature of dependence.

In this alternative approach, to understand the relation between financial sector development and real sector growth in different time scales, we use several non-parametric frameworks in conjunction with wavelet analysis methodology to enable multi-resolution examination. At first, Detrended Cross-Correlation Analysis (DCCA) is employed for extracting the nature association between the variables at different lags. Next, for expounding the time-varying traits of the association between the financial and real sectors, Wavelet Multiple Correlation (WMC) and Wavelet Multiple Cross Correlation (WMCC) techniques have been utilized. Diebold-Yilmaz Spillover analysis is used to critically evaluate the spillover connectedness among the assets. Finally, to comprehend the direction and extent of causal structure, Nonlinear Granger Causality Test has been used in conjunction with Maximal Overlap Discrete Wavelet Transformation (MODWT) in a scale-wise manner.

2. OBJECTIVES

For the Indian economy, the questions that we ask with respect to the relationship between financial sector development and real sector growth are:

- Is the relation similar in all time scales?
- How long do the impacts last?
- What is the nature of the association?
- Are the spillovers significant? If so, on what scale?
- Is the causality in the relationship between the two unidirectional or bidirectional?

We use a wavelet-based framework for our study which allows for granular analysis. Our framework enables us to understand, not only the directionality of the relationship, but also whether the relationships are strong or weak and during what time; do the relationships spill over, do short-term shocks have long-run consequences, are these relationships stable over all periods, and also are their lagged effects significant? Instead of using GDP as a proxy for the real sector, we study different real sectors separately. Our analysis will bring out the time-varying relationship between the financial sector and these sectors. Our study will also bring out which sectors correlate with the banking sector and the non-banking financial services sector separately.

3. PREVIOUS RESEARCH

Owing to practical implications, modelling financial and real sector interplay has received considerable traction in the literature. In this section, we briefly describe some of the previous research work that has investigated the relationship between the financial sector and the real sectors across different economies and different time scales.

Based on data from 1981 to 2000, Tang (2006) examined whether financial development would facilitate economic growth among the Asia-Pacific Economic Cooperation (APEC) countries. The paper considers the effects of three aspects of financial development on growth, namely the stock market, banking sector, and capital flows. Results suggest that among the three financial sectors, only stock market development shows a strong growth-enhancing effect, especially among the developed member countries.

Aizenman et al. (2013) suggested that developments in the financial sector had an asymmetric effect on the real sectors. The real sectors were sensitive to contractions in the financial sector, while they are not significantly responsive to expansion.

Samargandi et al. (2015) show that financial development does not have a linear positive long-run impact on economic growth. However, if a non-linear relationship is considered, then they find an inverted U-shaped relationship between finance and growth in the long run. This finding suggests that middle-income countries face a threshold point after which financial development no longer contributes to economic growth.

Ductor and Grechyna (2015) empirically evaluated the nexus of financial development, real sector, and economic growth. Their findings suggested the presence of nonlinear relationships and real sector growth heavily influenced the effects of financial sector development on economic growth.

Kenza and Eddine (2016) examine the impact of financial development on economic growth in the context of MENA countries. The measures of financial development they consider are private credit to GDP, M2/GDP, the ratio of commercial bank assets to the total of commercial bank assets, and central bank assets. Their results indicate that financial

intermediaries had a negative effect on the growth rate and they suggest financial reforms to improve the quality and quantity of financial services.

Guru and Yadav (2018) examined the relationship between financial development and growth using the banking sector and stock market development indicators as independent variables and GDP per capita growth as the dependent variable. The banking sector development indicators are the size of the financial intermediaries, credit to deposit ratio (CDR), and domestic credit to private sector, and stock market development indicators are the value of shares traded and turnover ratio.

Radjenovic and Rakic (2017) examine the interdependence between financial sector development, particularly capital market development and economic growth in Serbia. The variables include capital market size, the extent of liquidity, government consumption, interest rates, and inflation rates. The Granger causality test is carried out to determine long-run causality between the variables. The results indicate that capital market development stimulates economic growth.

Silva et al. (2018) demonstrated the interconnection of financial and real sectors in the Brazilian market and that shocks from the real sector transmitted to government-owned banks. Their work suggested close monitoring of interlinks for estimating systematic risk.

Biplob and Rokeya (2018) examine the relationship between financial sector development and economic growth in Bangladesh using time series data for the period of 1977-2016. Using the Johansen Co-integration test and Granger-causality test in Vector Error Correction Model (VECM) framework, the study found significant long-run causality from financial development to economic growth.

Paun et al. (2019) selected 45 low-income, middle-income, and high-income countries covering ten years (2006–2015) and observed that financial sector development, sophistication, and performance had a statistically significant effect on economic growth.

Ghosh and Datta Chaudhuri (2020) explored the dynamic interplay of market sentiment, sectoral indices, and individual stock prices in India by applying wavelet-based methodologies. The presence of herding behavior in the long run after the global financial crisis was observed.

Raghutla and Chittedi (2020) show that BRICS nations' money supply, exchange rate, and inflation have a significant positive effect on economic growth. Thus, policymakers should increase the real sector expenditure and develop the financial sector.

Sharma and Kautish (2020) investigate the impact of financial sector development on GDP growth in the four middle-income countries of South Asia over the period of 1990–2016. Using pooled mean group (PMG) estimation, this study examines whether, for these developing countries, GDP growth has been affected by the size of market capitalization and size of market turnover in the long run which is used as a proxy for stock market development. The study finds that the impact of the banking sector on GDP growth has remained relatively low in the region.

Ibrahim and Acquah (2021) use panel data from 45 African countries from 1980 to 2016 to examine causal linkages between the financial sector and real sector variables. They apply the panel Granger Non-Causality test and find that the causal nexus between FDI and economic growth is conditioned on the indicator of economic growth. They also find feedback causality between FDI and financial sector development, and financial sector development and economic growth.

Ghosh et al. (2022) thoroughly explored the detailed dynamics of the futures market in India during normal and new normal time horizons applying appropriate indicators of spot counterparts, sectoral outlook, market sentiment, market fear, and volatility as explanatory

variables. An ensemble of machine learning and explainable artificial intelligence-based frameworks suggested the futures prices of stocks belonging to different sectors were indeed predictable and predominantly driven by the spot markets and sectoral outlook.

Xu and Pal (2022) measured the impact of financial liberalization on the performance of the manufacturing sector in India using dynamic panel analysis. It was revealed that the financial liberalization policies exerted a positive influence on the overall productivity of the Indian manufacturing sector.

The impact of globalization and financial development on different socio-economic aspects in India has been documented in literature as well (Ohlan, 2017; Godil et al., 2021; Sethi et al., 2021; Panagariya, 2022). The said studies are, nonetheless, strictly restricted to a normal time horizon.

It can be observed that, although the existing literature has made considerable effort in decoding the interaction, it has remained confined to static analysis with limited variables. It, therefore, becomes imperative to extend the research towards modelling the dynamic time-varying nature of the interrelationship, and also at a granular level. Further, in the context of the current COVID pandemic which has caused worldwide instability, the relationship between the financial sector and the real sector has gained significance where demand and supply side effects have affected market outcomes and financial support in the form of interest waivers, liquidity infusion, increased government spending, and financial restructuring have gained importance. The present paper analyses whether the nature of the relationship between the financial sector and the real sector in the COVID phase is different from that of the Pre COVID phase.

4. Data Description

Two separate modelings have been carried out to achieve research objectives. The first one examines the relationship between the Banking (Bank) sector with 3 real sectors, Metal, Capital Goods, and Energy. This set of variables has been referred to as Set A variables throughout the remaining portion of the paper. The other scenario deals with the evaluation of the dynamic interaction of the Financial Service (FS) sector with Automobile (Auto), Infrastructure, and Realty, as representatives of the real sector. These variables have been referred to as Set B variables onwards. To capture the interplay during Pre-COVID time horizons, daily closing returns of underlying variables from April 1st, 2019, to March 31st, 2020, have been compiled from the data repository of 'Metastock'. The same data source has been leveraged to compile daily closing returns of all variables from April 1st, 2020, to September 30th, 2020, to capture the nature of interrelationship during the COVID phase. Tables 1-4 outline the descriptive statistics of the underlying datasets of our study.

It can be clearly seen that Shapiro-Wilk and Jarque-Bera test statistics have emerged to be significant during both Pre COVID and COVID phases. Thus, the considered variables under the Set A category do not abide by normal distribution during both regimes. A clear presence of nonlinearity in all four sectors during Pre COVID phase is imminent from the outcome of Terasvirta's NN test. It is largely due to the slowing down of the Indian economy during the said time horizons which created uncertainty in the market. Interestingly, during the COVID phase, none of the variables demonstrate a sign of significant nonlinear traits. Extreme shocks and fear owing to the pandemic led the

underlying variables to a bearish state. The dominance of unidirectional movement may explain the lack of nonlinearity.

Table 1 Properties of Set A Sectors Pre COVID

Properties	Bank	Metal	Capital Goods	Energy
Minimum	-0.17	-0.12	-0.15	-0.10
Maximum	0.08	0.08	0.08	0.09
Mean	-0.003	-0.002	-0.002	-0.001
Median	-0.0005	-0.002	-0.002	-0.001
Shapiro-Wilk Test	0.77^{***}	0.94^{***}	0.80^{***}	0.86^{***}
Jarque-Bera Test	3354.3^{***}	199.61^{***}	2433.1^{***}	742.03^{***}
Terasvirta's NN Test	6.03^{**}	16.68^{***}	9.11^{**}	28.13^{***}

Note: *** Significant at 1% level of Significance, ** Significant at 5% level of Significance, $^{\#}$ Not Significant, Terasvirta's NN Test: Terasvirta's Neural Network Test

Table 2 Properties of Set A during COVID

Properties	Bank	Metal	Capital Goods	Energy
Minimum	-0.08	-0.08	-0.05	-0.03
Maximum	0.11	0.08	0.05	0.07
Mean	0.002	0.003	0.002	0.002
Median	0.002	0.004	0.001	0.003
Shapiro-Wilk Test	0.97^{***}	0.96^{***}	0.97^{**}	0.97^{***}
Jarque-Bera Test	24.23^{***}	24.23^{***}	8.22^{**}	21.854^{***}
Terasvirta's NN Test	$0.073^{\#}$	$4.38^{\#}$	$0.14^{\#}$	$0.35^{\#}$

Table 3 Properties of Set B during Pre COVID

Properties	FS	Auto	Infrastructure	Realty
Minimum	-0.16	-0.14	-0.12	-0.11
Maximum	0.09	0.1	0.07	0.06
Mean	-0.001	-0.002	-0.001	-0.001
Median	0.001	-0.002	-0.0003	0.0009
Shapiro-Wilk Test	0.75^{***}	0.87^{***}	0.83^{***}	0.89^{***}
Jarque-Bera Test	3000.6^{***}	1244.9^{***}	1337.3^{***}	440.95^{***}
Terasvirta's NN Test	74.51^{***}	32.23^{***}	79.28^{***}	15.92^{**}

Table 4 Properties of Set B Sectors Pre COVID

Properties	FS	Auto	Infrastructure	Realty
Minimum	-0.08	-0.07	-0.04	-0.07
Maximum	0.08	0.10	0.07	0.06
Mean	0.002	0.005	0.003	0.002
Median	0.002	0.004	0.002	0.004
Shapiro-Wilk Test	0.98^{**}	0.91^{***}	0.96^{***}	$0.98^{\#}$
Jarque-Bera Test	14.01^{**}	121.23^{***}	61.47^{***}	4.33^{*}
Terasvirta's NN Test	$5.96^{\#}$	31.77^{***}	$10.3^{\#}$	$8.43^{\#}$

It can be observed that the variables belonging to Set B emerged to be nonparametric during both Pre COVID and COVID regimes. The outcome of nonlinearity inspection through Terasvirta's NN test suggests during Pre COVID phase all four sectors appeared to be nonlinear in nature. Abrupt state changes in the financial market owing to economic slowdown during the said period have largely accounted for nonlinearity. On the other hand, during COVID regimes, barring the Auto sector, none of the sectors have shown signs of significant nonlinearity.

5. RESEARCH METHODOLOGY

5.1. Detrended Cross-Correlation Analysis (DCCA)

As the underlying variables of financial and real sectors have demonstrated traits of heteroscedasticity and nonlinearity, the mere usage of the orthodox correlation test would not be appropriate to draw insights into the prevailing association. Podobnik and Stanley (2008) proposed a new framework, detrended cross-correlation analysis (DCCA) based on the theoretical framework of detrended fluctuation analysis (DFA) for investigating power-law cross-correlation between two-time series need not abiding parametric properties. In this research, we have adopted an extension of the DCCA method namely, the DCCA cross-correlation coefficient proposed by Zebenede (2011) for measuring the magnitude of association between daily returns of two variables at a time. It is estimated using Eq. (1):

$$\rho_{DCCA}(s) = \frac{F^2_{DCCA}(s)}{F_{DFA}(x_i^1)(s) * F_{DFA}(x_i^2)(s)} \tag{1}$$

where, F_{DCCA} denotes the traditional fluctuation function derived from DCCA whilst F_{DFA} representing the fluctuation function generated from DFA, x_i^1 and x_i^2 denotes the two-time series under consideration. The computed ρ_{DCCA} measures the amount of cross-correlation at a selected time scale, *s*. The magnitude of the DCCA cross-correlation coefficient ranges between -1 to 1. A value close to -1 signifies a negative association whereas a positive association prevails when its value emerges close to 1.

5.2. Detrended Cross-Correlation Analysis (DCCA)

Fernández-Macho (2012) introduced WMC and WMCC techniques to overcome several computational drawbacks of scale-wise assessment correlation and cross-correlation. Basically, the frameworks are built upon generated wavelet coefficients, $W_{ijt} = (w_{1jt}, w_{2jt}, \dots, w_{njt})$ on a multivariate stochastic process $X_t = (x_{1t}, x_{2t}, \dots, x_{nt})$, using MODWT at respective scales (λ_j). WMC $(\varphi_x(\lambda_j))$denotes a set of estimated multi-scale correlation figures by determining the square root of the regression coefficient of determination at each scale (λ_j) in a linear combination of wavelet coefficients having a maximum coefficient of determinism. The coefficient of determination regression of a variable (z_i) on a regressor set $(z_k, k \neq i)$ is computed using Eq. (2)

$$R^2 = 1 - 1/\rho^{ii} \tag{2}$$

where ρ^{ii} indicate the ith diagonal element of the inverse of the correlation matrix

Subsequently, the WMC is calculated using Eq. (3):

$$\varphi_x(\lambda_j) = \sqrt{1 - \frac{1}{\max diag\, P_j^{-1}}} \tag{3}$$

where P_j denotes the correlation matrix defined on W_{jt} and the max diag (.) operator is used for selecting the largest element.

The WMCC is computed by letting a lag (τ) between the actual and estimated figures of the criterion construct at each scale (λ_j) as shown in Eq. (4).

$$\varphi_x\tau(\lambda_j) = Cor(w_{ijt}, \hat{w}_{ijt+\tau}) = \frac{Cor(w_{ijt}, \hat{w}_{ijt+\tau})}{\sqrt{Var(w_{ijt})Var(\hat{w}_{ijt+\tau})}} \tag{4}$$

5.3. Diebold-Yilmaz Spillover

To gauge the extent of volatility contagion, the spillover index (SOI) measure of Diebold and Yilmaz (2009), has been utilized in this work. It estimates the SOI by determining the forecast's error variance by implementing a vector auto-regression model. The present research has utilized the SOI index to estimate the intra-spillover rates among the four chosen sectors during Pre COVID and COVID phases.

5.4. Wavelet Decomposition

Using discrete wavelet decomposition, the original time series observation disentangled into a series of subcomponents of different frequencies reflecting linear and nonlinear components. Decomposed parts of lower frequency bandwidth prevail for longer periods whilst the components associated with higher bandwidth prevail for shorter periods. Several algorithms have been reported for implementing decomposition. In this research, MODWT has been used which has previously been successfully applied for modelling financial time series and is known for having several advantages over orthodox discrete wavelet transformation (DWT) (Ghosh and Datta Chaudhuri, 2019; Ghosh et al., 2019; Ghosh et al., 2021; Jana et al., 2020). The present research has utilized multi-resolution analysis using MODWT at 4 levels of decomposition considering the number of samples available for both Pre COVID and COVID time frames. Current work resorts to Daubechies least asymmetric (LA) wavelet filter of length 8 for the actual decomposition process. The said decomposition is combined with nonlinear causality test based on neural network models for capturing scale-wise causal structure.

5.5. Nonlinear Causality Test

The causal association of financial time series is predominantly explored via the Granger causality test. However, the said test is only capable of detecting linear causal structure owing to its fundamental properties. Literature reports several nonlinear causality tests for time series analysis. In this research, we have utilized the nonlinear Granger causality test of *the 'NlinTS'* package of R to detect the causal structure across the decomposed granular components obtained using MODWT. The said test is designed based on the incorporation

of feed-forward neural networks based on two-way predictive analysis to account for nonlinearity.

6. Results and Analysis

In this section, based on the methodology adopted, we examine the dynamic association of financial and real sectors across the specified time regimes.

6.1. Findings of DCCA

Tables 5-8 present the figures of DCCA-Cross-Correlation figures for underlying variables.

Table 5 Outcome of DCCA on Set A during Pre COVID Regime

	Time Scale (Days)		
	3	7	15
Bank-Metal	0.7233527	0.6798493	0.6781169
Bank-Capital Goods	-0.1339252	0.08462575	0.48167117
Bank-Energy	0.7419062	0.6684102	0.6760967
Metal-Capital Goods	0.03626816	0.14215420	0.40242120
Metal-Energy	0.8163277	0.801333	0.7822637
Capital Goods-Energy	0.001819431	0.153852819	0.456903162

Estimated DCCA coefficient figures suggest the existence of a strong positive cross correlation between Bank and Metal across all time scales. Cross-correlation between Bank and Capital Goods, on the other hand, has appeared to be relatively weaker and advocates the presence of negative association as well during 3 days lag. The Association of Bank and Energy sectors has emerged to be similar to that of Bank and Metal. Therefore, among the chosen real sectors, Metal and Energy share a comparatively stronger bond with the financial sector.

Table 6 Outcome of DCCA on Set A during the COVID Regime

	Time Scale (Days)		
	3	7	15
Bank-Metal	0.6936634	0.6437001	0.33075862
Bank-Capital Goods	-0.19594646	0.04006762	0.48167117
Bank-Energy	0.6270362	0.5595826	0.6337167
Metal-Capital Goods	-0.15978826	0.09168101	0.32339216
Metal-Energy	0.6519984	0.5794979	0.5504941
Capital Goods-Energy	-0.10206444	0.03918955	0.27305501

It can be noticed that Bank and Metal sectors are highly positively cross-correlated at 3 days and 7 days lags while their association observes a dip in 15 days scale. A relatively low degree of cross correlation has emerged for Bank and Capital Goods sector at a time scale of 7 days and 15 days lag. Bank and Energy sectors have been found to be positively associated across different time lags. On the other hand, DCCA among the subsectors of

real sectors also demonstrates the presence of positive, negligible, and negative association patterns. Overall, the strength of association has seen a marginal decrease as compared to Pre COVID period.

Table 7 Outcome of DCCA on Set B during Pre COVID Regime

	Time Scale (Days)		
	3	7	15
FS-Auto	0.8092923	0.8008604	0.7772776
FS-Infrastructure	0.8675846	0.8445019	0.8246986
FS-Realty	0.7862788	0.7774274	0.7849782
Auto-Infrastructure	0.8449540	0.8191228	0.7842454
Auto-Realty	0.7372148	0.7240827	0.6979275
Infrastructure-Realty	0.7799858	0.7665851	0.7630102

Estimated DCCA coefficient figures clearly indicate the existence of a strong association across the time scales between all the pairs. All four sectors of Set B have been found to be positively associated with each other during Pre COVID regime. FS and Infrastructure sectors have emerged to share comparatively strongest association at a lag of 3 days. With the increase in time scale, the extent of association has declined for all constituent pairs. Amongst the real sectors, Auto and Infrastructure appear to be comparatively more linked to FS. This provides support to the fact that sales of these sectors depend on consumer/housing loans which are provided mostly by financial services companies.

Table 8 Outcome of DCCA on Set B during the COVID Regime

	Time Scale (Days)		
	3	7	15
FS-Auto	0.7197197	0.7095076	0.7516264
FS-Infrastructure	0.6961058	0.6592394	0.7261145
FS-Realty	0.6775208	0.6993603	0.7342715
Auto-Infrastructure	0.7566446	0.7707571	0.8004676
Auto-Realty	0.6806652	0.6648038	0.6913267
Infrastructure-Realty	0.6573807	0.6610222	0.7225326

It may be observed from Table 8 that in the COVID period, the strength of association among the pairs has diminished to some extent. However, with an increase in time scale, the extent of association has increased.

6.2. Outcome of WMC and WMCC

The following figures 1-4 exhibit the outcome of WMC-driven analyses.

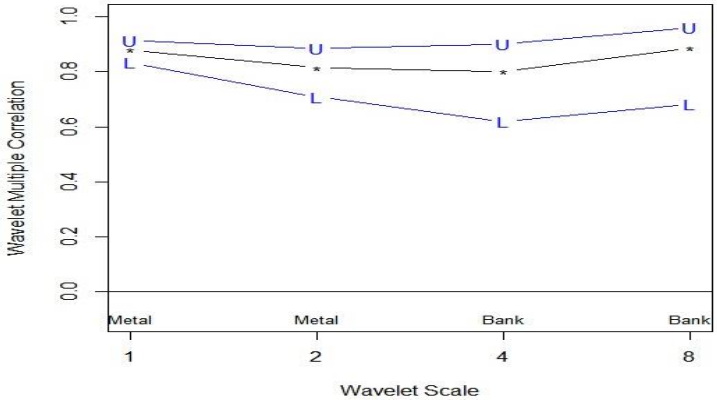

Fig. 1 Outcome of WMC Analysis of Set A during Pre-COVID Regime

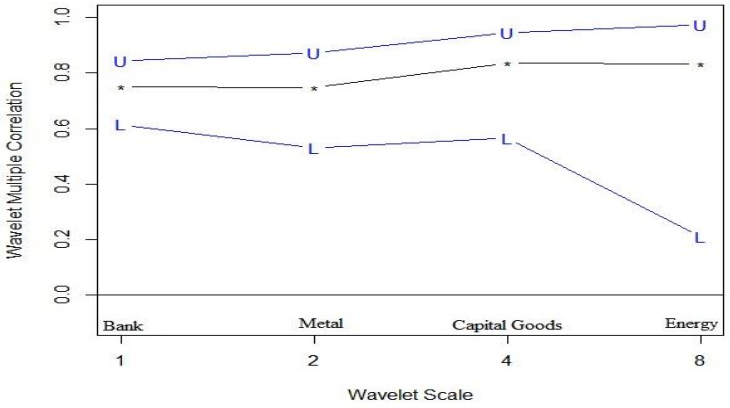

Fig. 2 Outcome of WMC Analysis of Set A Sectors during the COVID Regime

Figure 1 suggests the presence of a strong correlation between the financial and real sectors of Set A initially in scale 1 (2-4 days). It then experiences a marginal dip in scales 3 and 4 (weekly and fortnightly duration) and gains momentum again in scale 8 (monthly time horizon). Nevertheless, the co-integration manifested by WMC more or less remained stable and highly positive (0.7 on average) across the granular time scales which indicates that the considered sectors would offer very little diversification benefits during Pre COVID regime. Bank leads the co-movement in the long run while Metal dominates in the short run. On the other hand, during the COVID regime stable and positive co-integration can be observed across the scales, which also suggests little scope for diversification. Interestingly, Bank has appeared to be leading in the short run scale whilst Energy leads in the long run.

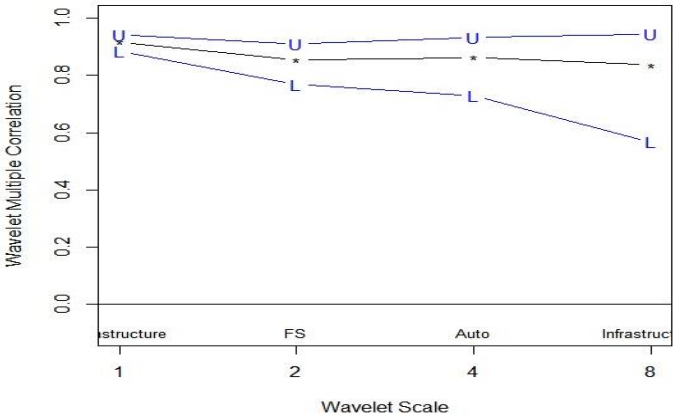

Fig. 3 Outcome of WMC Analysis of Set B during Pre COVID Regime

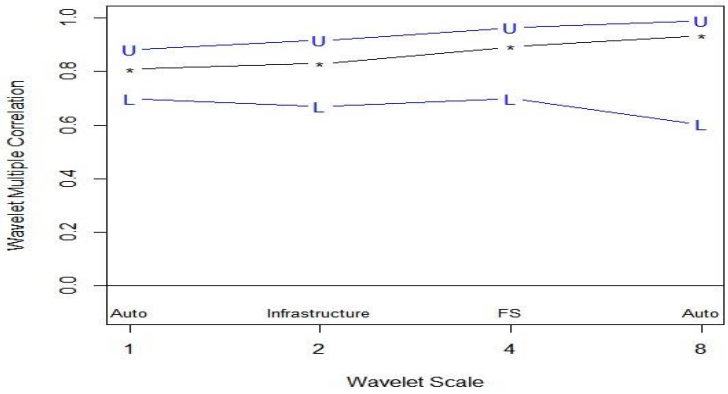

Fig. 4 Outcome of WMC Analysis of Set B during the COVID Regime

Financial and real sectors belonging to Set B demonstrate a strong positive co-integration structure during Pre COVID regime with a marginal dip in the strength of correlation on a higher scale as manifested by WMC. The average strength of correlation spanning across the four-time scales is above 0.8 roughly, which suggests the strength of co-movement of Set B sectors is relatively higher than the Set A counterparts which basically conforms to the findings of DCCA. Infrastructure has turned out to be the leader both in the shortest and longest time scales. FS and the Auto sector respectively lead in the intermediate time scales. Like Set A, Set B offers little scope for diversification. During the COVID regime (Figure 4), a monotonic increase in correlation from short to long-run scales can be observed among the underlying sectors. The auto sector and FS lead in the shortest and longest time scales, whereas infrastructure and FS lead in intermediate scales. The overall strength of association between Set B sectors has turned out to be comparatively greater than Set A sectors. However, the influence of the financial sector of Set B, i.e. FS sector, is not as impressive as that of the financial sector of Set A, i.e. Bank. We, next, present the findings of WMCC

analyses for a lag of one month. In Figures 5-8, the color bar on the right-hand side indicates the strength of correlation and also the names of leading sectors across the scales.

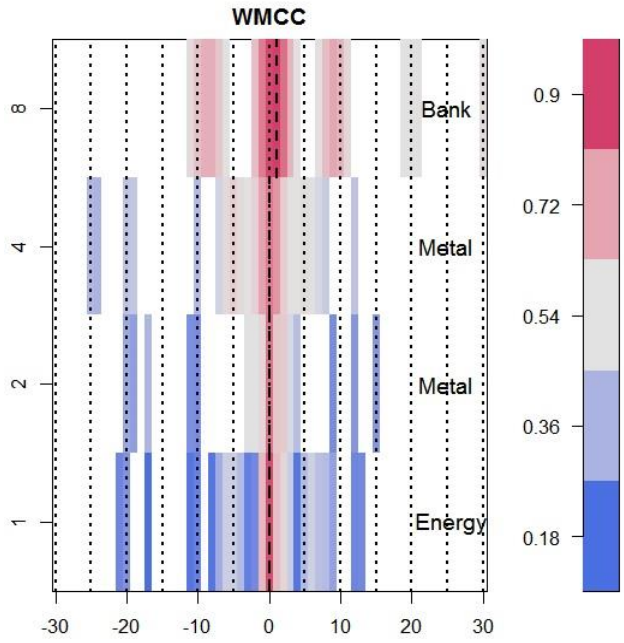

Fig. 5 Outcome of WMCC Analysis of Set A during Pre-COVID Regime

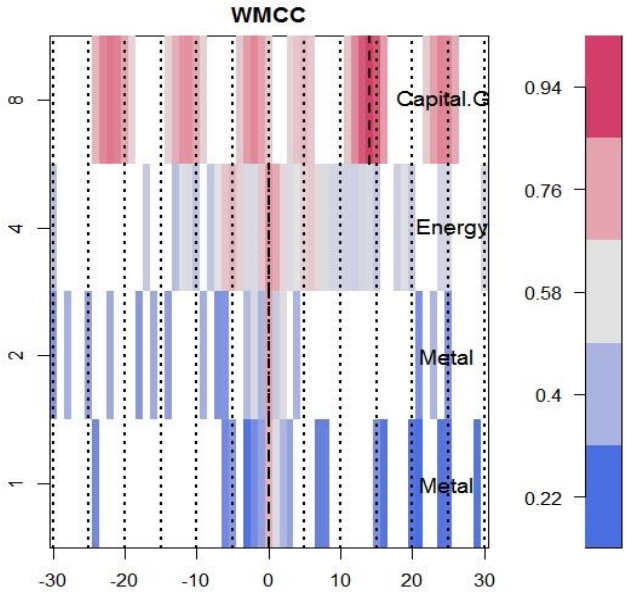

Fig. 6 Outcome of WMCC Analysis of Set A during the COVID Regime

For Set A, the strongest correlation during the Pre COVID phase can be observed at a lag of 10 days forward and backward direction. No sign of negative association can be observed. In other time scales (intraweek, weekly, and fortnightly periods), a marginal degree of association can be observed at different lags. Bank appears to be the leader in cross-correlation in long-run scales while Energy dominates the short-duration movement. During the COVID regime, the strongest correlation can be found to approximately spread across a lag of 25 days roughly at scale 4 of the monthly time horizon. It simply implies that the effect of the Pandemic has extended the prevalence of point-wise correlation across the lags. Similar to Pre COVID context, no sign of negative co-movement could be observed. A relatively low degree of correlation can be seen to be scattered across smaller time scales.

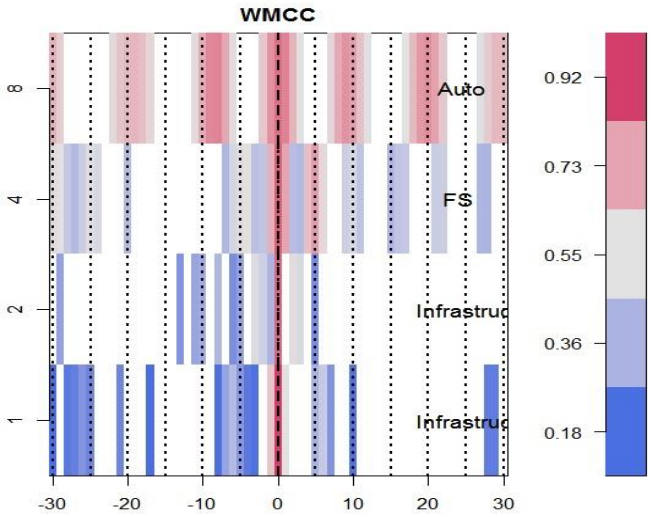

Fig. 7 Outcome of WMCC Analysis of Set B during Pre-COVID Regime

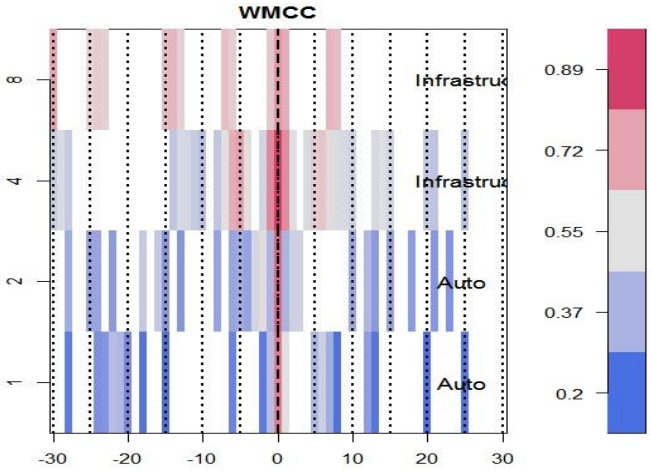

Fig. 8 Outcome of WMCC Analysis of Set B Sector during the COVID Regime

The concentration of the strongest correlation of Set B during Pre COVID context can be seen to span across entire 30-day lags at the highest time scale. Infrastructure leads in Scales 1 and 2 while FS and Auto sectors dominate scales 4 and 8, respectively. Likewise, in the earlier scenarios, no evidence of negative association can be found. For the COVID regime, the cross-correlation at different lags is lower, thus contradicting earlier cases. So FS and Sector B demonstrate different traits during the COVID pandemic.

6.3. Findings of Spillover Analysis

This section illustrates the findings of Diebold-Yilmaz spillover analysis to comprehend the nature and extent of volatility contagion from the Financial to Real sectors and inside Real sectors. The following tables 9-12 outline the results. Individual rows in the tables account for the quantum of received spillovers whilst the columns reflect the quantum of imparted spillovers.

Table 9 Outcome of Diebold-Yilmaz Spillover Analysis of Set A during Pre COVID Regime

	Bank	Metal	Capital Goods	Energy	From Others
Bank	40.21	6.09	43.34	10.36	14.95
Metal	4.49	68.93	24.94	1.64	7.77
Capital Goods	6.32	5.18	78.33	10.18	5.42
Energy	6.90	8.35	28.72	56.03	10.99
To Others	4.43	4.90	24.25	5.54	39.13

It can be seen that during Pre COVID phase Bank received high amount of spillover from the Capital Goods sector. Thus uncertainty in the Capital Goods sector resulted in a high degree of volatility in Bank sector. The metal and Energy sector received a considerable amount of spillover from the Capital Goods sector as well. Capital Goods on the other hand remained highly immune to significant contagion from other sectors. Overall it can be inferred that the shock in Capital Goods caused a ripple in the financial sector and other real sectors.

Table 10 Outcome of Diebold-Yilmaz Spillover Analysis of Set A Sector during the COVID Regime

	Bank	Metal	Capital Goods	Energy	From Others
Bank	16.99	54.45	12.76	15.81	20.75
Metal	19.48	44.79	8.31	27.42	13.80
Capital Goods	18.28	50.54	13.46	17.72	21.64
Energy	14.68	53.37	9.42	22.53	19.37
To Others	13.11	39.59	7.62	15.24	75.56

In the ongoing COVID regime, the Metal sector has emerged to be the top contributor to volatility spillover. It has affected Bank, followed by the Energy sector. Metal, on the other hand, has received the highest spillover from the Energy sector. Capital Goods, unlike Pre COVID time horizon, have remained largely dormant in transmitting volatility.

Table 11 Outcome of Diebold-Yilmaz Spillover Analysis of Set B during Pre COVID Regime

	FS	Auto	Infrastructure	Realty	From Others
FS	76.91	3.33	19.73	0.03	5.77
Auto	5.24	85.57	8.74	0.44	3.61
Infrastructure	9.27	0.28	90.07	0.39	2.48
Realty	2.54	2.37	5.58	89.52	2.62
To Others	4.26	1.49	8.51	0.22	14.48

In Set B during Pre COVID period, the FS sector received maximum volatility spillover from Infrastructure. Infrastructure has emerged to be the topmost contributor of volatility among the sectors. However, unlike Set A sectors, Set B sectors demonstrate relatively more resilience and immunity towards external shocks and interconnectedness through contagions.

Table 12 Outcome of Diebold-Yilmaz Spillover Analysis of Set B during the COVID Regime

	FS	Auto	Infrastructure	Realty	From Others
FS	12.68	26.49	11.39	49.43	21.83
Auto	13.52	28.88	9.09	48.52	17.78
Infrastructure	13.35	28.82	9.12	48.71	22.72
Realty	14.01	30.04	8.25	47.69	13.08
To Others	10.22	21.34	7.18	36.67	75.41

The structure of volatility spillover for Set B during the ongoing COVID regime, however, was completely different. It can be seen from Table 12 that FS has received maximum volatility spillover from the Realty sector, followed by the Auto sector. Defaults in auto EMI payments and housing loans have generated uncertainty in the financial services sector. In terms of imparting volatility, the Auto and Realty sector have again played a leading role. Inherent fear owing to the COVID pandemic has resulted in strong volatility transmission.

6.4 Outcome of Causality Inspection

To enable multi-resolution analysis, four levels of decomposition have been carried out using MODWT. Table 13 provides the time interpretation of scales of the decomposition process by MODWT.

Table 13 Time interpretation of different scales

Details	Wavelet Scales	Durations
D1	1	2 to 4 days(Intraweek scale)
D2	4	4 to 8 days(Weekly scale)
D3	8	8 to 16 days (Fortnightly scale)
D4	16	16 to 32 days (Monthly scale)

Tables 14-17 report the results of the nonlinear Granger causality evaluation. The bidirectional arrow, ↔ denotes the existence of bidirectional causality, and left headed arrow, ← indicates that the second variable Granger causes the first one, and the right-headed arrow, → suggests that the first variable Granger causes the second one.

Table 14 Results of Causal Assessment of Set A during Pre COVID Phase

	D1	D2	D3	D4
Bank-Metal	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Bank-Capital Goods	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Bank-Energy	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Metal-Capital Goods	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Metal-Energy	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Capital Goods-Energy	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$

Note: # Not Significant, *** Significant at 1% Level of Significance

It is evident from Table 14 that during the pre-COVID period for Set A, at short run time scales, intraweek, and weekly time horizons there was no significant causal interaction among the sectors. On the other hand, significant bidirectional causal interplay can be observed between all possible constituent pairs during fortnightly and monthly time scales.

Table 15 Results of Causal Assessment of Set A during the COVID Phase

	D1	D2	D3	D4
Bank-Metal	#	#	$\leftarrow^{***}$	$\leftrightarrow^{***}$
Bank-Capital Goods	#	#	$\leftarrow^{***}$	$\leftrightarrow^{***}$
Bank-Energy	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Metal-Capital Goods	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Metal-Energy	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Capital Goods-Energy	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$

Causal dependence analysis of Set A during the COVID regime indicates pretty similar findings as can be seen in Figure 15. However, on a fortnightly scale, the Bank sector has been causally driven by the Metal and Capital Good sectors in a unidirectional manner.

Table 16 Results of Causal Assessment of Set B during Pre COVID Phase

	D1	D2	D3	D4
FS-Auto	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
FS-Infrastructure	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
FS-Realty	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Auto-Infrastructure	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Auto-Realty	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Infrastructure-Realty	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$

For Set B, causality develops in higher time scales, i.e. fortnightly and monthly scales as bidirectional causality is observed for all concerned pairs (Figure16). The same result holds for the COVID phase (Figure 17).

Table 17 Results of Causal Assessment of Set B during the COVID Phase

	D1	D2	D3	D4
FS-Auto	#	#	$\leftrightarrow^{**}$	$\leftrightarrow^{***}$
FS-Infrastructure	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
FS-Realty	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Auto-Infrastructure	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$
Auto-Realty	#	#	$\leftarrow^{**}$	$\leftrightarrow^{***}$
Infrastructure-Realty	#	#	$\leftrightarrow^{***}$	$\leftrightarrow^{***}$

7. CONCLUDING REMARKS

At the beginning of the paper, we mentioned that we will not be taking any position regarding the causality between real sector growth and financial sector growth. Our objective is not to establish whether financial sector growth leads to real sector growth or vice versa. Instead, we delve into exploring the relationship between the two at i) a granular level and ii) at different time intervals. The belief behind this approach is that some information may be lost when we take broad sweeps of time and analyze data at an aggregative level.

In terms of approach, our contribution has four distinct aspects. First, it tries to understand the relationship between financial sector development and real sector growth through stock market indicators. We contend that sectoral stock market indices represent the current and expected real future performance of the constituent companies. Second, we differentiate between the banking sector and the financial services sector as the two primarily serve two different sets of companies. This enables us to analyze one-to-one correspondence between specific sectors of the real economy with the corresponding segment of the financial sector. Third, we consider a granular approach where we break down the time series data into different time intervals and then analyze the relationships for various time intervals. Fourth, we separately analyze the data for both Pre COVID and COVID periods. This helped us in understanding the nature, intensity, and duration of the shock that India faced, along with the rest of the world.

Our analysis yields the following results. The linear correlation plots for the aggregative level data show that the association between the metal and the energy sector with the banking sector was strong in the pre-COVID period, but the strength of the association fell during the COVID period. This fall in the level of association between Pre COVID and COVID period is even more marked for the financial services sector with the auto, infrastructure, and the realty sector, the latter seeing the most decline. The decline in the overall relationship for the banking sector can be attributed to the slowing down of the economy. The result for the financial services sector is the result of loss in income and livelihood at the micro level.

The DCCA analysis gives more focus to the relationships for different time intervals. One can observe that the relationship between the banking sector and the metal sector decreased significantly during the COVID regime as the time interval increased from 3 days to 15 days. For the financial services sector, there has been an across-the-board reduction in the correlation levels in the COVID period as against the Pre COVID period for different time intervals. We can infer that as the virus spread, the effect of a fall in demand was felt by the financial services sector as time increased.

WMCC calculations for the banking and the corresponding real sectors suggest that during the COVID regime, the strongest correlation can be found to be approximately spread across a lag of 25 days as against a lag of 10 days in the Pre COVID regime. It implies that the effects of the pandemic have extended the point-wise correlation across the lags. While the capital goods sector has led the other sectors, including the banking sector, in a longer time horizon in the COVID period, the auto sector has led the financial services sector in the same period.

The results of the Diebold-Yilmaz spillover analysis suggest that in the pre-COVID regime, there was not much volatility spillover from the banking sector to the real sectors, whereas there was a strong spillover from the capital goods sector to the banking sector. This changed during the COVID regime when an increase in banking sector volatility was felt in the real sectors. Further, the metal sector did affect the banking sector significantly.

The extent of volatility spillover from the financial services sector to the corresponding real sectors was not significant in the pre-COVID period, although there was some spillover from the infrastructure sector to the financial services sector. This changed significantly during the COVID period where we observe a significant large volatility spillover from the realty sector, followed by the auto sector. Our results corroborate real-life relationships where many non-banking financial services companies suffered defaults and liquidity shortages because of a severe downturn in the realty sector during this period.

To understand causal interplay, a nonlinear Granger causality assessment has been carried out on decomposed components through MODWT. Our results indicate that for the banking sector, in the Pre COVID period there was significant both-way causality between banking sector development and real sector growth on fortnightly and monthly scales. However, in the COVID period, we observe one-way causality between the metal and capital goods sector and the banking sector on a fortnightly scale. For the financial services sector, significant two-way Granger causality was observed in the fortnightly and monthly scales. This persisted in the COVID period also.

The contribution of the study lies in breaking up the financial sector into the banking sector and the financial services sector and also relating specific real sectors with the corresponding part of the financial sector. This has enabled us to garner deeper insight into the relationship. Our granular approach has enabled us to examine the relationships in different time spans and we have observed that the results have undergone a change. We have not come across any paper in the literature that has used this approach.

The literature has not identified any specific relation between the financial sector and the real sector. Our approach supports that, but establishes that the relationship is bi-directional at granular levels. The methodology adopted enables analysis of the relationship between specific sectors of the real economy with specific sectors of the financial sector. It goes beyond the literature in looking at the relationship at different time intervals and also during pre – COVID and COVID periods. The results indicate an overall weakening of the relationships in the COVID period.

Our framework revealed which section of the real sector affected the banking and non-banking financial sector significantly, and at what time intervals. This has important policy implications as it brings to the fore which companies can get affected by external shocks and which assets can turn non-performing. The latter, in turn, has serious implications with respect to the financial health of the lenders, their capital adequacy, and policy intervention. Our approach highlights the need for sectoral asset monitoring by the financial sector in the presence of external shocks.

We have not explicitly considered the IT sector, the healthcare sector, the pharma sector, the FMCG sector, and the oil and gas sector in our study. This is on our future research agenda.

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RAZVOJ FINANSIJSKOG SEKTORA I RAST REALNOG SEKTORA – POVEZANOST, PRELIVANJE I UZROČNOST PRE I TOKOM KOVID PANDEMIJE

U ovom radu predlažemo alternativni pristup razumevanju veze između razvoja finansijskog sektora i rasta realnog sektora u Indiji. Koristimo sektorske indekse sa nacionalne Berze (NSE) kao što su: Indeks kapitalnih dobara, FMCG Indeks, Energentski Indeks, Infrastrukturni Indeks, Metal Indeks, Indeks Nekretnina i Auto Indeks kako bi prestavili realni sektor. Za predstavljanje finansijskog sektora, koristimo Bankovni Indeks i Indeks Finansijskih usluga odvojeno. Predloženi okvir proučava veze na granularnom nivou kako bi razumeli nivo povezanosti, prelivanja i uzročnosti. Takođe analiziramo odnost između finansijskog sektora i realnog sektora u periodima pre i za vreme Kovid pandemije odvojeno. Naša metodologija istraživanja uključuje korišćenje Detrended kros-korelacione analize (DCCA), Vejvlet multiple korelacije (WMC), Vejvlet multuple kros-korelacije (WMCC), Diebold-Yimlaz okvira prelivanja i ne-llinearni test kauzalnosti. Naš granularni pristup nam je omogućio da ispitamo povezanost u različitim vremenskim intervalima i primećujemo da se rezultati menjaju. Intenzitet veze takođe je drugačiji u vreme pre i tokom pandemije Kovida.

Ključne reči: *Finansijski Sektor, Realni Sektor, Detrended Kros-korelaciona analiza (DCCA), Vejvlet multipla korelacija (WMC), Vejvlet multipla kros-korelacija (WMCC), Diebold-Yilmaz prelivanje*

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THE IMPACT OF R&D ACTIVITY ON THE BUSINESS PERFORMANCE OF HIGH-TECHNOLOGY COMPANIES

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Abstract. *This paper aims to examine the influence of R&D activity on the business performance of high-technology companies. In order to provide an empirical investigation of the impact of R&D activity on the business performance of high-technology companies, correlation and regression analyses have been utilized.*
This study discovered that investment in R&D has a positive influence on EBIT, net earnings, EBITDA, and total assets, while its influence on ROA was confirmed to be statistically significant and negative. Additionally, the influence of R&D intensity performance indicator (RDI) on ROA as a short-term financial performance indicator was not confirmed. The study revealed that return on R&D investment (RORDI) has a statistically significant and positive influence on ROA in the current, observed year.
The evaluation of the obtained results can be a basis for drawing more detailed conclusions, contributing to the future R&D strategy and existing literature, and emphasizing the importance of R&D investment for various business performances.
The originality of this study is reflected in the comprehensive analysis of the influence of specific indicators of R&D activity, such as RORDI, on the business performance of high-technology companies. This paper is also beneficial because none of the existing studies have explored the impact of investment in R&D on EBITDA.

Keywords: *R&D activity, R&D investment, business performance, profitability*

JEL Classification: O32, O34, M41

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INTRODUCTION

Research and development (R&D) are vital activities for the economic growth of companies through enhanced technological innovation and efficiency. R&D has gotten a lot of attention recently from academic, commercial, and political circles (Jung & Kwak, 2018). Due to the increasingly rapid technological progress, expansion of the globalization process, and intense rivalry (Jovanović et al., 2021), R&D activities are a critical precondition for preserving a competitive edge and improving the profitability of a company. In the era of a knowledge-based economy, R&D investments are not only essential for the success and survival of the companies, but also for the construction of conditions necessary for the prosperity of the national economy (Krstić & Rađenović, 2018). The knowledge-based economy is propelled by investments in R&D and various kinds of innovations.

R&D investment is a crucial factor in creating, maintaining, and strengthening the company's competitive advantage (Janjić & Rađenović, 2019). By conducting R&D activities, the company gets a chance to gain a competitive advantage, which will be reflected in the growth of profitability through the sale of new products and services and the introduction of efficient production methods, enabling entry into new markets or reducing production costs. On the other hand, companies do not always have adequate R&D capabilities (David et al., 2008). R&D investments are risky; hence the return on investment is unpredictable. Every investment in R&D represents a risk for the company. It has been suggested that technological advancement is the engine that drives capitalism. Firms that invest in R&D and innovate will prosper, while those that do not will stagnate (Rzakhanov, 2004).

The motive of the study is to investigate the impact of R&D activities and its indicators on certain business performances (Earnings before interest and tax - EBIT, Net earnings, Earnings before interest and tax, depreciation and amortization – EBITDA, Total assets, and return on assets - ROA), which were not the focus of relevant literature. The rationale for exploring the influence of R&D activities on certain business performances is that R&D investments are very significant for strategic positions and financially challenged, therefore the management of any organization has to continuously monitor all potential future benefits and effects. R&D investments are not contributing to the achievement of economic results for the current period. However, over a longer period, R&D investments should have an impact through the visible development and growth of the portfolio company's resources, i.e. total assets. To implement the corporate strategy, the business unit strategy, and the R&D strategy, R&D investments must have an impact on profitability indicators in the future period.

Having in mind the beneficial effects of R&D expenditures on the company's sustainable development, the purpose of this paper is to test the influence of R&D investment indicators on business indicators of high-tech companies that are leaders in R&D investments. Therefore, this study focuses only on one industry (Information and Communications Technology - ICT) and the most famous high-technology companies, such as Apple (ICT producers and services), Intel (ICT producers and services), Microsoft (ICT services), Samsung (ICT producers), Cisco (ICT producers and services), IBM (ICT producers), Oracle (ICT services), Philips (ICT producers) and SAP (ICT services). The current study utilizes bivariate correlation and panel regression analysis to test the proposed hypotheses. The study focuses only on one industry or more precisely nine high-tech companies and the data from eight years. Therefore, the overall results could be biased, but also very indicative of the theory and practice on this topic.

The structure of this study is organized as follows. Firstly, after the introduction, an overview of the relevant literature is given – the relevance of R&D activity for improving business performance and competitiveness, as well as the indicators of R&D activity. The theoretical aspect and the existing literature on the relationship between R&D activity and business performance are also presented. The second section presents the sample, researched variables, and methodology of research. The third section gives an overview of the results and their discussion. At the end of the paper, a summary of the conclusions is presented.

1. Literature Review

1.1. The relevance of R&D activity for improving business performance and competitiveness

The term *research and development* refer to the activities that businesses engage in creating new products and services, which in turn have an impact on a company's financial and non-financial performance. The concept of R&D is divided into two parts. In general, *research* is conducted to achieve a new scientific advance, enhance knowledge and discover and invent new methods, systems, and products, whereas "development" is the process of translating the outcomes of research and other information into a commercial product, or an improved design or plan for a new product or service (Zhao, 2002).

In today's world of fierce competition, companies have to recognize the dangers of imitation and the critical role of innovation and devote appropriate resources to R&D (Guo et al., 2016), resulting in competitive strength and affecting profitability levels. Due to the quick technological advancements and increasingly sophisticated consumer markets, companies are forced to consistently invest in R&D and innovation, which are regarded as the primary strategic factors for their success (Marković et al., 2020). The degree of innovation of these companies can be identified based on the part of the realized sales revenues that are invested in R&D. For the competitive advantage of innovative companies, it is very important not only to invest significantly in R&D, but also to have the highest intensity of investment in R&D and realize the high efficiency of investment in R&D. To boost revenues, earnings, labour productivity, profitability, technical innovation, and competitiveness, every company aims to increase the effectiveness and efficiency of R&D investment (Veselinović & Veselinović, 2019). Continuous growing investments in R&D lead to the efficiency of the use of these funds, which implies the creation and implementation of product and process innovations, which should contribute to the growth of the profitability of the companies.

The significance of R&D arises from its capability to encourage a company's economic growth by resulting in the innovation of new technologies that can improve a company's competitive advantage and strengthen its position in the market. R&D is regarded as the foundation for developing new products, processes, and services, giving companies a competitive advantage in terms of product and service innovation, and allowing them to become market leaders (Hall & Oriani, 2006). Companies can improve organisational knowledge and ability, the technical degree of accumulation, or develop new knowledge, by implementing R&D activities, which may ultimately affect business performance. Investing in R&D yields a higher-than-average rate of return on R&D investment and gives a company a distinct and long-term competitive advantage (Hsieh, et al., 2003).

1.2. Indicators of R&D activity

The majority of empirical research focuses on *R&D investment* and *R&D intensity (RDI)*, as very important indicators of R&D activity. Additionally, a significant measure of the realization of R&D activity is the achieved *Return on R&D investment (RORDI)*.

R&D investment, which is a crucial driver and cornerstone of sustainable and economic development in the twenty-first century, can have an impact on a company's viability and growth. R&D investments are vital for the long-term survival and success of every company. Investment in R&D is regarded as a critical component of high-technology investment (Karl-Heinz, 2005) and presents a significant source and basis of innovation (Wang et al., 2013). R&D investments include the entire process of developing new products and services towards the stage of commercialization (Wesley & Wonglimpiyarat, 2020, p. 5). Failure and irreversibility are unavoidable parts of the R&D investment process. Beside that, the future rewards and short-term effectiveness of R&D investments are usually unpredictable and uncertain.

R&D intensity (RDI) has been of great interest to academics, policymakers, practitioners and corporations during the last few decades. Furthermore, RDI is one of the most commonly used R&D indicators and in many studies, RDI represents the innovation levels of the companies and their sectors (Sher & Yang, 2005; Gui-long et al., 2017; Ameer & Othman, 2020). RDI can be defined as an enterprise's R&D expenditure divided by its sales revenue (Ortega-Argiles & Brandsma, 2010). RDI is a critical factor for evaluating a company's technological efficiency and innovative activities (Chao & Kavadias, 2013), as well as RDI is acknowledged as a significant measure for identifying a firm's strategic use of R&D (Lin et al., 2006). In semiconductor companies in Taiwan, higher RDI has been demonstrated to be a predictor of enhanced business performance (Sher & Yang, 2005).

The return on R&D investment (*RORDI*) has been the subject of significant literature from both theoretical and empirical perspectives (Lev & Sougiannis, 1996; Kothari et al., Leone, 2002; Anagnostopoulou & Levis, 2008). Investing in R&D does not always yield instant results and returns (Petković et. al, 2021). The fact that certain inventions appear slowly and are short-lived, while others are long-lasting or utilised in future R&D, is a factor that contributes to a disparity between R&D investments and returns. Companies that can turn the results of their innovative projects and creative initiatives into meaningful sales growth should expect future returns on their R&D investment (Cohen et al., 2013). The importance of the rate of return on R&D investment (RORDI) is represented in improving economic performance by increasing efficiency, developing and disseminating new knowledge and increasing the potential for economic growth. According to Shah (2008), as R&D expenses increase, the volatility of returns also increases. The rate of return on R&D investment (RORDI) can be analysed at many different levels of aggregation, including individual research projects, enterprises, industries and national economies. The profit in future consumption units generated by an increase in current R&D expenditure is known as the R&D social return rate. In the meantime, the private return rate is proportional to the increase in profits resulting from increased business innovation (Benavente et al., 2006).

The time-lag period has always been a significant factor to consider when examining R&D activities and processes. The required time to perform R&D activities causes a time lag; hence, R&D spending in the current period has not immediately impacted the financial performance of the company (Rao et al., 2013). Unlike other investments, R&D investment has a temporal lag and contributes to R&D results in the following periods. Some researchers have discovered the existence of a lag period when evaluating the impact of R&D expenditure on the financial

performance of a company. Lee and Lee (2007) used a time-lag model to assess the effects of explanatory variables such as R&D intensity and accounting profit rate ratio on corporate performance in 63 pharmaceutical companies from 2001 to 2006. They found that R&D intensity in the previous year had a beneficial impact on the current year's ordinary profit ratio, whereas R&D expenditures in the preceding two years had a negative impact.

1.3. The link between R&D activity and business performances

In the era of scientific-technological and technical progress, firms that decide to distribute a higher level of investment in R&D are predicted to earn more and achieve higher levels of business performance than organizations that invest less in R&D (Chao, 2011). R&D investments are critical since they show future growth potential in a company's performance. To generate and improve business performance in the future, many companies choose to invest in R&D as a valuable resource.

Therefore, this study investigates the link between the following:

- R&D investments, RDI and Earnings as valuable business performances which reflect economic results i.e., the numerator of profitability ratio (ROA);
- R&D investments and Total Assets i.e. denominator of profitability ratio (ROA);
- R&D investments, RDI, Return on R&D investment and profitability ratio (ROA).

Alarcon and Sanchez (2013) used a sample of more than 400 firms from 2000 to 2008, to investigate the impact of internal and external R&D expenditures on the business performance of agri-food firms. The results showed the positive influence of external R&D on business performance. Jaisinghani (2016) examined the association between RDI and business performance. Using dynamic panel data and a generalized method of moments, the results of conducted research revealed that RDI and business performance are positively correlated. According to the empirical results of Jin and Choi (2019), R&D investment and innovation activities have a considerable influence on corporate performance. Guo et al. (2020) demonstrated that R&D expenditures improve and have a positive impact on business performance.

1.3.1. The link between R&D investments, RDI and Earnings

Sougiannis (1994) examined whether R&D investments may be beneficial to the company. According to the findings, every dollar spent on R&D resulted in a two-dollar rise in earnings over seven years. The research on the companies that have technology-based growth companies listed on "Neuer Markt" leads to the conclusion that RDI has positive effects on sales growth (Wöhrl et al., 2009). The growth of sales revenue in the current period, logically, can contribute to the earnings growth in the same period.

Some researchers found that in R&D-intensive companies, R&D contributes more to the subsequent operating earnings than physical assets (Amir et al., 2007). Ciftci and Cready (2011) concluded that RDI increases operating earnings and stock returns. Jui et al. (2013) investigated the link between R&D and the financial performance of Taiwanese high-tech firms from 2000 to 2011. In their study, R&D expenditures raise the operating costs, which in turn, result in a decrease in operating earnings, despite increased net sales. Kiraci et al. (2016) studied the influence of R&D expenditures on a firm's short and long-term profitability of 46 publicly traded manufacturing enterprises listed on the Borsa Istanbul from 1998 to 2012. Their empirical evidence demonstrates a positive influence of R&D expenses on firms' operating earnings and net earnings in the long term. Caglar and Nisel (2017) state that marketing and

R&D expenses in the manufacturing industry hurt Earnings before interest and tax (EBIT) and net earnings. Xu et al. (2022) explored the effect of R&D input on the operating earnings of the wastewater companies listed on the Shanghai and Shenzen stock exchanges for the period from 2013 to 2020. The findings showed that R&D input has a positive and significant effect on company operating income.

1.3.2. The link between R&D investments and Total Assets

The existing literature does not analyze the impact of R&D investments on total assets. Total assets consist of current and long-term assets. These assets are material (physical and financial) and nonmaterial (intangible). This relationship between R&D investments and total assets is a very important research area, because R&D investments i.e., R&D cost (expense) that are realized over a certain period do not immediately increase total assets. R&D investments are "converted" into total assets, or capitalized, for varying numbers of years, depending on the industry. Capitalizing expenses is beneficial as companies provide new assets. R&D investments i.e., R&D expense over a certain period should contribute to the growth of a portfolio of resources i.e. total assets. The total assets of the company in the current period are a function of capitalized R&D investments in previous years (Abrahamas & Sidhu, 1998). Studies by Sougiannis (1994) and Ballester et al. (2003) stated that a period of 2 years is necessary for R&D investments to be capitalized. Some researchers (Awano et al., 2010) proved that R&D investments produce results after 4-7 years. The term *R&D investment* is used to point out the relevance of effectiveness and efficiency of R&D activity for increasing resources (assets) and value for shareholders.

According to Isaac et al. (2021), there is a statistically significant link between firms' total assets and R&D investment decisions. Zhou and Zhang (2022) investigated the impact of R&D investment on stock performance in a sample of 61 automotive companies from 2011 to 2020. The results of regression analysis revealed that R&D investment has a positive effect on stock returns for companies with higher total assets.

1.3.3. The link between R&D investments, RDI, Return on R&D investment and Profitability

Since the 1970s and 1980s, various studies have been conducted to determine the relationship between R&D expenses and corporate profitability (Branch, 1974; Schoeffler, 1977; Hirschey, 1982; Roberts & Hauptman, 1987; Grabowski & Mueller, 1988). Several studies suggest that R&D spending has a consistent and favourable impact on a company's profitability (Chan, 2001; Roberts, 2001; Shah, 2008; Ehie, 2010; Pindado, 2010).

Chen et al. (2005) discovered a link between R&D spending and ROA and ROE. Many other academics have examined the impact of R&D spending on company profitability using various profitability measures – the return on assets (ROA) and return on equity (ROE) (Yeh et al., 2010; Vijayakumar & Devi, 2011; Delmar et al, 2013; Vithessonthi et al., 2016) since it accurately reflects the company's positions. ROA indicates the earnings generated by the company's total assets. ROA presents a classic metric for determining a company's profitability and efficiency (Helfert, 2000). ROE shows how a company's profits correspond to its equity (Yeh et al., 2010).

The factors that determine profitability were investigated by Nunes and Serrasqueiro (2015). They analysed 187 companies in Portugal from 2002 to 2009 and concluded that R&D spending has a large and beneficial impact on profitability. Phuong and Manh (2017)

researched a sample of 359 listed firms on the Hanoi Stock Exchange from 2012 to 2016. The regression analysis results showed that R&D spending, dividend pay-out ratio and firms' size are considerably and positively influenced by ROA.

According to Archarungroj and Hoshino (1999), an increase in RDI leads to an increase in profitability, and when profitability increases, corporations will spend additional dollars on implementing R&D activities, resulting in an increase in R&D expenditure. High-tech companies in G8 countries when tested only for an influence of RDI show that when RDI increases, ROE, ROA and profit margin decrease, while an influence of RDI and RDI squared has an inverted U-shaped relationship with ROA and profit margin (Bloemendaal, 2020).

On the other hand, Chen et al. (2019) state that RDI does not always have a positive relationship with a company's performance. In their study, ROA is negatively correlated with RDI in the first period when investment in R&D was made, while the influence of RDI on ROA is negative. These results can be attributed to the lagged effect of R&D investments in the semiconductor industry that come in the succeeding years. The results of the conducted research revealed that RDI has a negative impact on profitability (short-term financial performance) and a favourable effect on firm value (long-term financial performance). Kounnou and Kyrkilis (2020) concluded that the impact of RDI on profitability has no statistical relevance.

Sinha and Mondal (2020) analysed 69 pharmaceutical companies in India from 2008 to 2017. The results of the conducted research reveal the negative and insignificant impact of the lagged value of RDI on ROE. On the other hand, many studies indicate that the positive relationship of RDI on companies' profitability is the most commonly found in the long-term analysis, and the effect can be interpreted with the inversed U-shape. Ozkan (2022) analysed 500 industrial firms in Turkey for the period 2013-2019. According to his findings, R&D expenditures have a negative impact on the current year's financial performance measured by ROE, ROA and ROS (Return on Sales) and this influence will turn positive after a year.

Cincera and Veugelers (2014) conducted a study on a sample of 1000 firms that belong to the European Union and non-EU for the period 2004-2009. The results revealed that the rate of return to R&D is positive for US young firms and statistically insignificant for average European firms in high technology-intensive sectors. Rocha et al. (2019) researched the effect of innovative efforts on the financial performance of firms on a sample of 2000 enterprises covering 40 sectors in 46 countries. In comparison to less efficient enterprises, the most efficient organizations generate better returns with the same level of R&D investment.

2. METHODOLOGY OF RESEARCH

This paper aims to investigate the influence of R&D activity indicators on the profitability of high-tech companies. The research is based on the data of the following indicators: *R&D investment*; R&D intensity (*RDI*), Return on R&D investment (*RORDI*); Earnings before interest and tax (*EBIT*), Net earnings; Earnings before interest and tax, depreciation and amortization (*EBITDA*); Total assets, and Return on assets (*ROA*).

Therefore, the research model is presented in Figure 1.

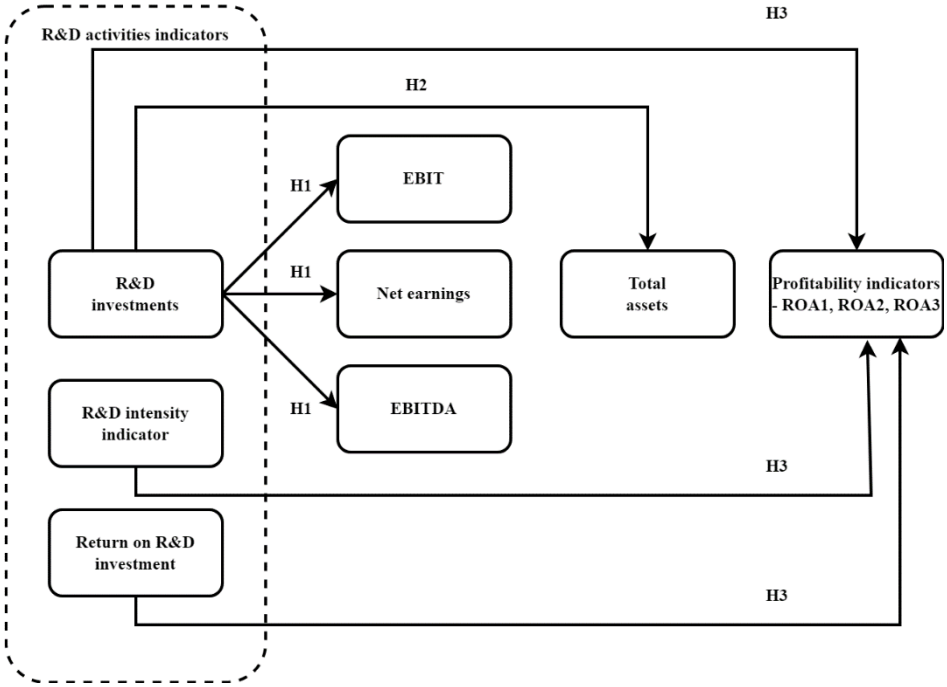

Fig. 1 Research conceptual framework
Source: Authors' presentation

In the following text, the computation process of researched variables is presented.

The R&D intensity indicator is different in various industries and is more valuable in high-tech enterprises (Milkovich et al., 1991). It is defined as expenditures in research and development divided by the company's sales. The following formula (Savrul & Incekara, 2015) is used to compute it:

$$R\&D\ intensity\ indicator = \frac{R\&D\ expenditures}{Sales\ revenue} \tag{1}$$

Return on R&D investment (RORDI) indicates how much of the company's gross profit in the current year was obtained from the prior year's R&D spending. RORDI is calculated using the formula below (Christensen & Van Bever 2014):

$$Return\ on\ R\&D\ investment = \frac{Gross\ profit_t}{R\&D\ expenditures_{t-1}} \tag{2}$$

Return on assets (ROA) is a traditional measure of company profitability. The profitability measure known as Return on Assets (ROA) is calculated in three different ways (Shapiro and Balbirer, 2000; Krstić & Bonić, 2016; Sardo & Serrasqueiro, 2017):

$$ROA_1 = \frac{Net\ earnings}{As} \tag{3}$$

and

$$ROA_2 = \frac{EBIT}{As} \tag{4}$$

where *EBIT* denotes the earnings before interest and tax, *As* denotes Total Assets. EBIT is calculated in the following way:

$$EBIT = Net\ earnings + Income\ tax + Other\ taxes \pm Net\ financial\ loss\ (earnings) \tag{5}$$

For the purpose of comparative analysis of a set of companies from different countries with different tax systems, as well as companies from different industries and different material and intellectual resources, it is desirable to use the term:

$$ROA_3 = \frac{EBITDA}{As} \tag{6}$$

where *EBITDA* stands for earnings before interest and tax, depreciation and amortization. *EBITDA* is calculated in the following way:

$$EBITDA = EBIT + Depreciation + Amortization \tag{7}$$

EBITDA is an analytically better indicator because it enables comparative analyses of companies operating in different countries and industries, with different internal financing policies and fiscal systems, as well as accounting policies for the depreciation of tangible and amortization of intangible assets.

Based on the previously given literature review, the following hypotheses are stated:

Hypothesis H1:

The R&D investments have a positive impact on the EBIT, net earnings and EBITDA.

Hypothesis H2:

The R&D investments have a positive impact on the total assets.

Hypothesis H3:

The R&D investments, R&D intensity (RDI) and Return on R&D investments (RORDI) of the current year have a negative impact on the ROA_1, ROA_2, and ROA_3 as short-term financial performance indicators.

In the research of this paper, data was obtained from the financial statements of the most famous high-technology companies, such as Apple, Intel, Microsoft, Samsung, Cisco, IBM, Oracle, Philips, and SAP. By studying the annual reports of named companies, secondary data was obtained from the websites of the companies and other publicly available databases to calculate research variables and conduct analysis. The analysed period covers the data from 2012 to 2019. Due to the global COVID-19 pandemic, 2020 is not included in the research. Therefore, the analysis covers 72 observations.

In the first seven models, R&D investment is an independent variable, while *EBIT*, net earnings, EBITDA, total assets, ROA_1, ROA_2 and ROA_3 are dependent variables. In the eighth-tenth model, the influence of RDI on ROA_1, ROA_2 and ROA_3 is assessed. The last three models examine the influence of return on R&D investment on ROA_1, ROA_2 and ROA_3 as the dependent variable.

The proposed model was tested using the program Stata (version 13.0).

Firstly, a descriptive statistic was calculated for the analysed variables. Furthermore, all raw data were transferred in natural logarithm values. This procedure was undertaken in order to overcome the problem of incompatibility of research variables and to achieve normal distribution of data.

Secondly, correlation analysis was conducted to assess the extent and direction of the relationships between the researched variables.

Lastly, panel regression analysis was used to evaluate the influence of the independent variable on the dependent variable in seven research models. After the identification of a balanced dataset and the assumptions are met, the fixed-effect model (FEM) and random-effect model (REM) were tested. Afterwards, the Hausman test for every model was performed to select FEM or REM. The Hausman test had a significance cut-off point of p = 0.05. Therefore, all values statistically significantly less than 0.05 indicate the selection of FEM, otherwise, REM was interpreted.

3. Results and Discussion of empirical research

Table 1 presents the descriptive statistics of the researched sample. The data on R&D investments implies that the mean value of the variable is 8,573.263 (SD = 6,495.203). RDI varies between 0.022 and 0.219 with a mean value of 0.125 (SD = 0.050). RORDI has a mean of 6.337 (SD = 3.801). Average values of dependent variables are: EBIT (mean = 20,709.346, SD = 17,944.585), EBITDA (mean = 27,185.620, SD = 21,913.647), net earnings (mean = 15,862.457, SD = 14,378.361), total assets (mean = 139,496.622, SD = 87,895.407). Lastly, average values of proxy indicators of ROA are: ROA_1 (mean = 0.099, SD = 0.045), ROA_2 (mean = 0.131, SD = 0.053) and ROA_3 (mean = 0.173, SD = 0.060).

Table 1 Descriptive statistics

Variable	Minimum	Maximum	Mean	SD
R&D investment (millions of $)	1,854.380	33,200.510	8,573.263	6,495.203
RDI	.022	.219	.125	.050
RORDI	2.332	28.268	6.337	3.801
EBIT (millions of $)	646.039	71,230.000	20,709.346	17,944.585
EBITDA (millions of $)	2,251.830	82,487.000	27,185.620	21,913.647
Net earnings (millions of $)	-39.000	59,531.000	15,862.457	14,378.361
Total assets (millions of $)	28,613.550	375,319.000	139,496.622	87,895.407
ROA_1	-.001	.237	.099	.045
ROA_2	.017	.314	.131	.053
ROA_3	.053	.332	.173	.060

Source: Authors' calculations

Table 2 presents the pair-wise correlations (Pearson Correlation) among all the analysed variables. The correlations between independent and dependent variables have medium to high practical effects. The investment in R&D is positively and significantly correlated with EBIT ($r = .532$, $p < .01$), EBITDA ($r = .675$, $p < .01$), Net earnings ($r = .519$, $p < .01$), Total asset ($r = .702$, $p < .01$). Moreover, R&D investment is positively correlated with profitability indicators ROA_1 ($r = .249$, $p < .01$), ROA_2 ($r = .251$, $p < .05$) and ROA_3 ($r = .387$, $p < .01$). On the other hand, RDI is only statistically significantly and negatively correlated with ROA_1 ($r = -.234$) at the level of significance of 5%. RORDI has a positive and significant relationship with ROA_1 ($r = .612$, $p < .01$), ROA_2 ($r = .661$, $p < .01$) and ROA_3 ($r = .467$, $p < .01$).

Table 2 Bivariate Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10
1.R&D inv.	1									
2.RDI	.173	1								
3.RORDI	-.212	-.577**	1							
4.EBIT	.532**	-.431**	.541**	1						
5.EBITDA	.675**	-.367**	.432**	.978**	1					
6.Net earnings	.519**	-.427**	.517**	.984**	.962**	1				
7.Total assets	.702**	-.306**	.290*	.905**	.938**	.892**	1			
8.ROA_1	.249**	-.234*	.612**	.722**	.672**	.759**	.496**	1		
9.ROA_2	.251*	-.227	.661**	.748**	.693**	.728**	.497**	.930**	1	
10. ROA_3	.387**	-.122	.467**	.638**	.650**	.606**	.430**	.811**	.885**	1

Note: Significance at 5% is indicated by *, while significance at 1% is indicated by **.
All significance tests are two-tailed.
Source: Authors' calculations

In the following part, the research models are investigated by employing panel regression analysis of the data. Firstly, the results of R&D investment influence are presented in Table 3.

Table 3 Panel regression results – R&D investment as a predictor

Independent variable	Research models						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	lnEBIT	lnNet Income	lnEBITDA	lnTotal Assets	ROA_1	ROA_2	ROA_3
	FEM	FEM	FEM	REM	FEM	FEM	FEM
Constant	7.103	6.959	6.953	6.333	.437	.586	.735
	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.019)	(0.014)
lnR&D investment	.274	.255	.328	.601	-.038	-.051	-.063
	(0.011)	**(0.003)**	**(0.002)**	**(0.000)**	**(0.012)**	**(0.052)**	**(0.043)**
Hausman test	81.48	6.32	10.13	1.74	16.22	25.25	38.56
	(0.000)	(0.012)	(0.001)	(0.187)	(0.000)	(0.000)	(0.000)
F / χ^2	10.66	17.09	20.41	30.7	10.4	5.2	5.75
	(0.011)	**(0.003)**	**(0.001)**	**(0.000)**	**(0.012)**	**(0.052)**	**(0.043)**
R^2	0.086	0.013	0.258	0.593	0.120	0.184	0.187

Note: p-value in the parentheses.
Source: Authors' calculations

According to the previously defined methodological assumptions of the panel regression analysis, models 1-5 and 7 are statistically significant. On the other hand, model 6 did not meet the assumptions of statistical significance but it is indicative because its significance is at the level of 10%.

Model 1: In this model, the influence that investment in R&D has on EBIT has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 81.48 ($p = 0.000$) so the FEM should be assessed. Model fit is significant at the level of $p < 0.05$ ($F = 10.66$, $p = 0.011$). R^2 indicates that the independent variable explains 8.6% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.274) on lnEBIT and its effect is statistically significant.

Model 2: In this model, the influence that investment in R&D has on net earnings has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 6.32 ($p = 0.012$) so the FEM should be assessed. Model fit is significant at the level of $p < 0.05$ ($F = 17.09$, $p = 0.003$). R^2 indicates that the independent variable explains only 1.3% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.255) on lnNetEarnings and its effect is statistically significant.

Model 3: In this model, the influence that investment in R&D has on EBITDA has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 10.13 ($p = 0.001$) so the FEM should be assessed. Model fit is significant at the level of $p < 0.05$ ($F = 20.41$, $p = 0.001$). R^2 indicates that the independent variable explains 25.8% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.328) on lnEBITDA and its effect is statistically significant. Therefore, the research hypothesis H1 is supported.

Model 4: In this model, the influence that investment in R&D has on total assets has been measured. It was hypothesized that the influence is positive. The Hausman test indicates χ^2 of 1.74 ($p = 0.187$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 30.7$, $p = 0.000$). R^2 indicates that the independent variable explains 59.3% of the variance of the dependent variable. Independent variable: lnR&D investment has a positive effect (.601) on lnTotalAsset and its effect is statistically significant. Therefore, the research hypothesis H2 is supported.

The results of the first four models indicate that an increase in R&D investments would lead separately to an increase in *EBIT*, net earnings, *EBITDA* and total assets if other factors' influence is constant.

Model 5: In this model, the influence that investment in R&D has on ROA_1 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 16.22 ($p = 0.000$) so the FEM should be assessed. Model fit is significant at the level of $p < 0.05$ ($F = 10.4$, $p = 0.012$). R^2 indicates that the independent variable explains 12% of the variance of the dependent variable. Independent variable: lnR&D investment has a negative effect (-.038) on ROA_1 and its effect is statistically significant.

Model 6: In this model, the influence that investment in R&D has on ROA2 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 25.25 ($p = 0.000$) so the FEM should be assessed. Model fit is significant at the level of 10% ($F = 5.2$, $p = 0.052$). R^2 indicates that the independent variable explains 18.4% of the variance of the dependent variable. Independent variable: lnR&D investment has a negative effect (-.051) on ROA_2 and its effect is statistically significant at the 10% level. Therefore, the results of this analysis are only indicative.

Model 7: In this model, the influence that investment in R&D has on ROA3 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 38.56 ($p = 0.000$) so the FEM should be assessed. Model fit is significant at the level of $p < 0.05$ ($F = 5.75$, $p = 0.043$). R^2 indicates that the independent variable explains 18.7% of the variance of the dependent variable. Independent variable: lnR&D investment has a negative effect (-.063) on ROA_3 and its effect is statistically significant. Therefore, the research hypothesis H3 is supported in this part of the analysis.

If all other influential factors unchanged, an increase in R&D investment would lead to a decrease in ROA_1, ROA_2 and ROA_3.

It should be noted that the panel analysis of the RDI effect on ROA indicators revealed (models 8-10) a negative sign of influence but not statistically significant. Therefore, the results of the analysis are not interpreted in the tables. Furthermore, the research hypothesis H3 is not confirmed in this part of the analysis.

The following table indicates the results of panel regression where the return on R&D is a predictive variable of ROA_1, ROA_2 and ROA_3.

Table 4 Panel regression results – Return on R&D investment (RORDI) as a predictor

Independent variable	Research models		
	Model 11	Model 12	Model 13
	ROA_1	ROA_2	ROA_3
	REM	REM	REM
Constant	.064	.084	.129
	(0.000)	(0.000)	(0.000)
Return on R&D investments	.001	.007	.007
	(0.000)	**(0.000)**	**(0.000)**
Hausman test	1.03	0.40	0.01
	(0.311)	(0.527)	(0.904)
F / χ^2	**56.08**	**95.23**	**65.68**
	(0.000)	**(0.000)**	**(0.000)**
R^2	0.172	0.313	0.190

Note: p-value in the parentheses.
Source: Authors' calculations

Model 11: In this model, the influence that returns on R&D investments have on ROA_1 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 1.03 ($p = 0.311$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 56.08$, $p = 0.000$). R^2 indicates that the independent variable explains 17.2% of the variance of the dependent variable. Independent variable: return on R&D investment has a positive effect (.001) on ROA_1 and its effect is statistically significant but very small.

Model 12: In this model, the influence that returns on investment in R&D have on ROA_2 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 0.40 ($p = 0.527$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 95.23$, $p = 0.000$). R^2 indicates that the independent variable explains 31.3% of the variance of the dependent variable. The independent variable: return on R&D investment has a positive effect (.007) on ROA_2 and its effect is statistically significant but very small.

Model 13: In this model, the influence that investment in R&D has on ROA_3 has been measured. It was hypothesized that the influence is negative. The Hausman test indicates χ^2 of 0.01 ($p = 0.904$) so the REM should be assessed. Model fit is significant at the level of $p < 0.05$ ($\chi^2 = 65.68$, $p = 0.000$). R^2 indicates that the independent variable explains 19% of the variance of the dependent variable. The independent variable: return on R&D investment has a positive effect (.007) on ROA_3 and its effect is statistically significant but very small. Based on the previous results, the research hypothesis H_3 is only partially supported in this research. Moreover, when the return on R&D investments would increase the ROA1, ROA2, and ROA3, also, respectively, and under the condition that other factors' influence is unchanged.

CONCLUSION

In today's global marketplace, R&D is the core determinant of sustaining competition. R&D is increasingly being linked to a company's profitability, growth and competitiveness in the market. Therefore, this paper's aim was to examine and explain the influence of R&D activity on business performance in the example of high-technology companies. The leading indicators of R&D activity that are widely used in the previous research and consequently in current research are R&D investments, RDI and RORDI. This research encompassed nine high-tech companies, their indicators of R&D activity and relevant business performances such as EBIT, net earnings, EBITDA, total assets and ROA were examined and confronted in the analysis.

Considering the data of the eight years, the panel regression analysis in this study of the high-technology companies has revealed that R&D investments have a positive influence on EBIT, net earnings, and EBITDA. Similarly, Aytekin & Özçalık (2018) detected a positive relationship between R&D investments and EBIT. Furthermore, the results of this study are in line with VanderPal (2015) who has found that R&D spending had a considerable and positive impact on net earnings. Some researchers (Sun et al., 2019) stated that higher R&D investments reduce EBITDA. Our results are, also, consistent with the findings of Dyrnes & Friestad (2020), who found that R&D was positively related to EBITDA margin.

In addition, conducted research confirms that R&D investments have a positive impact on total assets. There have been no comparable results or similar studies that have examined the association between R&D and total assets. Moreover, there is a gap and lack of consensus in terms of the effect of R&D on total assets, thus, we explored this area that has not been investigated before.

Based on the obtained empirical results, this study reveals that the influence of R&D investments on short-term financial performance indicators (ROA_1, ROA_2, and ROA_3 in the current year) is negative. Similar research conducted by Su et al. (2021) implies that R&D investments are a long-term characteristic of ROA and its influence on ROA is negative in the first year, but with a 2 or 3-year lag effect, the sign of influence turns positive. Additionally, the hypothesis in our study that RDI has a negative influence on three indicators of ROA was not confirmed. Contrary to our results, Wang and Chen (2022) revealed that there is a negative relationship between RDI and corporate performance (ROA and ROE). Bloemendaal (2020) found mixed results in the literature on how RDI influences companies' ROE and ROA. Moreover, his research indicates a negative correlation between RDI and profitability indicators of high-tech companies and the negative influence of RDI on the same indicators which supports the findings of our study. Lastly, this study reveals that RORDI has a statistically significant and positive influence on ROA_1, ROA_2, and ROA_3, but very small in scope. In addition, many studies (Nandy, 2020; Hazarika, 2021) have proven that a longer period is needed for R&D investments to start to pay off.

By emphasizing the significance of R&D spending on corporate performance, the paper substantially contributes to the literature that investigates the influence of R&D activity on the companies' profitability. The *originality* of this study is in this dimension of analysis – the impact of RORDI on ROA. The paper points out that not only investment in R&D has an impact on profitability indicators, but also return on investment in R&D (RORDI) has an influence on the companies' ROA. The influence of RORDI on ROA as a measure of

short-term financial success has not been studied, and there are no clear and concrete specific empirical conclusions in the literature. Our study will offer a unique and different viewpoint on the entire issue of estimating the impact of R&D expenditure on a company's profitability. The analysis of the relationship between R&D and ROA_3 is also novel because it uses EBITDA to improve the analytical capability of this indicator. That sheds light on the new approach to accessing the influence of R&D on ROA. Through EBITDA, it is possible to compare companies across different industries and countries. The effects of R&D investment on total assets have not been explored in the literature yet. This presents a substantial research challenge for the study and provides at the same time a new research perspective on the relevant literature. Therefore, the paper makes a contribution to the contemporary literature on this topic. This research is beneficial and provides practical implications and recommendations, giving guidelines for decision-making to corporate managers, potential R&D investors as well as implementers of R&D strategies.

The limitation of this study comes out from the size of the database and the number of analysed years. Moreover, the shortcoming of this research study arises from the fact that it examines the influence of R&D indicators on a company's short-term profitability, without taking into consideration lagged effect of these predictors on dependent variables. Lastly, the current study is focused only on one sector (ICT), so the results could not be generalized to other sectors.

The direction for future research is primarily reflected in extending the research period. Therefore, this might give additional empirical background for this issue. The time-lag period has always been a significant factor to consider when examining R&D activities and processes. While R&D investments have a negative effect on ROA indicators, the positive influence of return on R&D investment (RORDI) on ROA could be justified by the lag period. The consideration of the effect of the lagged value of R&D on performance is very logical, so the possible direction for future research stems from that investigators can conduct an analysis of time-lagged R&D on return on investment (ROI). By expanding the number of analysed companies and introducing additional industries into analysis, and especially through a comparative analysis of different sectors in order to see the differences, future research on this topic will generate more generalised conclusions and grounded recommendations for practice.

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UTICAJ ULAGANJA U ISTRAŽIVANJE I RAZVOJ NA POSLOVNE PERFORMANSE VISOKO-TEHNOLOŠKIH KOMPANIJA

Cilj ovog rada je da se ispita uticaj aktivnosti I&R na poslovne performanse visoko tehnoloških kompanija. Kako bi se izvršila empirijska analiza uticaja aktivnosti I&R na poslovne performanse visoko tehnoloških kompanija, korišćene su korelaciona i regresiona analiza.

Ova studija je otkrila da ulaganja u I&R imaju pozitivan uticaj na EBIT, neto dobit, EBITDA i ukupnu aktivu, dok je njihov uticaj na ROA pozitivan i statistički značajan. Pored toga, uticaj intenzivnosti I&R na ROA kao kratkorčnog indikatora finansijskih performansi nije potvrđen. Studija je otkrila da povraćaj ulaganja u I&R ima statistički značajan i pozitivan uticaj na ROA u tekućoj, posmatranoj godini. Evaluacija dobijenih rezultata može biti osnova za donošenje detaljnijih zaključaka, doprinoseći budućoj strategiji istraživanja i razvoja i postojećoj literaturi, naglašavajući značaj ulaganja u I&R za poslovne performanse preduzeća. Originalnost ove studije ogleda se u sveobuhvatnoj analizi uticaja specifičnih indikatora aktivnosti I&R na poslovne performanse visoko tehnoloških kompanija. Ovaj rad je takođe koristan zbog činjenice da nijedna od postojećih studija nije istraživala uticaj ulaganja u I&R na EBITDA.

Ključne reči: *Aktivnosti I&R, ulaganja u I&R, poslovne performanse, profitabilnost*

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Review Paper

CARBON ACCOUNTING IN THE PUBLIC SECTOR – CHALLENGES, APPROACHES AND PERSPECTIVES FOR MUNICIPALITIES

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Abstract. *Nowadays, combating climate change and its effects due to the anthropogenic greenhouse effect is one of the central challenges for society and politics in order to prevent further increase of greenhouse gases in the atmosphere and thus become climate neutral. An indispensable prerequisite for the selection, implementation and monitoring of the effectiveness of measures to reduce greenhouse gas emissions is the measurement and accounting of emissions through the implementation of a carbon accounting system. Compared to companies, the topic of carbon accounting at the municipality level has so far received less public attention. Therefore, this paper deals with the specific challenges, the approaches and the perspectives of municipal carbon accounting.*

Key words: *carbon accounting, greenhouse gas emissions, municipalities, climate changes*

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1. INTRODUCTION

Sustainability and sustainable development in general, as well climate protection in particular, are among the dominant issues of the 21st century. According to one of the oldest and most common definitions of sustainability, „sustainable development aims to ensure that the needs of the present are met without risking that future generations will not be able to meet their own needs" (UN, 1987, Chapter I 3 No. 27, p 15). The importance of the issue and its broad scope imply that sustainable development should be approached internationally. In September 2015, the United Nations (UN) member states adopted the Agenda 2030 (UN, 2015a). At the heart of the Agenda are the 17 Sustainable Development Goals (SDGs), which are further divided into 169 sub-goals (Lorson & Haustein, 2022). The municipality level is explicitly considered in the SDGs, with SDG 11 stating that cities and settlements should be made inclusive, safe, resilient and sustainable. Measures for climate protection can be found in SDG 13 (Koch et al., 2019). The main cause of climate changes is the human-induced greenhouse effect: human activities, such as the burning of fossil fuels, cause an increase in greenhouse gases in the atmosphere, leading to a steady global warming and ultimately to the problems of rising sea levels, increasing frequency of extreme weather, droughts and generally negative consequences for biodiversity and ecosystems.

The UN Framework Convention on Climate Change (UNFCCC) is considered to be the origin of international climate policy (UN, 1992, UNFCCC). It was signed by 154 countries at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. By ratifying the convention, the industrialized countries undertake to continuously account for their greenhouse gases (GHG) and to report annually in an inventory, the National Emissions Inventory. This is because the key to limiting climate changes lies in reducing GHG emissions to the point of complete GHG neutrality. GHG neutrality or climate neutrality describes the state in which no net contribution to the concentration of greenhouse gases in the atmosphere is made, i.e. any emissions are either avoided or compensated. If this consideration refers only to the specific greenhouse gas CO2, this is referred to as CO2 neutrality (Butler et al., 2015). In addition, a climate conference (Conference of the Parties, COP) has been held annually since 1992. A groundbreaking conference took place in Kyoto in 1997 (COP3) with the adoption of the Kyoto Protocol (UN, 1998). This set limits on GHG emissions for the first time. At the 2015 conference in Paris (COP21), the Paris Agreement (UN, 2015b) was reached, replacing the Kyoto Protocol, which expired in 2020, and committing its participants to limit global warming to well below 2°C and preferably to 1.5°C above pre-industrial levels. In December 2019, the European Green New Deal (European Commission, 2019) was unveiled, making Europe the first continent to become GHG neutral by 2050.

Increasingly, science and politics are warning that current efforts in the climate crisis fall far short of what is needed to curb the human-induced rise in temperature. This is clear from the current Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), in which the IPCC assesses the global residual CO_2 budget from the beginning of 2020 at around 400 gigatons, compliance with which will enable the 1.5 °C target to be achieved with a probability of 67% (IPCC, 2021).

2. Fundamentals of Carbon Accounting

As an indispensable prerequisite for GHG mitigation measures, carbon accounting leads to a GHG balance sheet or inventory through the measurement and reporting of emissions (Brohé, 2016). In this context, the term carbon footprint is often used. The fundamental issue here is which greenhouse gases are to be recorded. Natural and anthropogenic greenhouse gases account for less than 1% of the components of the atmosphere, since their main components, measured by volume fraction, are nitrogen at 78.08% and oxygen at 20.94% (Bridgman, 2005). Important natural greenhouse gases are hydrogen, carbon dioxide (CO_2), methane (CH_4), ozone and nitrous oxide (N_2O). In addition, there are fluorinated greenhouse gases, so-called F-gases, which are exclusively caused by humans (Brohé, 2016). Hydrogen or ozone occur in large quantities, but unlike the other greenhouse gases, they play only a minor role in the anthropogenic greenhouse effect. The political targets for greenhouse gas reduction are based on the Kyoto Protocol of 1997. This initially anchored six greenhouse gases to be documented: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs/HFCs), perfluorocarbons (HFCs/PFCs) and sulfur hexafluoride (SF_6) (Chang & Bellassen, 2015). At the 18th UN Climate Change Conference in Doha in 2012, the harmful gas nitrogen trifluoride (NF_3) was added to the list for the upcoming second period of the Kyoto Protocol (UN, 2012). Consequently, the accounting should, as far as possible, not only take into account CO_2 or carbon compounds, as the term "carbon accounting" might suggest, but also the other relevant greenhouse gases.

In order to determine a total quantity of GHG emissions, the values of all greenhouse gases considered in the balance must first be converted into a common unit (Brohé, 2016): Since CO_2 has the greatest significance for the anthropogenic greenhouse effect, this gas is used as the reference value. All greenhouse gases are converted into CO_2 equivalents (CO_2e) according to their relative Global Warming Potential (GWP). The GWP_N is the ratio of the contribution of a specific gas to the greenhouse effect over a given period N to the corresponding contribution of CO_2. Current calculations of CO_2 equivalents are regularly based on the determined GWP of the IPCC. CH_4, for example, has a GWP_{100} of 28 and thus 28 times the effect of CO_2 over the period of 100 years (UBA, 2020).

In detail, the calculation is technically complex and offers room for discussion at many points. For example, in order to prepare a GHG balance, the so-called inventory boundaries must be defined in order to delimit for which subsystem, for which geographical area and for which time period the effects are to be recorded. The issues of completeness and responsible allocation of GHG emissions are also much discussed, with two different approaches to accounting. According to production-based accounting (territorial accounting), all emissions that are emitted within the spatial boundary of a considered territory are included in the balance. Emissions from the export of locally produced goods are included, while emissions related to imported goods are excluded (Peters, 2008). In contrast, consumption-based accounting includes all emissions caused by all consumption within the territory under consideration, even if they are emitted outside the territory. The choice of methodology undoubtedly has important implications for the level of GHG emissions identified (Hoornweg et al., 2011). Territorial accounting is the predominant approach in practice and is also the subject of national emissions inventories to be prepared under the UNFCCC, which follow the IPCC accounting rules (IPCC, 2006).

3. THE ROLE OF MUNICIPALITIES IN CLIMATE CHANGE

Due to increasing urbanization and the associated energy consumption and CO_2 emissions, municipalities are contributing their share to climate change. At the same time, the negative effects of climate change are directly felt in cities through extreme weather events, such as flooding caused by heavy rainfall, water shortages, heat waves, or changes in the microclimate and the creation of heat islands (Cutter et al., 2012; WBGU, 2016). This proximity to the problem also results in proximity to the solution, providing good reasons for climate protection efforts and ultimately for carbon accounting in municipalities. Through politically close contact with citizens, municipalities can mediate between different interests, promote citizen participation and increase the acceptance of measures (DIFU, 2018).

To take advantage of opportunities to share information and scale activities, municipalities can also form networks internationally; among the largest are the Climate Alliance, with 1,915 members from 27 mostly European countries (Climate Alliance, 2022), and the Global Covenant of Mayors for Climate & Energy (GCoM), with approximately 12,500 cities (GCOM, 2022) representing over one billion people, nearly one-eighth of the world's population.

3.1. Approaches to the design of carbon accounting at the municipal level

With the growth of climate protection as a separate municipal area of responsibility, the first local energy supply concepts were developed in the 1980s and 1990s, specifically including measures for the economical use of energy (Blümling, 2000; Müschen, 1998). Internationally, there was no leading carbon accounting standard at the municipal level for a long time. Instead, many independent attempts existed to design a suitable approach, which meant that the comparability of GHG balances suffered (for example Hillman & Ramaswami, 2010; Sovacool & Brown, 2010).

It should be noted that the GHG accounting of municipalities is not limited to the activities of the central administrative unit or the accounting of municipal enterprises, but includes all activities in the geographical area of a municipality.

In the following, an international standard for GHG accounting will be presented.

3.2. Global Protocol for Community-Scale Greenhouse Gas Inventories

Since 2014, the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC) has been an internationally recognized and practiced accounting standard, revised in 2021 as version 1.1. It is an adaptation of the GHG Protocol Corporate Standard developed for companies to the community level. It was developed by three organizations, the World Resource Institute (WRI), the C40 Cities Climate Leadership Group and ICLEI - Local Governments for Sustainability, in cooperation. The GPC standard aims to provide assistance in preparing a comprehensive GHG balance sheet to support municipal climate protection planning.

The GPC standard consists of three parts and a likewise three-part appendix with supplementary information. Part 1 describes the basic requirements for accounting, in addition to an introduction to the development and purpose of the GPC. Part 2 contains the specific guidelines for calculating GHG emissions, since for the majority of activities emissions cannot be measured directly and therefore must be estimated using activity data and emission factors (e.g., using the IPCC's Emission Factor Database (EFDB)).

Finally, Part 3 deals with GHG emissions mitigation goal setting and monitoring the implementation of these goals. Furthermore, it deals with the management of the quality of GHG balances and the possible verification.

3.2.1. Accounting in accordance with the GPC standard

A city's GHG inventory should follow the general accounting principles of relevance, completeness, consistency, transparency, and accuracy (WRI et al., 2021).

Inventory boundaries are derived from the geographic area (e.g., administrative sphere of influence or actual city boundary), time period (e.g., one year), the seven Kyoto Protocol GHGs to be covered, and emission sources.

Emission sources are categorized into the six sectors of Stationary Energy, Transportation, Waste, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Other Scope 3 Emissions; additional subsectors are possible.

In addition to the categorization, emissions are divided into three scopes (WRI et al., 2021), See also Figure 1:

- Scope 1 emissions are emissions emitted within the city boundary, allowing aggregation at the regional or national level without double counting.
- Scope 2 emissions result from the use of electricity, heating, water vapor, and cooling within the city boundary, with emissions from generation originating outside the city boundary.
- Scope 3 emissions occur outside the city boundary, but as a result of activities within the city boundary. The inclusion of Scope 3 emissions in the GHG balance is largely optional due to the difficulty of obtaining and preparing data.

Scope 3 emissions are also referred to as upstream emissions, or gray emissions, which occur during the extraction, production, and transportation of energy sources or products and services consumed by city residents (Hoornweg et al., 2011). The decision on the scope of included Scope 3 emissions has an enormous impact on the total amount of emissions accounted for, as this category is mostly the largest item. In one study of eight U.S. cities, the inclusion of the Scope 3 category increased total GHG emissions by

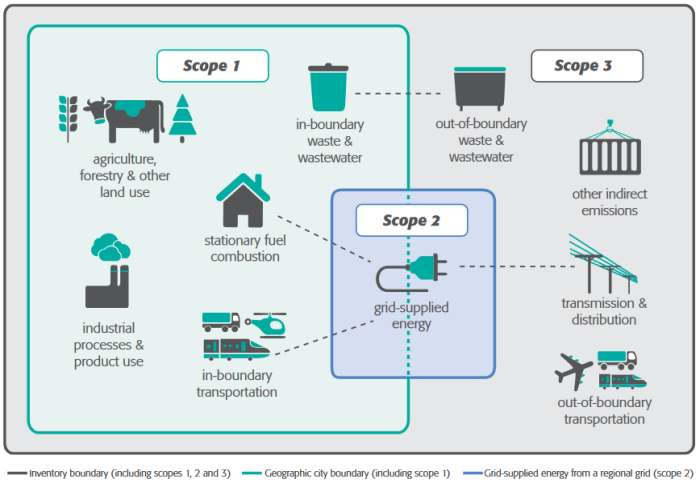

Fig. 1 Relationship between inventory boundaries and scopes in the GPC standard
Source: WRI et al., 2021, p. 36.

47% on average (Hillman & Ramaswami, 2010). In terms of accounting approaches, the scope 1 category clearly corresponds to a pure territorial accounting according to production-based accounting, while the other two Scope 2 and 3 categories follow the consumption-based accounting perspective (Hoornweg et al., 2011).

The GPC standard basically distinguishes between two different but complementary frameworks, the scopes framework and the city-induced framework (WRI et al., 2021). The former intends to report all emissions from activities within the city boundary by categorizing emissions by scopes. The latter allows accounting entities to choose between reporting according to levels known as BASIC and those known as BASIC+. These represent a different scope and level of detail, as each includes only certain Scope 1-3 emissions from selected categories (WRI et al., 2021). Figure 2 shows the sources and scopes covered by the GPC.

3.2.2. Stationary Energy

Scope 1 includes emissions from the combustion of fuels in buildings and industry and fugitive emissions from the extraction, conversion, and transport of fossil primary energy sources. Scope 2 emissions from this sector result from the consumption of energy from the regional or national grid. Scope 3 includes emissions from proportional losses in the transmission and distribution of energy (WRI et al., 2021).

The Stationary Energy sector contains a total of nine subsectors, such as residential, commercial/public buildings, parts of manufacturing, parts of the energy industry, parts of agriculture/forestry/fisheries, fugitive emissions from the processing of coal, and those from the processing of oil and natural gas (WRI et al., 2021). There is an additional residual category for unspecified emission sources. Emissions from energy production in the city, which is fed into the grid from there, represent a special case. These emissions are only taken into account when forming a sum of all Scope 1 emissions. However, they are neglected when determining scope 2 emissions in order to avoid double counting (WRI et al., 2021).

For the building subsectors, there is guidance on dealing with mixed-use buildings (WRI et al., 2021). Manufacturing industries include emissions from the combustion of energy sources in stationary facilities or off-road transportation within the industrial site. If possible, they can be further subcategorized by industry. For this subsector in particular, the standard provides several examples to distinguish it from other sectors (WRI et. al., 2021). In the energy industry, three activities are distinguished: the production of primary energy sources, their subsequent processing and transformation, and ultimately the production of energy that is fed into the grid. Separate discussion is given here to cogeneration, trigeneration, energy production from waste, and bioenergy (WRI et al., 2021). In the agricultural sector, for example, emissions are generated during the use of agricultural machinery and generators (WRI et al., 2021). Fugitive emissions occur during the extraction, conversion, and transportation of fossil fuels. These processes are broken down separately for coal and for oil and natural gas (WRI et al., 2021).

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
STATIONARY ENERGY			
Residential buildings	✓	✓	✓
Commercial and institutional buildings and facilities	✓	✓	✓
Manufacturing industries and construction	✓	✓	✓
Energy industries	✓	✓	✓
Energy generation supplied to the grid	✓		
Agriculture, forestry, and fishing activities	✓	✓	✓
Non-specified sources	✓	✓	✓
Fugitive emissions from mining, processing, storage, and transportation of coal	✓		
Fugitive emissions from oil and natural gas systems	✓		
TRANSPORTATION			
On-road	✓	✓	✓
Railways	✓	✓	✓
Waterborne navigation	✓	✓	✓
Aviation	✓	✓	✓
Off-road	✓	✓	
WASTE			
Disposal of solid waste generated in the city	✓		✓
Disposal of solid waste generated outside the city	✓		
Biological treatment of waste generated in the city	✓		✓
Biological treatment of waste generated outside the city	✓		
Incineration and open burning of waste generated in the city	✓		✓
Incineration and open burning of waste generated outside the city	✓		
Wastewater generated in the city	✓		✓
Wastewater generated outside the city	✓		
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
Industrial processes	✓		
Product use	✓		
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)			
Livestock	✓		
Land	✓		
Aggregate sources and non-CO_2 emission sources on land	✓		
OTHER SCOPE 3			
Other Scope 3			

✓ Sources covered by the GPC
Sources required for BASIC reporting
+ Sources required for BASIC+ reporting
Sources required for territorial total but not for BASIC/BASIC+ reporting (*italics*)
Sources included in Other Scope 3
Non-applicable emissions

Fig. 2 Sources and scopes covered by the GPC
Source: WRI et al., 2021, p. 41.

Scope 1 emissions from fuel combustion are obtained by multiplying the emission factor of an energy carrier by its consumption, which represents activity data (WRI et al., 2021). Energy consumption is determined using factors that indicate the average location-specific energy production (location-based method). For activity data of Scope 2 energy

use emissions, utilities or surveys can provide actual consumption values. Otherwise, national data modeled or scaled via building types provide relief (WRI et al., 2021). Scope 3 emissions are calculated by multiplying those Scope 2 energy consumptions by a loss factor (WRI et al., 2021).

3.2.3. Transportation

The classification of emission sources in the transport sector is complicated by the fact that traffic often crosses borders. Basically, Scope 1 includes emissions from fuel combustion of all passenger and freight transport within the city boundary. Scope 2 includes emissions from electricity consumption for electric vehicles at intra-city charging stations. Scope 3 includes the shares of emissions from cross-border trips that are outside the city boundary, as well as any emissions from a port or airport. Similar to the Stationary Energy sector, Scope 3 also includes emissions from the proportionate losses in the transmission and distribution of energy that are attributable to electric vehicles (WRI et al., 2021).

The five types of transportation – road, rail, water, air, and off-road – make up the subsectors of the Transportation sector (WRI et al., 2021). For each of the five transport types, very detailed information is provided in the standard.

For the calculation of road transport emissions, for example, there are four methods to choose from (WRI et al., 2021). The first method works top-down and uses total intra-urban fuel sales as a measure of transportation activity (fuel sales method). The other three methods are bottom-up oriented. They are based on the so-called ASIF model (Activity, Mode Share, Intensity, Fuel). According to this model, emissions are calculated by multiplying the mileage by the fuel consumption and the emission factor. For the second method, the number and length of all trips must be known. Then, all intra-urban and 50% of the cross-border trips are accounted for (induced activity method). The third method corresponds to a classical territorial balance and thus includes all transport activities within the city boundary (territorial method). The fourth method includes all transport activities of residents and is therefore comparable to a consumer balance (resident activity method).

Transport activity data can be obtained from surveys, by modeling, by asking the relevant institutions or by scaling regional and national data (WRI et al., 2021).

4. SUMMARY AND OUTLOOK FOR FURTHER CHALLENGES

The paper concludes that at the municipal level, the characteristics of the institution of the municipality as well as the specific purpose of the GHG balance must be in the foreground. This is because a municipal GHG balance mainly forms the control and decision-making basis for the implementation of measures to achieve climate and emission targets. Priority must therefore be given to recording Scope 1 and 2 emissions as correctly and accurately as possible. Only when these necessary prerequisites have been met can and should municipal carbon accounting be expanded to include Scope 3 and consumption-based emissions.

In addition to selecting suitable accounting approaches for a GHG inventory, municipalities face further challenges. It is often not possible to obtain all the necessary data at the municipal level in a sufficiently disaggregated form. The primary goal is always to achieve the highest possible data quality, which increases the fewer estimates

and scalings have to be made. To achieve a high proportion of primary data, intensive cooperation with various local institutions and authorities is necessary (DIFU, 2018).

Another key aspect for municipalities is the question of financing. Municipalities have limited financial resources for the accounting of GHG emissions and the subsequent implementation of mitigation measures. This also applies, for example, to the hiring and training of personnel. Although financing is undoubtedly a major challenge, it must be borne in mind that any damage caused by failure to take climate protection measures will be associated with significantly higher costs in the future (Gouldson et al., 2015, p. 5: "Overall, local climate protection measures pay off and lead to considerable savings in the long run").

The sluggish development of municipal carbon accounting is also due to the lack of binding reduction targets and the lack of obligation. As an aspect of climate protection, carbon accounting fits into the catalog of tasks of a municipality as a voluntary self-governing task (Kern et al., 2005). Related to the challenge of financing, it competes with investments in other voluntary tasks, such as culture and sports. Consequently, in municipalities, a limited additional benefit faces potentially enormous additional costs, creating an incentive problem for carbon accounting (Cochran, 2015). Consequently, the fact that climate protection, carbon accounting and the widespread diffusion of climate-neutral alternatives are associated with economic benefits and other additional benefits, such as improved air quality, ecosystem protection or noise abatement, which increase the quality of life for the municipality's citizens, is all the more important.

In order to work towards a targeted reduction of emissions, the carbon accounting system should be integrated into a holistic carbon management cycle. After the analysis of the actual state, which in this case is done by the municipal carbon accounting and the resulting GHG balance, the five classic stages of the management cycle follow: goal setting, planning, decision, realization and control (Lorson & Haustein, 2022). To increase transparency regarding GHG emissions and achieved reduction targets, the GHG balance can be embedded in voluntary sustainability reporting. In this way, a municipality's sustainability efforts could be presented in a bundled way and accounted for - as well as for the financial use of resources. In addition, sustainability should be further integrated into governance systems, such as internal control and risk management systems or internal audit.

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RAČUNOVODSTVENO OBUHVATANJE EMISIJA UGLJEN DIOKSIDA U JAVNOM SEKTORU – IZAZOVI, PRISTUPI I PERSPEKTIVE NA NIVOU GRADA/OPŠTINE

U današnje vreme borba protiv klimatskih promena i njenih efekata zbog antropogenog efekta staklene bašte jedan je od centralnih izazova za društvo i politiku u cilju sprečavanja daljeg povećanja emisija ugljen dioksida u atmosferi i ostvarenja klimatske neutralnosti. Neizostavni preduslov za izbor, implementaciju i praćenje efikasnosti mera za smanjenje emisije gasova sa efektom staklene bašte je merenje i obračun emisija kroz implementaciju računovodstvenog sistema obuhvatanja tih emisija. U poređenju sa preduzećima, tema računovodstvenog obuhvatanja emisija ugljen dioksida na nivou jednog grada ili opštine do sada je privukla manju pažnju javnosti. Stoga se ovaj rad bavi specifičnim izazovima, pristupima i perspektivama računovodstvenog obuhvatanja emisija ugljen dioksida na nivou jedne opštine.

Ključne reči: *računovodstveno obuhvatanje emisija ugljen dioksida, emisije gasova sa efektom staklene baste, grad/opština, klimatske promene*

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MODIFIED AUDIT OPINION AND EARNINGS MANAGEMENT IN STATE-OWNED COMPANIES: EVIDENCE FROM SERBIA

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Abstract. *The aim of the author of this paper is to examine the relationship between Earning Management (EM) and modified audit opinion among state-owned companies in the Republic of Serbia. The study sample consists of 64 state-owned companies whose financial statements were subject of audit by State Audit Institution in period 2018-2021. To detect EM, the financial statements of these companies for the four-year period 2018-2021 were used. The results of the study indicate that there is no positive relationship between EM and the auditor's modified opinion, i.e. that the difference in the distribution of the modified opinion in state-owned companies in which EM is identified and those in which EM is not identified is not statistically significant. These results initially point to the conclusion that auditors do not take EM into account when forming opinions, and do not send warning signals to users of financial statements. However, if one looks at the participation of the modified opinion on the financial statements of state-owned companies in which EM is identified, and especially the motive of EM, it can be said that the auditors of the State Audit Institution are adequately dedicated to this issue.*

Key words: *discretionary accruals, manipulations, qualified opinion, adverse opinion, disclaimer of opinion*

JEL Classification: H83, M41, M42

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1. INTRODUCTION

State-owned companies, with their important role in the provision of services of general interest, are oftenviewed as a tool for accelerated economic development and expansion, in strategically important economic activities. State-owned companies fulfill their obligation to provide information on financial position and business success through financial reporting. Financial statements, as the final product of financial reporting, contain a variety of useful information on the basis of which it is possible to evaluate previous and future achievements. As this information is crucial for decision-makers, its reliability and objectivity must not be questioned. In this regard, it is necessary to ensure high-quality financial reporting that will ensure social well-being as the supreme goal of society. Audit plays a significant role in increasing the credibility of information in financial statements, providing independent assurance of its truthfulness and fair presentation. The auditor's opinion based on objective evidence strengthens the financial accounting discipline and the responsibility of the ones preparing financial statements, thus laying the foundations of trust and mutual communication between State-owned companies and their stakeholders.

There is plenty of information in financial statements; however, "one of the most significant criteria for evaluating the performance and prospects of a business is earning measured by accounting" (Doan et al., 2021, 131). As state-owned companies are more than ever under pressure to increase their operational efficiency, improve their own and competitiveness of the economy as a whole, provide public services of higher quality at a lower price and responsibly use limited public funds, the auditors should pay special attention to earnings management (EM). EM implies active profit manipulation in order to make a changed impression of the company operations. EM is a "hot" topic because the management's tendency to show the company's performance as different from what it really is, by profit smoothing, is not rare. For this reason, auditors are expected to focus additionally on EM when performing their procedures and, in the case of its identification, send a clear signal to the users of the information in the form of a modified opinion. By modifying opinions, the auditor controls the work of managers and limits their opportunistic behavior (Barizah et al., 2005). Failure to disclose EM in financial statements of state-owned companies and issue an unmodified/positive opinion can have far-reaching negative consequences for the entire economy.

Examining the relationship between the auditor's modified opinion and EM in state-owned companies in the Republic of Serbia is primarily aimed at assessing the auditor's commitment to this issue. The auditor's modified opinion on financial statements in which profit manipulation is identified indicates the quality of the procedures they have implemented. As Akbaryan Fard et al. (2020) point out, audit quality is the auditor's ability to discover and report important distortions and discover manipulations in net income. This further significantly reduces EM (Imen & Anis, 2021), that is, as Othman & Zegnal (2006) point out, in case of high quality of audit, managers are not willing to perform manipulations through profit management.

The remainder of the paper is structured as follows. After this Introduction, the second section of the paper provides literature review on the basis of which hypotheses are defined. In the third section of the paper, the design of empirical research is presented. Results of research are presented and discussed in the fourth section, while the fifth section provides the conclusions.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

EM practices were introduced in recent years, as a number of serious scandals occurred in some firms (like the collapse of Entron Company) that overstated profits to trick investors and users (Sharf & Nassar, 2021). Many authors have dealt with the definition of EM, so Ronen & Yaari (2008) argue that EM can be defined as the alteration of the firm's reported earnings by managers to either mislead external users of financial statements or to influence contractual outcomes. Healy & Wahlen (1999) indicate that "EM occurs when managers use judgment in financial reporting and in structuring transactions to alter financial reports to either mislead stakeholders about the underlying economic performance of the company or to influence contractual outcomes that depend on reported accounting numbers." Some authors focus on flexibility in accounting standards when defining this concept, so Dechow & Skinner (2000) define EM as the abuse of accounting techniques and principles, i.e. a legitimate practice or deliberate omission of material facts with the intention of deceiving users of accounting information. Also, Baralexis (2004) notes that "EM is the process of intentionally exploiting or violating the GAAP or the law to present financial statements to suit one's interest." Certainly, whichever approach is present in the definition, EM implies the management intervention to determine the amount of profit, i.e. showing a higher profit and a better balance sheet or showing a lower profit and a worse balance sheet, depending on the interest.

Although the EM concept is initially associated with private companies, the application of the accrual accounting basis in state-owned companies brought EM to the attention of many scholars in the field (Bisogno & Donatella, 2022). Also, the reason is that state-owned companies assume an arrangement in which the management characteristics of private and state-owned companies coexist, all in order to provide public services at a high level, and due to increased exposure to the capital market and tougher competition, state-owned companies must continuously improve their performance in order to survive on the market (Bonić & Đorđević, 2017). State-owned companies with poor results have a harder time accessing the capital market, which can additionally slow down their development, and for these reasons, management's tendency to hide profit, i.e. to abuse flexibility in financial reporting based on the choice of alternative accounting methods and estimates is not rare. Apart from this, Capalbo et al. (2018) highlight that "there are as many reasons to expect a positive relationship between the ownership of state-owned companies enterprises by political communities and EM as there are reasons to presume a negative one." "Arguments in favour of a positive relationship rely on: (a) the expectation of a relatively lower quality of corporate governance in state-owned companies, which is often linked to a greater degree of managerial discretion; (b) the greater heterogeneity of stat-owned *accountees*, which increases the potential addressees of state-owned companies and creates incentives for EM; (c) the fact that state-owned companies' economic and financial results impact a quantitatively and qualitatively unidentifiable group of subjects (the community acting as the residual owner), thus decreasing the expectation that reporting of those results will be monitored, as compared to the alternative hypothesis of readily-identifiable private investors" (Jones, 1991); and (d) the limited technical expertise of the addressees of state-owned companies reporting (Shleifer, 1998, Grossi & Thomasson, 2015, Bruton et al., 2015, Koh, 2003, in Ruggiero et. al. 2022). Examinations of the presence of EM in state-owned companies are relatively recent and therefore limited. However, the results of the Ruggiero et al. (2022) research show that "managers of state-owned companies with higher

levels of public ownership are more likely to practice EM", while Capalbo, (2014) also provides evidence that "EM by state-owned companies decreases with firm size and increases with profitability."

The flexibility of International Financial Reporting Standards/International Accounting Standards and the possibility of choices between accounting policies and estimates have created a scope for applying different methods of earnings management. For these reasons, the question of whether financial statements are a reliable information base for business decision-making is quite justified. Audit should provide an answer to that question. "The objective of auditing financial statements is to allow the auditor to express an opinion as to whether the financial statements, on all material issues, have been prepared in accordance with the prepared financial reporting framework." However, "audit opinion issued by an auditor not only indicates whether the organization is complying with accounting standards and is concerned about its financial management, but it is also an important factor for detecting and preventing fraudulent activities" (Bell & Zimmerman, 2007). The auditor's opinion can be: positive/unmodified and modified. Auditors express a positive opinion when they are convinced that the financial statements truthfully and honestly show the real state of affairs, profit, financial status, income, expenses, in accordance with accounting standards. However, when identifying EM the auditor is expected to express a modified opinion (Qualified Opinion, Adverse Opinion or Disclaimer of Opinion) and thus provide signals to the users of the information. Which type of modification "the auditor will apply is determined by the effect of ER on the truthfulness and objectivity of the financial statements" (in accordance with ISA 705). If the auditor assesses that the identified EM has a material but not pervasive effect on the financial statements he will express a qualified opinion. On the other hand, if the EM has a material and pervasive effect on the financial statements, and they contain misstatements, he will express a negative opinion. If, on the other hand, the auditors are unable to collect enough adequate evidence (which may be a consequence of concealment by the management due to the presence of EM), the auditors will express a qualified opinion if those limitations have a material but not pervasive effect, that is, they will abstain from giving an opinion if they have a material and pervasive effect on the financial statements.

As audit is seen as one of the main guardians of the truth and objectivity of financial statements, therefore "it is vital to examine the association between auditor's opinion and EM in a situation where the propensity to manage earnings is high" (Tsipouridou1 & Spathis, 2014). The relationship between auditor opinion and EM is one of the most important issues among researchers in this field. To date, several studies have been conducted that deal with this relationship; however, the results show conflicting opinions.

Some authors claim that there is no positive correlation between EM and the auditor's modified opinion, that is, that the EM is negatively related to the qualified audit opinion. This group of authors includes: Tsipouridou & Spathis (2014) who "examined this relationship in companies listed on the Athens Stock Exchange"; Gajevszky (2014) in companies listed on the Bucharest Stock Exchange; Othman et al. (2017) in companies listed on the Bursa Malaysia which is classified as PN17, Garcia-Blandon et al. (2014) in companies in Spain, Veronika & Julisar (2020) in companies listed on the Indonesia Stock Exchange, Sharf & Nassar (2021) in companies listed in Amman Stock Exchange in Jordan, Imen & Anis (2021) in Tunisian firms listed on the Tunis Stock Exchange.

On the other hand, there are numerous research results that indicate the opposite, i.e. the existence of a positive correlation - the probability of expressing a modified audit

opinion and EM. Francis and Krishnan (1999) examined this relationship in listed companies in the United States; Doan et al. (2021) in Vietnamese listed companies on the Ho Chi Minh City Stock Exchange and Hanoi Stock Exchange; two studies: Moazedi & Khansalar (2016) and Abolverdi & Kheradmand (2017) "evaluate the effect of EM on type of auditor report in companies listed on Tehran Stock Exchange (TSE)."

Based on the above, the following hypotheses are developed:

H1: There is a significant positive correlation between auditor's modified opinion and EM,

H2: The auditor's modified opinion is represented to a greater extent than expected in state-owned companies in which EM has been identified, in contrast to state-owned companies in which it has not been identified.

3. METHODOLOGY

3.1. Sample selection and variables

For the purposes of testing the correlation between EM in state-owned companies in the Republic of Serbia and the auditor's modified opinion, state-owned companies whose financial statements were audited in the period from 2018 to 2021 were taken into account. The data was primarily collected from the 2018, 2019, 2020 and 2021 annual reports of the State Audit Institution, to identify that the financial statements of 73 state-owned companies were subject to audit. The same reports were the source of data on auditors' opinions on the financial statements of the mentioned companies. That is, to detect manipulative financial reporting., the financial statements of these companies for the four-year period 2018-2021, available on the Business Registers Agency website, were used. Since complete data were not available for nine state-owned companies, those companies were excluded from the research. After the implementation of the mentioned criteria, the final sample included 64 state-owned companies and a total of 264 financial statements for the purposes of EM calculation.

3.2. Selection and measurement of variables

In order to test the defined hypotheses, the auditor's opinion on the financial statements of state-owned companies represents a categorical variable. Bearing in mind that the auditor's opinion on financial statements can be unmodified/positive and modified (Qualified Opinion, Adverse Opinion or Disclaimer of Opinion), this variable has two values: 0 if the opinion is unmodified and 1 if the opinion is modified. Analysis of audit opinions on financial statements of state-owned companies by year and type is presented in Table 1.

Table 1 Audit opinions on financial statements of state-owned companies by year and type

Audit opinion type	2018		2019		2020		2021		Total	
Unmodified opinion	**3**	**13.04%**	**2**	**16.67%**	**4**	**26.67%**	**1**	**7.14%**	**10**	**15.63%**
Modified opinion:	**20**	**86.96%**	**11**	**83.33%**	**11**	**73.33%**	**12**	**85.71%**	**54**	**82.81%**
With exception/s	19	82.61%	9	75%%	11	73.33%	12	85.71%	50	78.13%
Adverse	0	0	2	16.67%	0	0%	0	0%	2	3.13%
Disclaimer of opinion	1	4.35%	0	0%	0	0%	1	7.14%	2	3.13%
Total audit opinions	**23**	**100%**	**12**	**100%**	**15**	**100%**	**14**	**100%**	**64**	**100%**

Source: Annual Activity Reports for 2018, 2019, 2020 and 2021.

EM defined as the second variable indicates manipulation in financial statements. Numerous models have been developed to calculate EM over time (Discretionary accruals models, Accruals quality models, Probit and logit models, etc.). However, auditors mostly use Discretionary accruals models, which imply the separation of the total accruals into a non-discretionary part, as economically determined accruals, and a discretionary part, as managerially determined accruals, because managers have discretion over the choice of accounting methods and estimates. For those reasons, Discretionary accruals (DA) is a measure of EM. If state-owned companies do not manipulate earnings, it is to be expected that the DA component will be zero. Otherwise, if the value of DA is significantly different from zero, it means that there is a practice of manipulating earnings in the observed period. At the same time, if the value has a positive sign, it means that earnings manipulation was carried out at a higher level, and on the contrary, if the value is negative, it means that the manipulation was carried out with the aim of presenting the financial result worse than it is.

According to a large number of conducted studies, the discretionary accruals models that are considered the most reliable are the Jones model (1991) and the modified Jones model (Dechow model (1995) and Kasznik model (1999)). For the purposes of DA in state-owned companies, we opted for Kasznik, a modified Jones model, which, in addition to possible income manipulation under the Jones model, also monitors changes in receivables from sales and changes in net cash flow from business activities. Kasznik model has the following form:

$$TA_{it}/A_{it-1} = \beta0*1/A_{it}\text{-}1+ \beta1*(\Delta REV_{it}\text{-}\Delta REC_{it}/A_{it-1}) + \beta2*(PPE_{it}/ A_{it-1})+ \beta3*(\Delta CFO_{it}/ A_{it-1}) + \varepsilon_{it} \quad (1)$$

Where:
TA_{it} - total accruals for the company i in the current period t;
A_{it-1} - total assets for the company i in the previous year t-1
β0, β1, β2, β3 - estimated parameters or regression coefficients;
ε_{it} - residual variable or Discretionary accruals (DA)=Earnings management (EM)
ΔREV_{it} - change in net sales revenues of the company i in the current year t compared to the previous year t-1;
ΔREC_{it} - changes in net receivables from sales in the current year t compared to the previous year t-1
ΔCFO_{it} - change in net cash flow from operating activities in the current year t compared to the previous t-1
PPEit - gross value of property, plant and equipment for the company i in the current year t
The DA procedure involves a three-phase approach:
First of all, TA_{it} is calculated using the cash approach, as follows:
$TA_{it} = NI_{it} – CFO_{it,}$ where NI_{it} - net income for the company i in current year t.
In the second stage, the non-discretionary NDA_{it} follows. More precisely, as $TA_{it}= NDA_{it} + DA_{it,}$ i.e. $TA_{it}= NDA_{it} + \varepsilon_{i,}$ then using multiple linear regression analysis we get NDA_{it}
In the third stage, we get DA_{it} as follows*:*
$DA_{it} (\varepsilon_{it})= TA_{it} - NDA_{it.}$

All variables in the model are divided by the value of total assets at the beginning of year A_{t-1} to mitigate potential heteroskedasticity.

After calculating the variables and initiating a multiple linear regression analysis, the values of the regression coefficients (β0, β1, β2, β3) were obtained, which gave the model of discretionary accruals for state-owned companies in the Republic of Serbia the following form:

$$\varepsilon_{it} = TA_{it}/A_{it-1} – ((-8309,77)/A_{it}\text{-}1+ (-0,008)*(\Delta REV_{it}\text{-}\Delta REC_{it}/A_{it-1}) + -0,063*(PPE_{it}/A_{it-1})+ 0,616*(\Delta CFO_{it}/ A_{it-1}) \quad (2)$$

This model was applied to a selected sample of state-owned companies in order to reveal the prevalence of earnings manipulation in financial statements. In order to test the claim about earnings manipulation in financial statements, i.e., to determine which state-owned companies' DA deviates statistically significantly from zero, a t-test was performed for each public company individually. By comparing the average DA value of each state-owned company with the expected value of this parameter (zero), we found that in 23 state-owned companies this deviation was statistically significant, that is, they manipulated income. At the same time, in 6 state-owned companies, DA had a negative sign, which indicates that in these companies the results were manipulated downwards, while in as many as 17 companies, this indicator had a positive sign, that is, in those companies, manipulation was performed in order to present income as better than it is.

For the purposes of connecting the EM and the auditor's opinion, DA takes the following values: 0 if manipulation is identified and 1 if manipulation is not identified.

3.3. Methods

As the research relates to the correlation between two categorical variables, the Chi-square test of independence will be applied in order to examine whether there is a statistically significant difference in the modified auditor's opinion in state-owned companies in which manipulation was identified and those in which it was not identified. Also, the Chi-square goodness of fit test will be used to test whether the observed distribution of modified opinion within State-owned companies where manipulation was identified corresponds to the one expected based on the structure of modified opinion for the total population.

4. Empirical Results and Discussion

A Chi-square test of independence was applied to test the correlation between the auditor's modified opinion and EM. Table 2 summarizes the results of the distribution of auditors' opinions in state-owned companies of the Republic of Serbia in which manipulation was identified and those in which manipulation was not identified.

Table 2 Distribution of auditors' opinions in state-owned companies of the Republic of Serbia

			Manipulation		
			Exists	Does not exist	Total
Audit Opinion	Modified	Count	22	32	54
		% within Audit Opinion	40.7%	59.3%	100.0%
		% within Manipulation	95.7%	78.0%	84.4%
		% of Total	34.4%	50.0%	84.4%
	Unmodified	Count	1	9	10
		% within Audit Opinion	10.0%	90.0%	100.0%
		% within Manipulation	4.3%	22.0%	15.6%
		% of Total	1.6%	14.1%	15.6%
		Count	23	41	64
		% of Total	35.9%	64.1%	100.0%

Source: Author's calculations based on data available in Annual Activity Reports for 2018, 2019, 2020 and 2021 of State Audit Institution and Financial Reports for 2018, 2019, 2020 and 2021 state-owned companies in sample

Chi-square test of independence (with continuity correction according to Yates') showed no significant correlation between observed variables, X^2 (1, N = 64) = 2.257, p = .133, phi= .233.

Table 3 shows the results of the Chi-square goodness of fit test of differences between the identified and expected distribution of modified opinion within state-owned companies where manipulation was identified and those where it was not.

Table 3 Observed and Expected Frequencies of Audit opinion by type and the existence of manipulation in financial statements

		Observed N	Expected N	Residual
Manipulation exists	Modified	22	19.1	2.9
	Unmodified	1	3.9	-2.9
Manipulation does not exist	Modified	32	34	-2.0
	Unmodified	9	7	2.0

Source: Author's calculations based on data available in Annual Activity Reports for 2018, 2019, 2020 and 2021 of State Audit Institution and Financial Reports for 2018, 2019, 2020 and 2021 state-owned companies in sample

Table 3 clearly shows that the observed modified auditor opinion on the financial statements of state-owned companies in which manipulation was identified (22 modified opinions) is higher than expected (19.1), established based on the previously set proportion, i.e. the opinion structure for the total population. Nevertheless, the result of the Chi-square goodness of fit test indicates that it is a very small difference that is not statistically significant ((X^2 (1, N = 23) = 2.609, p = .106).

The previous table also indicates that the observed modified auditor opinion is represented to a lesser extent (32) than expected (34) in state-owned companies in which manipulation in financial statements was not identified. However, even that difference is not considered statistically significant ((X^2 (1, N = 41) = .712, p=.399).

The presented results make it clear that none of the hypotheses about the correlation between EM and the modified auditor opinion have been confirmed. First, the distribution of modified opinion in state-owned companies in which manipulation was identified and in those in which it was not is not statistically significant. True, most of the auditor opinions on financial statements of state-owned companies in which manipulation was identified was modified (as many as 22 out of 23). However, the situation in terms of modified auditor opinion is no better for state-owned companies where manipulation was not confirmed - out of 41 auditor's opinions, 32 have been modified.

Also, although the modified auditor opinion in state-owned companies in which manipulation was identified is more prevalent than expected, and on the contrary, less prevalent than expected in state-owned companies in which manipulation was not identified, these differences are minor, i.e. they have no statistical significance.

The results obtained in this way on the sample of state-owned companies in the Republic of Serbia are consistent with the results of research by Tsipouridou & Spathis (2014), Gajevszky (2014), Othman (2017), Garcia-Blandon (2014) Spain, Veronika (2020), Sharf&Abu-Nassar (2021), Imen&Anis (2021) and point to the fact that there is no significant correlation between EM and the modified auditor opinion.

Since, according to many authors (Othman & Zeghal, 2006; Imen & Anis, 2021), audit quality is a significant factor in identifying EM, the obtained research results, at

first glance, point to a low level of auditor commitment to the issue of EM, that is, "auditors do not take into account the effect of EM when forming the audit opinion." In this way, they are not even able to warn users of information from financial statements by modifying their opinion. However, if we analyze modified opinions in relation to non/identification of EM, the situation may change.

Table 4 presents the types of modified auditor opinion on financial statements of state-owned companies in which EM has been identified. As the table shows, as many as 22 state-owned companies in which EM was identified received a modified auditor opinion (which makes up 95.65% of the total of 23).

Table 4 Modification of Audit opinion in state-owned companies in which EM has been identified

Type of modified opinion	Number of state-owned companies with identified EM
With exception/s	19
Adverse	2
Disclaimer of opinion	1
Total	22

Source: Authors' calculation

Based on the analysis of the audit reports of these State-owned companies and especially the summary of detected irregularities and the stated basis for expressing a modified opinion, the auditors identified 20 State-owned companies that manipulated earnings by overestimating or underestimating income and expenses. Of those 20 State-owned companies, 17 were found to have manipulated revenues and expenses, which had a material but not pervasive effect on the financial statements, which is why those companies received a qualified auditor opinion on financial statements. In 2 state-owned companies, the manipulation had a material and pervasive effect on financial statements, which is why those companies received a negative opinion. In one company, the auditors were limited in gathering enough relevant audit evidence (which may be a consequence of concealment of evidence by the management due to manipulations), and the auditor abstained from issuing an opinion at that company. In the remaining 2 state-owned companies, the auditors failed to identify the manipulation of income and expenses, but based their qualified opinion on financial statements on non-up-to-date records and non-compliance of data with relevant state institutions.

Based on this analysis, it would be unrealistic to criticize the quality of the audit procedures implemented, because out of 23 state-owned companies where EM was identified, 22 received a modified opinion on the financial statements, while in one company the auditors made an omission.

On the other hand, if we looked at the 32 state-owned companies that received a modified opinion and the DA did not indicate that, then we could look for the answer in the EM category. More precisely, Ronen & Yaari (2008) "classify EM in three distinct groups:

- White EM (beneficial) enhances the transparency of reports,
- Gray – Managing reports within the boundaries of compliance with bright-line standards (gray), which could be either opportunistic or efficiency enhancing and
- Black – Black earnings management involves absolute misrepresentation. It assumes practices intended to misrepresent or reduce transparency in financial statements."

Therefore, in 32 companies in which no EM was identified and which received a modified auditor's opinion on the financial statements, it is possible that the auditors identified the so-called Gray EM.

5. CONCLUSION

Earnings management assumes one of the strategies of financial result' manipulation, where the management tends to show a changed impression of the business by a legitimate choice of accounting procedures or a deliberate omission of material facts. Although it was initially associated with companies in the private sector, the concept of EM is increasingly discussed in the public sector as well. This is primarily in state-owned companies that use the accrual basis of accounting, which is also the case with state-owned companies in the Republic of Serbia. In addition, state-owned companies are increasingly exposed to competition, along with strict budget constraints and institutional and management changes, which results in the management's desire to make appropriate interventions in the financial reporting process in order to achieve some specific goal.

As EM seriously questions the truthfulness and reliability of information in financial reports, and auditing is one of the most important links in the supply chain of financial reporting quality, the question of the ability of auditors to recognize EM is increasingly highlighted. Users of information from financial statements expect the audit to adequately control the correct application of accounting standards, pre-defined accounting policies and procedures and, accordingly, to express their opinion on the objectivity and fairness of the financial statements, i.e. on whether they have been drawn up in accordance with all relevant issues with legal and professional regulations. In cases of identification of EM, auditors act in the public interest by modifying their opinion.

The purpose of the research conducted in the paper was to examine the relationship between the auditor's modified opinion and EM in state-owned companies in the Republic of Serbia. The obtained results did not support the hypothesis that there is a significant positive relationship between modified audit opinion and EM, nor that there is a statistically significant difference in the distribution of modified audit opinion in state-owned companies in which EM is identified and in those where it is not. Based on these results, one gets the first impression that auditors do not approach EM with due care. However, the distribution of the auditor's modified opinion in state-owned enterprises in which EM was identified and the analysis of the basis for the expression of the modified opinion in the entire population indicate the opposite.

The contribution of this paper is twofold. Furthermore, bearing in mind that the relationship between EM and modified audit opinion is one of the most important subjects of interest among researchers worldwide, it is of great importance to determine and present this relationship in state-owned companies in the Republic of Serbia. In this way, awareness will certainly be raised about the presence of EM in state-owned companies and, in particular, about the importance of auditing as a mechanism for preventing and detecting manipulations. Consequently, all this has the potential to influence the improvement of the quality of financial reporting of state-owned companies in the Republic of Serbia.

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MODIFIKOVANO MIŠLJENJE REVIZIJE I UPRAVLJANJE DOBITKOM U JAVNIM PREDUZEĆIMA – STANJE U SRBIJI

Cilj autora ovog rada jeste da istraže vezu između upravljanja dobitkom i modifikovanog mišljenja revizora u javnim preduzećima u Republici Srbiji. Uzorak istraživanja čine 64 javna preduzeća čiji su finansijski izveštaji bili predmet revizije od strane Državne revizorske institucije u periodu 2018-2021. godine. Za potrebe identifikovanja upravljanja dobitkom u ovim javnim preduzećima korišćeni su finansijski izveštaji u periodu 2018-2021. Rezultati istraživanja ukazuju da ne postoji pozitivna veza između upravljanja dobitkom i modifikovanog mišljenja revizora, odnosno da razlika u distribuciji modifikovanog mišljenja u javnim preduzećima u kojima je identifikovano i onima u kojima nije identifikovano upravljanje dobitkom nije statistički značajna. Ovakvi rezultati inicijalno upućuju na zaključak da revizori ne uzimaju u obzir upravljanje dobitkom prilikom formiranja mišljenja, te ne šalju upozoravajuće signale korisnicima finansijskih izveštaja. Međutim, ukoliko se sagleda distribucija modifikovanog mišljenja o finansijskim izveštajima javnih preduzeća u kojima je identifikovano upravljanje dobitkom, a posebno motiv upravljanja dobitkom, može se reći da su revizori Državne revizorske institucije adekvatno posvećeni ovom pitanju.

Ključne reči: *diskrecioni obračun, manipulacije, mišljenje sa rezervom, negativno mišljenje, uzdržavanje od mišljenja*

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GREEN QUALITY AND SUPPLY CHAIN MANAGEMENT AS A FACTOR OF SUSTAINABLE COMPETITIVENESS

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502.12:005.6

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Abstract. *The assumption the paper is based on is that in modern economy it is not enough to provide economic performances which will satisfy the owners of the companies and provide product and services which will satisfy customers, considering the relationship between costs and quality. Other two perspectives have to be included into the analysis, and they concern people-society issues and planet-environmental issues. This leads to the concept 3P that includes: Profit, People and Planet. According to this concept, one of the main challenges for the companies and supply chains they belong to will be to provide green product design, green lean processes and operations, as well as green supplying. For this reason, in this paper the authors analyse the green component of the sustainable competitiveness, with the objective to show the way from quality management (quality products and processes) and environmental protection through sustainable supply chain management with the accent on supply chain greening to economy competitiveness.*

Key words: *sustainable, competitiveness, quality management, standards, supply chain*

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1. INTRODUCTION: SUSTAINABLE COMPETITIVENESS AS CONTEMPORARY CONCEPT OF ECONOMY DEVELOPMENT

Although competitiveness is important topic in developed, as well as in developing countries, their focus is different. While developed countries must continually improve their soft pillars like innovation, business sophistication, and social cohesion, developing countries must improve both hard and soft pillars. It is obvious that developing countries have to do more, including the fact that they have to identify institutions, policies and factors that make a nation productive in correlation with social and environmental development (Herciu & Ogrean, 2014).Either way, the challenge of all countries in modern conditions definitely concerns sustainability with two main aspects: social and environmental.

In general, the goal of any sustainable development strategy is to strive to balance the three key factors of sustainable development (Vasiljev, 2011): economic development (economy and technology) with social balance and environmental protection (with the rational disposal of natural resources).

In 1990, the European Union adopted the concept of sustainable development, verified by the United Nations at the Second United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992. The concept of sustainable development is institutionalized at a global level, which means that it can only be achieved in the integrated unity of economic, environmental, social, political and cultural components, that is, sustainability. One of the important issues raised at this Conference was to highlight the crucial role of the economy in providing the conditions for achieving sustainable development.

Sustainable growth represents one, but very important component. It means that economic growth has to be based on green technologies (Balkyte & Tvaronavičiene, 2010). Sustainable growth may be provided based on sustainable competitiveness of the economic entities it incorporates. In this sense, sustainable competitiveness goes beyond the economic results including some other elements which contribute to social and environmental results. In order to explain the significance of social and environmental aspects of competitiveness, Aiginger, Barenthaler-Sieber & Vogel (2013) showed the evolutionary way of competitiveness approach: from input-oriented evaluation to outcome-oriented evaluation (Figure 1).

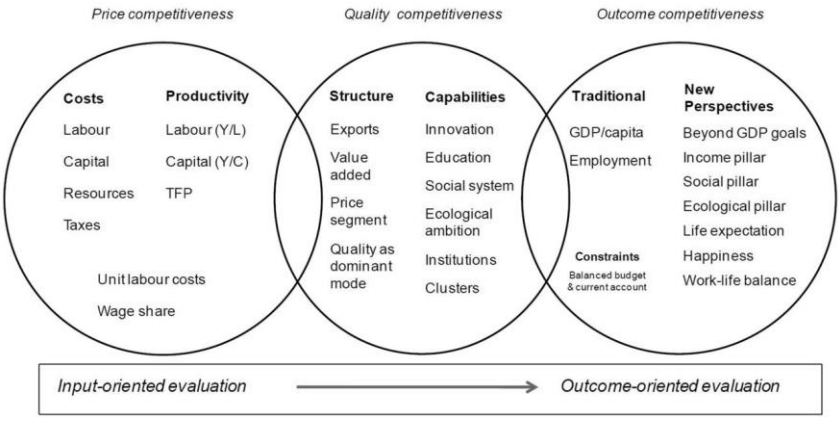

Fig. 1 Towards a concept of competitiveness under new perspectives
Source: Aiginger, Barenthaler-Sieber & Vogel, 2013, p. 11.

A typical definition of outcome competitiveness along these lines is offered by the European Commission (2010): "the ability of an economy to provide its population with high and rising standards of living and high rates of employment on a sustainable basis" (According to Aiginger, Bärenthaler-Sieber & Vogel, 2013). From figure 1 it may be concluded that modern conditions for doing business are more demanding comparing to the Quality Era. Actually, sustainable competitiveness assumes the upgrading of quality with social and environmental pillar.

The importance of those two aspects of sustainability, social and environmental, is emphasized by introducing customized coefficients for the pillars included in Global Competitiveness Index - GCI. Each pillar can be converted into customized coefficients with a score of 0.8 to 1.2, which are used to adjust the GCI results downwards or upwards. Therefore, the result of sustainability adapted to GCI ranges from + - 20% in relation to the basic GCI.

The main idea of the research presented in this paper is to indicate connection between implementation of standards and sustainable competitiveness. Precisely, if greening is present in managing quality and managing supply chain, then positive effects on sustainability have to appear (Figure 2).

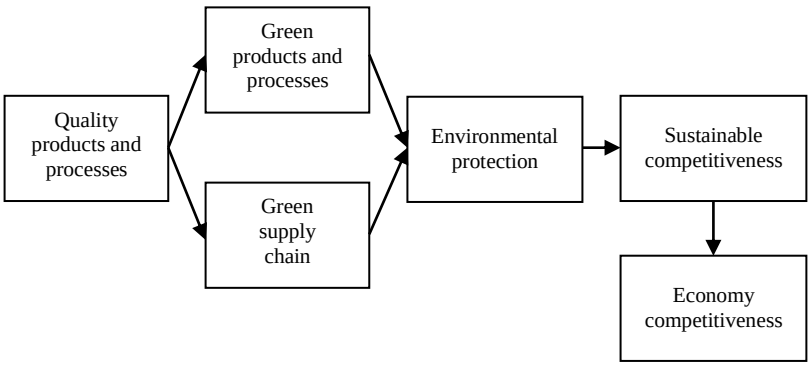

Fig. 2 The influence of *greening* on sustainable competitiveness

Achieving sustainable competitiveness is not only the challenge at the national, economy level, but also at a company level. In fact, sustainable competitiveness of economy and companies are connected. For that reason, the following paragraphs will explain the significance of sustainable competitiveness and then how it can be accomplished at enterprise and supply chain level through the component concerning environmental protection.

2. SUSTAINABILITY AT SUPPLY CHAIN LEVEL

Value creation is vital for companies that operate within the partnership. The goal of each partnership, as well as the supply chain, is profitability based on the fulfillment of consumers' demands by providing adequate value. Value creation implies the provision of high quality products and services. However, besides achieving customer satisfaction in the supply chain, it is also very important to analyze a set of factors that affect the ability of the supply chain to add and create value. The ability to create value is much higher in the situation where there is a stable relationship between partners. The existence of

effective relationships among partners affects the return on investment as well as the increase in the gross margin (Gibbs & Humphries, 2009, p. 158). Therefore, value creation in the supply chain is the result of the built relationships among partners, as well as the maintenance and improvement of these relationships.

Therefore, individual businesses compete no longer as solely autonomous entities, but rather as supply chains (Lambert & Cooper, 2000), which brings the researches one step forward towards supply chain sustainable competitiveness. Implementation of sustainability concept at supply chain level is more difficult than implementation of the same concept at the level of country or individual company. Because of a great number of partners and different individual objectives between them, it is necessary first to define one goal at the supply chain level in the context of environmental protection. However, problems in the implementation of sustainability concept come from the fact that one partner could be part of a few chains. In this regard, the possibility of implementation of the sustainability concept by those partners that are present in several chains is questionable. Especially important is the environmental component of the sustainability. Today, managers of supply chains use this green practice with the purpose of creating satisfaction from the environmental point of view. Also, managers of supply chain use this practice as a strategic weapon for achieving sustainable competitive advantages (Hosseini, 2016).

Sustainable supply chain management could be defined as management of cooperation between partners in supply chain and also management of material and information flows by taking into care economic, environmental and social requirements (Seuring & Muller, 2008). According to Hassini et al. (2012) sustainable supply chain management represents management of process, operations, resources, and information through supply chain with the purpose of maximizing profitability of supply chain and social well-being and minimizing negative environmental impact (Taticchi, Tonelli & Pasqualino, 2013). The process of implementing sustainable solutions in the supply chain is time-consuming and can generate numerous problems that effectively discourage business managers and entrepreneurs from continuing their efforts to implement environmentally-friendly solutions (Zimon, Tyan & Sroufe, 2019, p. 232).

For survival of today's supply chains it is not enough to provide just high economic performances. Sustainable concept includes triple bottom line model. This model shows that supply chain must achieve great performances in each area: environmental, social and economic. Figure 3 shows elements of triple bottom line model (Rogers, 2011; Carter & Rogers, 2008). According to research (Carter & Rogers, 2008) and interviews with 35 managers from 28 companies it was found that there is a strong bond between those factors and sustainability concept. None of the interviewed managers suggested other factors that should be included into the analysis.

Sustainable supply chains must be focused on increasing productivity, but without environment contaminating and with respect to all key stakeholders. In that sense productivity could be achieved by doing more with less, or by reducing costs and resources (Rogers, 2011).

Strategic direction of today's supply chains is building an appropriate sustainability which will provide lasting profitability.

Fig. 3 The Sustainable Supply Chain
Source: Rogers, 2011, p. 12

Organizational culture is very important for providing sustainability at the supply chain level (Lambert, Cooper & Pagh, 1998). It represents the set of attitudes, values and beliefs that are enacted on a day to day basis in an entire supply chain, or, more simply, the way things are done in the supply chain (Epstein, Buhovac & Yuthas, 2010). In modern conditions supply chains have to create organizational culture that incorporates learning and innovation, and provides well defined infrastructure for improvement projects implementation, which means sharing common values and beliefs in order to reach desired quality level based on integration. Sustainability concept has to be embedded into the organizational culture.

Transparency can be a factor of better coordination among partners through supply chain. Common procedures and documentation with the information system at the level of supply chain could provide high degree of transparency and sustainability, by reducing number of transactions and transaction costs (Rogers, 2011). Sustainable supply chain transparency is the visibility and disclosure of sustainable supply chain information between actors within and outside the supply chain (Schäfer, 2022).

Risk management at the company level includes a segment that seeks to eliminate, reduce or control risks (Zsidisin & Wagner, 2010, p. 3). Supply chain risk management follows a fairly traditional risk management process, with focus on identifying and minimizing risk at the supply chain level rather than at the company level (Ghadge, Dani, Chester & Kalawsky, 2013). Supply chain sustainability risk management, as a component of sustainable supply chain management, expands the scope of supply chain risk management by including supply chain risk factors associated with social and environmental aspects of sustainability (Xu et al., 2019).

3. THE INFLUENCE OF PRODUCT/PRODUCTION QUALITY ON THE ENVIRONMENTAL QUALITY

Companies are increasingly faced with natural environmental challenges, more rigorous environmental regulations, and consumers who have awareness of the need to preserve the environment and environmentally friendly products. In this sense, there is an emphasized need to harmonize environmental regulations with EU regulations, to adjust the infrastructure of the company to environmental protection, to innovate technological processes, to rational natural resources management, and to introduce the environmental management system in order to ensure the survival in an increasingly demanding and competitive market. This implies that quality management system and environmental management system have to be connected and balanced. Although some authors (Aiginger, Barenthaler-Sieber & Vogel, 2013) speak about the term outcome competitiveness, this does not mean that quality era is over. On the contrary, this new step forward puts even more attention to quality and standards for providing sustainable economic development.

In fact, during the entire lifetime of the product, it is necessary to take into account ecological parameters, because if it is taken into the account at the stage of development what can happen during the process of their usage or their production in sense of endangering the environment, then the chances for minimizing or avoiding ecological problems are higher. This means that, in each company, special attention must be focused on potential pollution, related to the specifics characteristics products and technological processes.

The design and quality of production process is closely related to product design and quality. The production process must not degrade the internal environment of the company, nor its external environment. Finally, ecological approach must be present, not only in design and production, but also during the use and disposal of products.

In the era of mass consumption, quality standards implementation was inspired by economies of scale and facilitated the creation of futures markets (Daviron, 2002). Today, quality standards are focused on production and process methods rather than on the final product (Reardon et al., 2001). According to Guasch, et al. (2007) patterns of trade have significantly changed in that way that an intense competition has eroded the profitability of low-cost manufactures, while, on the other hand, higher-quality markets have not been subject to falling profitability. This also confirms the relevance of quality for achieving sustainable competitive advantage.

This brings into the analysis the question of quality standards. However, it is very important not to observe the certification as an end in itself, either for marketing or for internal reasons, since standards alone cannot produce sustainable improvements in organizational performance (Guasch, et al., 2007, p. 103). Rather, managers must use standards, procedures and tolls as means to implement quality management systems and to make quality become the way of doing business. Implementation of quality management system usually assumes two steps: First, it starts with the implementation of quality standard ISO 9001 and then ISO 14001.

The basic objective of the ISO 9001 series is to define a unique system that provides the ability of the product supplier to always ensure the product meets the requirements of the market and the needs of the customer. Advantages of implementing ISO 9001 are not brought into question (Poksinska, Dahlgaard & Eklund, 2003; Feng, Terziovski & Samson, 2007; Sampaio, Saraiva & Guimarães Rodrigues, 2009).

Therefore, at the initiative of numerous international institutions (International Chamber of Commerce, World Industrial Environment Council, British Institute for Standardization and

others), the International Organization for Standardization, in 1994, brought a new set of standards, which deal with the elements of the environmental management system - ISO 14000.

A series of environmental standards includes two basic areas, namely: arranging relationships in the field of environmental protection and determining the impact of the quality of products (services) on the environment and the criteria for their ecological development. In fact, this means that each organization must: reduce the negative impacts on the environment by its activities (Yang, Hong & Modi, 2011), and achieve a continuous improvement in performance related to environmental protection.

A benefit from the application of ecological standards is felt by the society as a whole, or, in other words, by every individual through healthier living conditions. Benefits are also provided to organizations that want to show that they are better than competitors that they take care of environmental protection, of their customers, as well as employees and workers from their internal environment. Therefore, the introduction and implementation of ecological standards is in the recent past, and in the future it will be even more emphasized, presented as an essential condition for the survival of companies on the global market. Under the increasing pressure of international, non-governmental and environmental consumer movements and large-scale supply of all types of goods on the global market, countries with developed economies incorporate in their legislation an obligation to respect environmental protection standards.

Finally, it is important to note that both sets of standards, the standards ISO 9001 and ISO 14001 series, have gained worldwide reputation as the generic standards of the management system. This means that the same standard can apply to any activity and to any organization, small or large, regardless of whether it is production or service organization, in any sector, and regardless of whether the organization is private or state-owned.

4. Practical Implementation of Green Approach in the Enterprises in Serbia

Governments, community activists, non-governmental organizations (NGOs), consumers and global competition, environmental organizations, as well as academic research community and supply chain actors are the key drivers of developing green working practice (Carbone & Moatti, 2008; Wognum, Bremmers, Trienekens, van der Vorst & Bloemhof, 2011; Hassini, Surti & Searcy, 2012).

Some companies implemented green practice to the extent required by law. Some companies are example of superficial and non-compulsory green working practice, as companies from electronic industry with the motto *Think before you print* (Hassini, Surti & Searcy, 2012).

In modern market conditions, the use of natural resources in production process is very important, especially for textile and clothing industry which are characterized by strong competition and short life cycle. There are well known examples of bad green practice and problems in global companies such as Nike, Levi Strauss, Benetton, Adidas and C&A, with inhuman working conditions and environmental contamination (Caniato et al., 2012, p. 661). Some authors gave the *green fashion* name to the companies with implemented green approach (Kogg, 2003; Forman & Jorgensen, 2004).

According to the research conducted by Carbone & Moatti (2008) companies from automotive, metallurgy, chemicals, electronics are more concerned with green issues then

companies from textile industry. For example, 84% of analysed companies from electronics industry, 87% from chemicals industry and 100% companies from metallurgy are interested in implementation of green approach in their supply chain, while 60% of analysed companies from textile industry are interested in this issue (Carbone & Moatti, 2008).

In order to check the presence of quality management and environmental protection standards in practice of companies and supply chains the research was conducted in the Republic of Serbia, in 2021, on the sample comprising 124 companies. Questionnaire included 25 questions, concerning quality and green issues at company and supply chain level. During the data collection, care was taken that the interviewed managers represent the companies that are partners in certain supply chains. In that way, it was ensured that managers respond to all questions in the questionnaire, including the ones that concern supply chain sustainability. Among those questions, there were a few that concerned four perspectives of supply chain management sustainability, where interviewed managers were offered to suggest some new factors, which they consider important. However, there were no suggestions from managers. Some of the research results are presented in the following paragraphs, with the intention to test the following hypotheses:

H1 – There is no difference between significance of ISO 9001 and ISO 14001 for increasing company's competitiveness,

H2 – There is no dependence between company's size and implementation of ISO standards,

H3 – There is positive correlation between perspectives of supply chain sustainability concept.

In order to test the first hypothesis, managers' marks about the significance of those standards for their business have been used. ISO 9001 standards gained a little better marks (average mark 2.73, compared to 2.35).

According to the research, 63.3% of the companies in the sample have implemented ISO standards (series 9001), while only about 2/3 of them have both very important previously mentioned series of ISO standards (9001 and 14001). In order to test the hypothesis that *there is no dependence between company's size and implementation of ISO standards*, χ^2 test has been used. Based on the test results (sig. equal 0.157 for ISO 9001 and 0.234 for ISO 14001), this hypothesis should be accepted, meaning that there is no dependence between the observed variables.

Most of the companies included in the sample, which are part of certain supply chains, went green and chose quality as a competitiveness strategy due to their partners' requirements (more than 75%). This supports the fact that very small number of companies take care about cost of quality and cost of environmental protection and externalities. Figure 4 shows presence of cost of quality evidence in the observed sample.

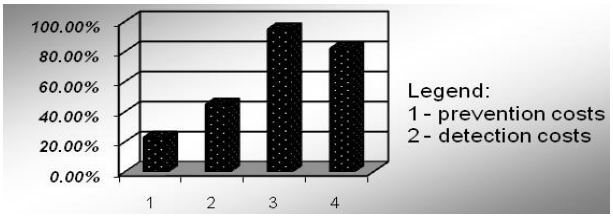

Fig. 4 Costs of quality evidence in the sample
Source: Authors

The situation is not better when it is about externalities. Only 23% of companies in the sample have data about their externalities, and about 36% actually had some kind of investment concerning environmental protection.

In order to evaluate to which extent companies in Serbia are oriented towards sustainability, factors from the four perspectives (Transparency - T, Risk management - R, Strategy - S, Organizational culture - C) were analysed. Those perspectives include different number of factors (Figure 3), precisely, five, five, three and four, respectively. For that reason, and in order to further analyse the collected data, analysis has been performed between factors included into one perspective and its average value correlation.

Table 1 Correlation analysis results

		T	R	S	C
T	Correlation Coefficient	1.000	.139	.114	.051
	Sig. (2-tailed)	.	.125	.209	.572
	N	124	124	124	124
R	Correlation Coefficient	.139	1.000	.047	.038
	Sig. (2-tailed)	.125	.	.608	.678
	N	124	124	124	124
S	Correlation Coefficient	.114	.047	1.000	.145
	Sig. (2-tailed)	.209	.608	.	.107
	N	124	124	124	124
C	Correlation Coefficient	.051	.038	.145	1.000
	Sig. (2-tailed)	.572	.678	.107	.
	N	124	124	124	124

Source: Authors

According to the correlation coefficients (at least around 0.500) and significance (0.000) it has been concluded that average values for each perspective are valid for further analysis. As opposed to those correlations, based on the data from Table 1 it may be noticed that there is no correlation between four perspectives of supply chain management sustainability in the observed companies.

Finally, when it comes to implementation of green concept at supply chain level, the situation is pretty much the same as stated in conclusions of some other authors. For example, as the strongest motive for greening the supply chain managers pointed regulatory constrains (64%) and requirement from partners – existing companies in the supply chain (56%). It is very disappointing that only 16% of interviewed managers stated that the companies they represent implemented green practice into their supply chains because they believe it is the only accepted way for doing business in modern conditions. This is very similar to the research results conducted by Carbone and Moatti (2008). For example, the main motive for designing green supply chain stemming comes from regulatory constraints (73% of the surveyed companies recognized this as a key motive) and improving the image of company and whole supply chain (60% of companies from analysed sample).

5. CONCLUSION

After cost and quality competitiveness comes another era in the economic life and its outcome -competitiveness, meaning that it is not enough just to achieve competitiveness and high economic performances, but also to take care about the human and environmental issues, since it is the only way to make achieved competitiveness sustainable. This applies at company level, as well as at the economy level.

Sustainable development at the macro level depends on efficient and effective use of limited resources. Therefore, each country needs adequate tools for dealing with the problem of the implementation of green law, reducing the use of fossil energy, encouraging of recycling and reuse of waste. These problems are also real at a company level or at supply chain level, bearing in mind that today competitiveness exists between chains and significantly less between companies.

For that reason, this paper presents steps and elements for supply chain sustainability concept implementation, with focus on environmental component of sustainability. Green component of sustainability has roots in quality management. Environmental issues have to be analysed and recognized even during product designing, but especially during production process. The production process must not degrade the internal environment of the company, but neither its external environment. Finally, ecological approach must be present, not only in design and production, but also during the use and disposal of products.

Environmental protection has to be one of the objectives of supply chain management, too. Ability of supply chains for *greening* concerns resource saving and waste reducing, and, based on that, providing competitive advantage. Taking care of the environment at supply chain level is very important since it assumes integrating all process through production life cycle.

According to the research results, quality and environmental issues are not very popular at companies and at supply chain level in Serbia. Compared to some results from the developed countries, it may be concluded that situation is not enviable in the companies in Serbia. Especially, when it is about sustainability concept at supply chain level, it seems that situation is chaotic, rather than balanced and oriented towards environmental protection and, further, sustainability. Another worrying issue is the fact that interviewed managers have not suggested any other factor or element of sustainability that is specific for the environment in which they operate. This is, actually, the confirmation that sustainability still does not have the attention which it deserves in the Republic of Serbia, and which is necessary for achieving and keeping competitiveness. In this regard, future research must be focused on finding the best way to promote the concept of sustainability within the company and also at the level of supply chain, in order to develop awareness of the concept importance, and thus increase the interest of supply chain management for its implementation.

However, the research results can only be conditionally accepted, since the significant limitation is the fact that is was conducted on the relatively small sample. For that reason, there was no statistical approval for conducting the analysis about implementation of standards concerning quality and environmental protection.

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ZELENI KVALITET I UPRAVLJANJE LANCEM SNABDEVANJA KAO FAKTOR ODRŽIVE KONKURENTNOSTI

Pretpostavka na kojoj je baziran rad je da u savremenoj ekonomiji nije dovoljno obezbediti ekonomske performanse, koje će zadovoljiti kupce, s obzirom na odnos troškova i kvaliteta. Druge dve perspektive moraju biti uključene u analizu, a tiču se ljudi - socijalnih pitanja i planete - životne sredine. Ovo dovodi do koncepta 3P: Profit, People i Planet. Prema ovom konceptu, jedan od glavnih izazova za kompanije i lance snabdevanja kojima pripadaju biće obezbeđivanje zelenog dizajna proizvoda, zelenih lean procesa i operacija, kao i zelenog snabdevanja. Iz tog razloga, u radu autori analiziraju zelenu komponentu održive konkurentnosti, sa ciljem da pokažu put od upravljanja kvalitetom (kvalitetnih proizvoda i procesa) i zaštite životne sredine preko održivog upravljanja sa akcentom na ozelenjavanje lanca snabdevanja do konkurentnosti privrede.

Ključne reči: *održivost, konkurentnost, upravljanje kvalitetom, standardi, lanac snabdevanja*

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