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REVIEW ARTICLES

Evaluation of Mining Enterprises Within The Framework of International Financial Reporting

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Abstract

The different structure of the enterprises operating in the mining sector from other sectors is important in terms of the comprehensibility of the information they present in the financial statements. In the "IFRS 6 Exploration and Evaluation of Mineral Resources" standard, the issues to be considered in the reporting of mining enterprises are included. In this study, how the mining sector should be examined within the framework of financial reporting is given. In the article, firstly, the importance of the mining sector in Turkey, difference from other sectors and in the world was evaluated, mining activities are explained and then the standards in the reporting of mining enterprises in the finance sector were discussed. The aim is to compare the reporting standard required by IFRS 6, which determines the accounting policies of mining enterprises, with generally accepted accounting policies. In the study, it has been researched how the profit and loss situation of mining enterprises can change according to the International Accounting Standards and Tax Procedure Law, the conditions that can create deferred taxes are discussed, and the effect of this situation on companies is emphasized.

Keyword

Mining Operations, Tax Procedure Law, International Financial Reporting Standards

1. INTRODUCTION

"Mining Sector", which is one of the sectors that add value to our country's economy, provides the basic inputs needed by other sectors, especially the industry, and also creates new employment areas in rural areas. According to the Report of the Mining Research Commission of the Turkish Grand National Assembly, approximately 10 billion tons of mines worth 1.5 trillion USD are produced in the world every year. 75% of this production is energy raw materials, 10% is metallic minerals and 15% is industrial raw materials. Thanks to these data, it becomes clear how important the mining sector is for the world economy (Sönmez, 2016: 316). The USA, China, South Africa, Canada, Australia and Russia are among the countries that play a role in the world's mineral reserves and mineral production. The Republic of South Africa is rich in gold, platinum group metals, manganese, chromium and aluminum. China is rich in iron, lead, manganese, molybdenum, tin, zirconium, zinc, phosphate mines. Canada has uranium, zinc, gold, copper, nickel, cobalt,

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iron, oil and natural gas mines. Australia is rich in coal, iron, rutile, zinc, lead uranium and the USA is rich in lead, molybdenum and phosphate ores. In addition, Saudi Arabia, Kuwait, Iran and Russia have significant reserves in oil production that are not included in the mining group. Canada, Australia and the USA are the leading countries that invest the most in mineral exploration activities.

Considering Turkey, the complex geological structure has led to the discovery of various mineral deposits. Our country is rich in energy raw materials such as industrial raw materials, metallic mines, lignite and geothermal resources. However, except for a few mines, our worldwide reserves are limited. Turkey is among the self-sufficient countries in terms of the diversity of its mineral resources. Boron minerals take the first place among the mines that our country is rich in. The size of the demand realized in the world markets and the production volume provided in the country are the main factors that determine the exports realized by the mining sector in Turkey. The developments in the global markets are effective especially in the export of metallic ore, and the positive economic developments in the world markets offer important development opportunities to Turkish mining.

Mining has some differences compared to other businesses. In the mining sector, production is made from natural resources that are consumed and cannot be reproduced until they reach the production stage, and preliminary studies such as research, evaluation and preparation for production are carried out. Due to the impact of natural events in the mining sector, there is a great risk of failure and loss compared to the risks in other production enterprises.

New mining sites are risky and uncertain for mineral reserves, making it difficult to apply economic management methods. For this reason, mining activities take a long time to take place and therefore delays are experienced in income generation. There are also additional costs incurred to restore the mined area. Mining enterprises, unlike other enterprises, also receive reactions from non-governmental organizations due to the damage to the environment (Özkan & Aksoylu, 2012).

In terms of the position of the mining sector in the world and national economy, it is important that the financial information regarding this sector is accurate, reliable and comparable. The differences in accounting and reporting principles for the sector increase the costs of producing financial information, while restricting access to accurate and reliable financial information. Accounting policies for the mining sector are regulated in the IAS 38-Intangible Assets standard and IAS 16- Tangible Fixed Assets standard. The IFRS-6 Mineral Resources Exploration and Evaluation Standard was published to be implemented in 2006.

In this article, it is aimed to emphasize how the companies that will report according to IFRS-6 should apply their accounting policies. In our study, the reports declared by the enterprises according to the Tax Procedure Law and international accounting standards are emphasized and the effect of the company on the profit-loss situation is discussed.

In this context, mining activities in the first part of the study explained. In the second part, the financial statements to be prepared by the mining enterprises according to the Tax Procedure Law are emphasized, and in the third part, the preparation of the financial statements according to the international accounting standards is explained. In the last part of the study, the regulations on the accounting of mining activities in our country's legislation and the effect on the company's situation are discussed.

2. MINING ACTIVITIES

Mining activities are operations involving the safe extraction of geological raw materials in the earth's crust from their location in order to obtain economic value. Mining activities include different production processes according to the type and usage areas of the mine, but most production stages are included in all activities. Mining is a set of processes that starts with exploration activities, continues with ore production and enrichment processes, and ends the project with closing the areas where the ore ends and reintroducing the working area to nature.

Pre-Production Activities

The first work to be done to reveal an ore deposit is the start of exploration activities. Methods such as the examination of mineral deposits from maps, geological studies, aerial photographs and mapping form the basis of mineral exploration studies. Exploration activities, which constitute the first step for the realization of the project, continue in the following process, including the production phase. At the planning stage, a preparation process is foreseen according to the production capacity of the mine, the areal size and the technology to be applied. In this process, all areas are made ready for the mine to start production, and this process can take up to 1 year according to the specified criteria. Construction and installation of structures such as mine roads, waste or waste areas, ore preparation and enrichment facilities are carried out at this stage. Before the construction of all project units, the vegetative soil of the determined thickness is taken and stored in a designated area to be used in rehabilitation activities. At the same time, this process can be carried out in parallel with production within the scope of land preparation in units that will be newly established or whose active usage area has expanded depending on the project progress stage. In case the mining method in which the mine will be produced is underground, underground entrance structures such as wells and galleries are constructed to provide access to the ore in accordance with the production-term plans. These structures are applied by drilling-blasting or special excavation methods and take place underground. In order for ore production to start, all underground units determined during the planning phase, such as fortification structures, ventilation, human and material transport routes, are created during the preparation process. In open pit mining, however, the topsoil on the surface of the study area is taken first, if available, by adhering to the production-term plan. If the ore deposit, which is mostly encountered in formations such as limestone, basalt and marble, is formed on the surface, mineral production can be started directly. In case the ore deposit is deeper, the uneconomical rock, which is called waste, is loaded onto trucks by drilling or dismantling method according to the structure of the rock and transported to the waste storage area. Rust production can also be carried out simultaneously with ore production. This situation has been determined in the production-term plan according to the economic evaluations.

Production Activities

Extraction of ore from underground is carried out in two ways using surface and underground mining methods. Open pit mining, or in other words, surface mining, is a form of production applied in areas where the ore is close to the ground surface, for the economical extraction of the cover layer (rust) on the mine when necessary. When the surface mines opened for operation today are examined, it can be said that three different methods are applied in general. These; Lignite and coal mines with horizontal ore deposits, metallic mines with inclined or steeply branched ore deposits, industrial raw materials and natural stone mines with ore deposits formed on a slope near the surface can be exemplified. Underground mining, on the other hand, is a form of production in which the ore is extracted by creating galleries or wells in case the ore cannot be economically extracted by deep and open pit method. In addition, there are special production methods such as underground gasification and solution mining, which are classified as underground mining. Following the preparatory work, the ore is prepared by extracting it from its location, enriching it if necessary, then placing it on the market or transporting it to the place where it will be used. The main purpose of the mining method determined at the feasibility stage is to determine the scope of production activities. The ore obtained through production activities is not always suitable for direct use or sale due to its physical and chemical properties. In order to make these kinds of ores suitable for their use, they should be subjected to ore preparation and, if necessary, enrichment processes. With the ore preparation processes, it is aimed to obtain a product with the requested physical properties such as particle size and shape without interfering with the chemical properties of the ore. The most commonly used ore preparation processes are; applications such as crushing, grinding, screening, classification, solid-liquid separation. Depending on the characteristics of the mine structure, ore preparation processes can be carried out in dry or aqueous environments. Ore beneficiation applications are usually made after the ore preparation process. Manual or mechanical sorting, sorting by size, gravity separation, magnetic separation are the most commonly used physical separation methods. The part containing the ore grains intended to be obtained in ore enrichment is considered as concentrate, and the part separated from the other side is considered as waste. If the concentrate obtained is suitable for sale, it is put on the market or directed to further enrichment processes such as refinery to

remove the impurity content. The resulting waste is evaluated with alternatives such as storage, use for filling purposes, and transfer to disposal facilities.

Post Production Activities

The final stage of the mining projects, the closure and rehabilitation period, is actually carried out together with the operational activities, it is applied intensively at the end of the operation period, and continues in the form of environmental monitoring after the closure.

Closure and rehabilitation activities carried out in parallel with operational activities; In order to restore the areas whose production or storage process has been completed and temporarily used areas to nature in a suitable quality, the area can be leveled or covered with a top cover in accordance with its design, and the vegetative soil stripped during the construction period is moved to these areas and laid again. At the end of the operation period, it is aimed to dismantle the structures, level the entire activity area in accordance with the topography, and make the area adapt to nature by carrying out the activities included in the rehabilitation planning (planting soil, afforestation, etc.).

3. EXAMINATION OF MINING ACTIVITIES ACCORDING TO TAX PROCEDURE LAW

In Article 316 of the Tax Procedure Law, "the concession and cost values of the mines and quarries that lost their material value due to the decrease in the ore due to operation, their size and nature upon the application of the relevant parties, and separately for each mine and quarry, It is destroyed over the proportions to be determined by the Ministries of Industry". If the enterprise has its own license, the price to be redeemed is the concession price. The concession price includes all the expenses related to the determination of the ore such as the preparation of the topographical maps required to obtain the concession, the fees of the technical and other personnel sent to the mine site, the drilling costs, and the expenses such as concession fee, stamp duty. If the usage right is leased or purchased, the amount to be amortized in the acquired mines is the cost price. This price includes the price paid to the concessionaire in exchange for the acquisition of the mine from the concessionaire and the related expenses. The depreciation amounts to be calculated over the cost values of tangible and intangible assets are determined by estimating the useful lives of these assets, while the cost values of the operating and concession rights capitalized as special depletion assets are converted into expense and what rates will be destroyed is determined on the basis of the amount of reserves extracted or planned to be extracted in the mine sites (Uygun, 2013). According to the Tax Procedure Law, there is no regulation on recording or capitalizing exploration and development expenditures as expenses. It is envisaged that the expenditures will be recorded at cost.

According to tax laws, expenses incurred during the acquisition of oil exploration rights, development expenses and operating expenses are capitalized as Intangible Assets. Expenses incurred in order to obtain the right to explore and capitalized with cost are amortized through depreciation during the period that the exploration right is held. According to tax laws, it is also possible to record the incurred expenses of mining operations as direct expenses. The benefit of spending on preparations for land cover removal in order to mine in an area; Since it is limited to the amount of oil or mineral to be purchased from there, the said expenditures are subject to special depletion (Sevilengül, 1998). These expenditures are reported as "Special Exhaustion Asset" in the Uniform Accounting System in practice in our country.

According to the Uniform Accounting System, "Search Expenses"; It is the account in which the expenses made to determine whether the mineral deposit is suitable for operation and the petroleum exploration expenses are followed. Internationally accepted accounting policies require these expenses to be capitalized in a single temporary account as soon as they are incurred and transferred to a different account according to the result of the exploration activity (Hacırüstemoğlu & Boz, 2006). The depreciation calculated for the research and development periods of the mining sector is generally included in the income statement, but if the depreciable asset is used in the production of other assets, they are included in the cost of the asset subject to production. The depreciation of the fixed asset used in the development phase of the mine should be capitalized like all other direct expenses of the development phase. If producible mineral ore reserves are found as a result of exploration activities, these expenses are amortized. If the search result is negative, these expenses are recorded as direct loss. "Preparation and Development Expenses" account within the asset

group subject to special depletion; It is the account in which the expenses incurred as a result of the operations required to make the ore or oil ready for extraction, such as removing the cover over the mine, entering the underground mine and dividing the mineral deposits into pieces suitable for production, are followed. Both accounts are amortized through depreciation. The depreciation rates to be applied to oil exploration and development expenditures are determined separately by the Ministry of Finance, taking into account the reserve situation. According to IAS 38 Intangible Assets, "the amortized value of intangible assets with finite useful lives can be determined after deducting that value". However, a residual value is not foreseen for intangible assets in the Tax Procedure Law.

4. EXAMINATION OF MINING ACTIVITIES ACCORDING TO INTERNATIONAL FINANCIAL REPORTING STANDARDS

Mining activities consist of the stages described above. The prominent issues in accounting for these activities are; determining the scope of the expenses to be capitalized, amortizing the capitalized expenses and accounting for closing activities. The International Financial Reporting Standard (IFRS-6) on the Exploration and Evaluation of Mineral Resources determines the financial reporting principles for the expenditures incurred during the exploration and evaluation of resources, not the financial reporting principles for the development of mineral resources. IFRS-6 states that businesses should determine a policy for capitalizing or recording the expenditures made during the research and evaluation phase as a period expense and that this policy should be applied consistently (IFRS-6, Art. 9). This standard does not focus on accounting practices related to other stages other than the research and evaluation stage. At the recognition stage, exploration and evaluation assets should be measured at cost. In the next measurement, either cost or revaluation model is used (IFRS-6, Art. 12). Research and evaluation assets should be classified as tangible or intangible assets according to their structure (IFRS-6, Art. 15). Where the carrying amount of research and evaluation assets exceeds the asset's recoverable amount, the research and evaluation asset should be reviewed for impairment. Impairment is measured in accordance with IAS-36 “Impairment of Assets” (IFRS-6, Art.2-b).

Impairment

Assets are assessed for impairment when circumstances indicate that the carrying amount of the exploration and evaluation asset may exceed its recoverable amount. The entity measures, presents and publicly discloses the resulting impairment loss in accordance with IAS 36. One or more of the following conditions indicates that an entity should test research and evaluation assets for impairment.

- The entity's right to conduct research in a particular area expires during the period or will expire in the near future, and is not expected to be renewed.

- Significant expenditure for further exploration and evaluation of mineral resources in a particular area is not budgeted or planned

- The exploration and evaluation of mineral resources in a particular area did not result in the discovery of commercially viable amounts of mineral resources and the entity decided to cease such activities in a specific area

-Adequate information is available to indicate that although improvement in the particular area is likely to progress, full recovery of the carrying amount of the research and evaluation asset through successful development or sale is not possible.

In such or similar circumstances, the entity applies an impairment test in accordance with IAS 36. The purpose of this Standard; It is to determine the principles that should be applied to ensure that a business is not monitored for a value greater than the recoverable amount of its assets. The carrying amount of an asset; If it is more than the amount that will be recovered through its use or sale, the related asset is followed up with a higher amount than its recoverable amount. If this is the case, the asset is impaired and the Standard requires the entity to recognize the impairment loss. The standard also regulates when an entity should reverse an impairment loss and the disclosures that must be made to the public. An entity establishes an accounting policy for the allocation of research and evaluation assets to cash-generating units or groups of

cash-generating units in order to assess them for impairment. Each cash-generating unit or group of units to which research and evaluation assets are distributed cannot be larger than the segments of the entity based on primary or secondary reporting as determined in accordance with IFRS 8 Operating Segments (IFRS 6, p. 21).

The level determined by the entity for testing exploration and evaluation assets for impairment may include one or more cash-generating units (IFRS 6, p.22).

Depreciation In Mining Operations

According to IFRS-6, expenditures incurred during the research and evaluation phase can be capitalized depending on the policy determined by the enterprises. IFRS-6 does not directly regulate the depreciation of capitalized research and evaluation expenses. However, according to the Standard on Tangible Fixed Assets (IAS-16), the depreciation method used is required to show the entity's consumption of the economic benefit of an asset. For this purpose, the Standard is to leave the most appropriate method to the preference of the enterprise; recommends straight-line depreciation, declining balances, and unit of production methods. Capitalized expenses are considered intangible assets and must be depreciated (amortized). The investment made by mining enterprises in the mine is finite, that is, it cannot continuously reproduce itself as in other industrial sectors. For this reason, depreciation should be deducted from the revenues obtained from mining activities (Common and Sanyal, 1998). Thus, mining enterprises will consume some of their income while maintaining the initial value of their capital. It is given the chance to create research capital in order to replace the existing source or to find additional reserves (Oygür, 1995).

Mine Closing Cost

Closing costs are recorded as expense in the period they are incurred. The entity is required to set aside provisions for future reinstatement and renewal transactions. The amount of provision to be allocated must be estimated very well. Since mining investments are long-term investments, the time value of money gains importance in determining the provision amount. In this case, the provision amount required by the enterprises for the said expenses will be the present value of the expenses estimated to fulfill the obligation, calculated with an appropriate discount rate. The provision amount should be updated as of each balance sheet date. These provision expenses can be capitalized according to the wishes of the enterprises. International Accounting Standards neither prohibit nor require the capitalization of provisions.(Karapınar et al., 2010)

As for the principles of accounting for expenditures incurred during development, production and closure activities, which are among the activities of mining enterprises, it is regulated in the standard that expenditures related to the development of mineral resources cannot be accounted for as exploration and evaluation assets (IFRS-6.10). Expenditures related to the development activity will be measured and recorded in accordance with the provisions of the “IAS 38 Intangible Assets” Standard. Removal and restoration liabilities that mining enterprises encounter as a result of closing activities are reflected in the financial statements in accordance with the “IAS 37 Provisions, Contingent Liabilities and Contingent Assets” standard (IFRS-6.11).

Expenditures incurred when the technical feasibility and economic adequacy of extracting ore from a mineral resource are determined are not classified as research and development assets. This requires reclassification of these expenditures (IFRS 6.17). If impairment is detected during reclassification, impairment losses are recognized.

Open Pit Mining

"Open pit mining operation", which is one of the mine production methods, is taken from the ground in a way that includes "loosening, digging, loading, unloading, laying the cover layer on the mine mass, shaping the dump area according to the project, making it suitable for the natural environment, loosening it, and

building the roads leading to the quarry" (the process is called stripping.) refers to the mine production operations.

Pursuant to the provision in the 42nd article of the Income Tax Law No. 193, the works related to stripping are considered as construction works and if it spreads to more than one year, it is within the scope of "construction and repair work extending to years". is being evaluated. Among the comments of Turkish Financial Reporting Standards, "IFRS Interpretation 20 Pickling Costs in the Production Stage of Open Mine", waste cleaning, stripping, etc. used for. These stripping activities carried out to reach the mine are accounted for as non-current assets under the name of "assets related to stripping-related activities" within the framework of the determined rules. The cost items related to the stripping operations of the ongoing business are accounted for in accordance with the IAS 2 Stocks standard text. Asset items related to stripping operations are recorded in accounting records as improvements to an existing asset and classified as tangible fixed assets or intangible assets, in relation to the nature of the parts created by the existing asset item. Cost items related to stripping that may occur before production in the development step of the mining operation are included in the capitalization process as an addition to the cost to be depreciated during the establishment, development and construction phases of the mine. These cost items in the asset are generally consumed with the start of production, by depreciation or amortization according to the unit method. These cover layer removal and stripping operations also include the continuation of the mining operation throughout the production period.

Formation of Deferred Tax

In the application of TFRS 6, enterprises choose an accounting policy for which expenses to be expensed or capitalized in the accounting of expenses related to mining activities. If capitalization of the expenditures in the exploration and evaluation phase is chosen among the stages of the mining activity, the said expenditures are measured at cost as an asset. Expenditures in the development phase are evaluated within the scope of TAS 38. Expenditures in the production and closing stages are generally recognized as an expense unless they are an expense that falls under the definition of an asset. Expenditures before obtaining licenses related to mining activities are not within the scope of TFRS 6, and enterprises choose their accounting policy to expense or capitalize these expenditures. In terms of tax legislation, the concession or cost of mining activity is capitalized. In fact, the expenses in question are the costs of acquiring the necessary licenses to operate in mining. However, some of the expenditures defined as research and evaluation expenditures in TFRS 6 are also included in the definition of concession or cost value in the tax legislation. In other words, the concession or cost value includes both the expenses for obtaining a license and some research expenses. However, if these expenses are selected to be expensed, a deductible temporary difference will be equal to the difference between the expensed amount and the capitalized amount, and the deferred tax asset should be calculated over this difference.

In the application of TFRS 6, capitalized research and evaluation expenditures are valued using the cost model and revaluation model in subsequent measurements. In tax application, it is not clearly stated which measure will be used in subsequent valuations. Therefore, the provision of Article 289 of the TPL should be applied. In this case, the buildings and land in question are valued with their tax values, the others, if any, with the stock market value, if not, with the precedent value, if not, with the precedent value. The amount capitalized as a concession or cost value will generally be measured at its recorded value in the following periods. After the explanations above, if the value calculated according to the cost or revaluation model used in accordance with TFRS 6 of the activated exploration and evaluation assets is different from the value calculated according to the tax legislation, a deferred tax asset will need to be calculated. In case of choosing the cost model, the most important factors that will lead to differentiation are the selection of a depreciation method other than the production quantity method in accordance with TFRS 6 and the allocation of impairment. In accordance with the tax legislation, the production amount method is generally used and no impairment is recognized. The reason for the impairment is important in terms of tax legislation. If the impairment is due to a decrease in the mineral reserve, further depreciation will be made; therefore, the impairment would have been taken into account indirectly through depreciation. On the other hand, TFRS 6, p. The cases of impairment listed in Article 20 are also cases that allow direct expense in terms of tax legislation.

5. CONCLUSION

In our study, the accounting and financial reporting processes of the research, development and production activities of the mining sector were examined. Although there are not many different and unique applications regarding the mining sector in terms of Turkish Tax Law, separate accounts are defined for R&D expenses. Mining operation accounting has been specially arranged because the amount of ore contained in each mine and the operating conditions are different. The depreciation rate of the mines will be determined separately for each mine and it is essential to know the reserve amount in order to be subject to depreciation. In order for mines to be subject to depreciation, the amount of ore in them must decrease. The amount of depreciation that can be allocated will be determined according to the ratio of the amount of ore mined during the year to the apparent reserve. Without these conditions, it is not possible to depreciate the price paid for the mine site in any way. Regarding the standards examined in our study, IFRS 6 regulates only the research and evaluation phases of the mining industry, refers to IAS 16 and IAS 38 related to other operational phases, so it is not a detailed mining standard. In terms of Fixed Asset Valuation and Depreciation in mining enterprises, both fields are based on cost value in the initial recognition. In terms of determining the economic life of depreciation, the Tax Procedure Law is based on the generally accepted depreciation periods for tangible fixed assets.

It is based on taking into account the practices of the market and on the amount of reserves in special depleted assets. In IFRS, the determination of the useful life of tangible assets is left to the experience and foresight of the enterprise, and the economic life of assets subject to special depletion is determined according to the amount of reserves.

In the process of comparing the financial statements according to the Tax Procedure Law and International Accounting Standards, which is one of the main objectives of our study, it has been evaluated that the company may be in loss as a result of the reclassification and valuation in IFRS.

Profitability rates may decrease as a result of classifications, provisions, severance pay, deferred tax effects and contributions of an enterprise operating in the mining sector, on the financial statements prepared in accordance with the provisions of the Tax Procedure Law. As a result of this, as a result of the conversion of these financial statements of the businesses that appear to be profitable in the financial statements prepared in accordance with the provisions of the Tax Procedure Law, it is revealed that the business may declare a loss in the converted financial statements as a result of the conversion of these financial statements.

The differences between the financial statements that are required to be regulated legally according to the Tax Procedure Law and the IFRS financial statements are noteworthy.

When the financial statements prepared for the purpose of determining the tax base and the realistic and comparable IFRS statements are compared, it is concluded that their financial performance has weakened. It can be said that the financial statements prepared according to the Turkish Accounting Standards are more dynamic and up-to-date than the ones prepared according to the Tax Procedure Law, reveal the risks posed by the resources and assets of the business more clearly, and enable the opportunities to be seen more clearly. Lenders, investors and business owners can make clearer and more accurate financial analysis.

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REVIEW ARTICLES

Exploring a Scientific Research Methodology in Social Sciences: Steps for Analyzing Non-Stationary Heterogeneous Panel Data

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Abstract

Accurate and rigorous applications of the econometric analysis is crucial when writing a high-quality analytical research paper in social sciences. This article provides the basic framework on how to construct econometric analysis for heterogenous non-stationary dynamic panel datasets. Panel data econometrics is a very broad field, naturally it will not be possible to include all methods in this study. Thus, we present details of the specific selected highly used standard panel data tests and estimations (Im-Pesaran-Shin unit root testing, Pedroni's cointegration test, panel data ordinary least squares) in this paper and explain why and under which conditions these methods are applied. We employ theoretical formulations of mentioned tests and estimations along with Engle and Granger's error correction mechanism in order to determine the order of integration and long-run relationship between the panel variables. In summary, we aim to explain basic steps for a straightforward empirical panel data research process for new researchers in social sciences.

Keyword

Econometric Analysis, Panel Data, Unit Root, Cointegration, Panel Data Ordinary Least Squares (PDOLS)

1. INTRODUCTION

Using econometrics when drafting research papers is a commonly used methodology in social sciences, particularly in economics and finance. Econometrics research focuses on examining the relationship between variables as it uses various types of statistical and empirical methods over different data sets.

Today, since it is easier to reach datasets through trustable sources like national statistical organizations, central banks, international organizations and/or public institutions, the tendency to do rigorous econometric investigations through powerful econometric and statistical packages have substantially increased. Taking into account that econometrics has close ties with mathematics and statistics, econometric tools have started to be widely applied over model estimations targeting to obtain reliable and quantifiable results in various branches of social sciences.

Since doing econometric research is not always very straightforward, researchers should first know the basic assumptions in order to choose the right methodology and the model for their investigation. Reliable and

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complete results can only be ensured by paying attention to asking right questions and following accurate econometric tools in addition to acknowledging characteristics of the data and details of the modelling. The data should possess specific characteristics to perform an econometric analysis while the hypothesis tests and hypothesis shall be constructed decently.

In this respect, this article aims to provide junior researchers from different disciplines of social sciences a perspective concerning panel data analysis. Taking into account that panel data began to provide more space for the researchers when compared with cross-section or time series, the use of both linear and nonlinear analysis of panel data research has immensely increased particularly after 1980s.

Panel data econometrics is widely applicable in economics as the scholars usually use economic theory in search of the potential variables that clarify or determine the phenomenon under consideration. Logical-deductive economic and finance models of the conduct of agents are often utilized to form fundamental chains of causality that leads in predicting variables to the dependent variable. We normally have a set of independent variables to explain the theory in econometrics; while it is not always empirically possible to elucidate economic matter of interest if the model is not strong enough to validate the empirical relationship.

As noted, panel data is one of the means to test relations between the variables. It basically means measuring the same variable over same set of units of time. Measured units can be individuals, countries, firms, universities, schools etc. Hsiao (2005) indicated that panel data *(longitudinal data)* typically refer to data containing time series observations of a number of individuals, as the data involve at least two dimensions; a cross-sectional dimension, indicated by subscript *i*, and a time series dimension, indicated by subscript *t*.

Time dimension plays an important role in panel data research as it sometimes causes serial correlation to occur. Panel data differs from the cross-sectional data as it sparks off unobserved and systematic differences across units to emerge, correlated with observed elements. In other words, panel data methodology helps to control dependencies of the unobserved over dependent variables. Normally, when constructing traditional linear regressions, these dependencies can lead to biased estimators. Constructing panel data sets can be beneficial to tackle individual unobserved heterogeneity since the data involve points within time.

It can be claimed that three major panel data models are used in the literature, which are *pooled OLS, fixed effects model and random effects model*. Pooled OLS model is similar to applying an OLS in the cross-sectional data as if the data under consideration does has an individual and time dimension in itself (the propositions are just like of ordinary linear regressions.) Fixed effects models are the models based on the differences between individual entities. This modelling approach helps removing the unobserved effects, as the unobserved impacts can be linked with observed covariates.

A random effects models pay regards to individual variations as well as time dependent ones, while the model helps us to discard the biases which change in time and stay unobserved. This model assumes the unobserved impacts are not dependent of the covariates.

In addition, there are some other types of approaches to the analysis of panel data in the literature including change score, graphical chain, pseudo panel data, structural equation models, latent variable models, among others. Although separate in modelling, there are obvious similarities between these approaches. For instance, according to Berrington et al. (2006), there is a small difference when choosing between cross-lagged panel models and graphical chain ones, or between random effects models and latent growth curve models. The authors consider the preference will highly depend on a plenty of factors which include the type of the response variables (continuous, binary, ordinal, etc.), number of variables to be included in the analysis, and weighting issues etc.

The static framework of fixed effects approach is based on estimating the individual parameters, while no assumptions on the distribution of the intercepts is required. Another feature of this approach is that the individual intercepts can be generated through the covariates. The Conditional Maximum Likelihood (CML) and joint maximum likelihood (JML) are the estimation methods used within this approach where the latter includes estimating of individual intercepts one by one for each individual in the sample while the former concentrates on the elimination of the effect of the individual intercept with sufficient statistics by the use of a logistic model which was implemented in 1980 for the first time.

Panel data econometrics is a very broad field, and has various application techniques. For instance, the choice or the condition of an individual in the current period whether influencing his/her future choice (or condition) constitutes an important question in panel data evaluations. The effect is identified as "true state dependence" denoted by Heckman (1981), if the choice in the current period has a direct impact on the future choice while it is identified as indirect (namely spurious state dependence) which works through the presence of unobserved time-constant individual heterogeneity. Within this respect, Heckman's *random effects logit model* controls for initial condition and estimated by maximum likelihood.

In 1990s, economists started to apply panel data methods to examine the economic theories involving particularly micro level individual data. In order to refrain from hypothesizing on heterogeneity and unobserved shocks, researchers usually placed their estimations on expected values which are alluded to rational expectations.

The *fixed-effect logit model* proposed by Honoré & Kyriazidou (2000) was estimated by maximizing a Kernel function and it included discrete covariates estimated on the basis of a weighted conditional log-likelihood. Besides, Hsiao (2005) developed the *dynamic logit model* by including the lagged response variables and individual intercepts to the model further to time varying and/or time-constant individual covariates. Since the fixed effects approach was not operable with huge parameters space and the use of time invariant variables was not possible, the random effects approach was introduced where the individual intercepts are random parameters with a specific distribution of their values.

In the last two decades, panel data analysis sprawled and expanded: production functions have been estimated using semi parametric methods while dynamic censored regression models were proposed in addition to the flexible parametric models. Scholars now focus not only on the parameters but also on the on partial effects in nonlinear model.

The types of panel data are very decisive in determining which methods to apply. For example, while examining *horizontal section dependence* in macro panels, there is no need to test such a phenomenon in micro panels due to the short time dimension. The presence of cross-section dependency will determine the type of unit root tests to be used (1st and 2nd generation unit root tests).

There is a growing usage of panel data in different fields of social sciences, for instance, economics to energy, environment to education. One of the first seminal applications was by Balestra & Nerlove (1966). According to Hsiao (2005), three factors contribute a lot to the exponential rise in the panel data studies recently, which can be depicted as follows: *(i)* availability of the panel data; *(ii)* challenging and competitive methodology, *(iii)* panel data have greater capacity to explain and model the complex human behavior when compared with the time series and cross section data. As noted by Hsiao, today we see that there has been a surge in the use of panel data analysis to estimate dynamic econometric models compared to cross section and time series data modelling.

Bond (2002) noted there are advantages of using panel data over the cross-section: dynamic models cannot be estimated using single point one-time observations while cross-section surveys offer limited information for dynamic relationships from earlier time spans. Panel data can be considered advantageous when compared with the aggregate time series as micro dynamics can be hidden and obscured by aggregation biases, while panel data explores heterogeneity in adjustment dynamics between different types of economic agents. As per Bond (2002), genuine panel data with repeated observations on the same individuals, can be applied to create parameter estimates since it allows more of the variation in the micro data.

Concerning this, Moundigbaye et al. (2018) emphasized that the researchers can choose among a wide variety of possible estimators as one of the key matters is to handle cross sectional dependence. The author discussed three approaches to handle this, as misspecification problems, which reduce the number of parameters to be estimated, may arise if cross-sectional dependencies cannot be reduced to a function of distance (Corrado & Fingleton, 2012). Moundigbaye et al. (2018) perform Monte Carlo experiments to create evidence on the performance of panel data estimators.

Not only choosing among the estimators to be used, but also determining which panel model to employ is crucial for an authentic panel data analysis. To illustrate it, Elhorst (2014) put forward that those different

modifications are required to estimate the fixed and the random effects model extended to include endogenous interaction effects or interaction effects among the error terms.

As of today, econometric researchers have the chance to select among many models including commonly used ones like the fixed effects model, the random effects model, the fixed coefficients model, the random coefficients model, and the multilevel model. To illustrate it, in addition to mentioned models, Baltagi et al. (2003) were the first to consider the testing of spatial interaction effects in a spatial panel data model, and they provided a survey of the specification and estimation of spatial panel data models.

In this study, we try to provide basic information on the types of panel data, sorts of tools which should be used, in addition to explaining selected panel data tests and estimations. The study is organized as follows: Section 1 introduces the topic, Section 2 provides econometric formulations and the logic behind formulations, and Section 3 conveys the conclusions.

2. ECONOMETRIC FORMULATION

Linear models are still frequently referred in panel data applications while random sampling is used as a realistic assumption for the populations. When compared with linear models, one can assert that nonlinear models are harder to estimate as the problematic issue is how to tackle unobserved heterogeneity, which is a common issue for panel data econometrics as well.[1]

Social scientists continue to investigate the nature of panel data empirically using numerous methods for exploring the characteristics of these datasets. The development of empirical analysis on panel data requires the applications of several econometric methodologies. Since panel series have long time dimensions, and this allows the researchers to use cointegration and unit root testing to decide the order of integration and relationship between variables.

In this paper, details of the specific selected highly used standard panel data tests and estimations (Im-Pesaran-Shin unit root testing, Pedroni's cointegration test, panel data ordinary least squares) in this paper. First, for the heterogeneous panels Im, Pesaran & Shin (1997) test estimates the t-test for unit roots. Relying on the Dickey Fuller (DF) t-stat of each unit, the test supposes that, *under the null hypothesis*, non-stationarity exists for the series. The test acknowledges common time and individual effects and time trends. This unit root testing is still widely used in the literature.

Pedroni's cointegration test is a 2-step residual-based test based on Engle-Granger methodology. Pedroni extended the cointegration test by Engle-Granger which is predicated on an investigation of residuals through calculating I (1) variables. The residuals are expected to be I (0) in case there is cointegration between variables.

Ordinary least squares in panel data (PDOLS) estimator is an extension to the panel data case of the dynamic ordinary least squares estimator (DOLS) used in time series data, and has the same purpose of estimating a long run equilibrium relationship in non-stationary time series. This is implemented over nonstationary data which show a cointegrating relationship between variables. In short, *(i)* Im-Pesaran-Shin unit root test is employed to determine if the variables are stationary in variance, which is necessary since the variables entering a cointegrated panel must be non-stationary, *(ii)* the statistics proposed in Pedroni (1999) that will make it possible to determine whether the variables define a cointegrated panel and *(iii)* the method of dynamic PDOLS included in Pedroni (2001), with which we estimate the long-term relationship. *(iv)* we also explore error correction model (ECM) which solves the problem on how to integrate into a dynamic model both long-run information contained in variable levels (cointegration) and short-run information contained in variables in differences (stationarity).

[1] If the covariate appears to be persistent for the linear panels with small T, this can be considered as a significant problem for the linear model.

In the following section, we introduce the theoretical and foundational formulations associated with mentioned tests and estimations:

Im-Pesaran-Shin Unit Root Test

After scholars like Breitung & Meyer (1994), Quah (1994), Im et al. (2003), and Levin et al. (2002) formed new approaches to the univariate unit root tests to the panel data, the popularity of cointegration applications to the panel data have increased in the literature. [2] As scholars explored the advantages of panel data, more attention were given to the cointegration tests and estimation with regression models using panel data. Kao (1999), Pedroni (1996, 1997) and Phillips & Moon (1999) led the first works.

The leading studies in the unit root testing field by Breitung & Meyer (1994), Quah (1994), Levin and Lin (1993), Im et al. (1995), and Maddala & Wu (1999) aimed to determine whether economic data are stationary or integrated by implementing classic ways. To start with, Breitung & Meyer (1994) introduced an asymptotic normality of DF test for panel data, which involves a small time series component and a bigger cross-section dimension. Quah (1994) derived a unit root test for panel data with extensive time series and cross-section variations. Levin & Lin (1993) explored the asymptotic distributions for unit roots on panel data while Im et al. (1995) criticized the Levin and Lin (1993) stats and offered some alternative methods. Hadri (1999) claimed that it would be beneficial to apply tests of the null hypothesis of stationarity as well as tests of the null hypothesis of a unit root. To do this, Hadri (1999) extended the tests to panel data with i.i.d. disturbance terms across *i* and over *t*, and displayed how to accommodate the case of heterogeneous disturbance terms across *i*. In addition, Levin et al. (2002) used pooling cross-section time series data for testing the unit root hypothesis. The authors revealed, *thanks to the Monte Carlo simulations,* that for the panels of moderate size asymptotic findings produce a well-performing approximation to the test statistics, while the power of the panel-based unit root test is exceptionally high.

Im-Pesaran-Shin unit root test is one of the regarded unit root test for testing for stationarity in panel data analysis. [3] The reason why we decided to detail Im-Pesaran-Shin test in our research when compared to other tools is this test allows for unbalanced panels while many others presume that the dataset is balanced. The test by Im-Pesaran-Shin predicts *t* test for heterogeneous panels developed by while it allows for time trends and individual effects. The basic assumption is that the series under null are non-stationary. The major difference between Levin & Lin (1993) and Im-Pesaran-Shin is that Levin and Lin assumed all series are stationary under alternative while Im-Pesaran-Shin considers just some are stationary. The theoretical foundation of the test is as follows:

Let's consider a sample of *N* cross sections observed in *T* time periods and y_{it} generated by an autoregressive order process ($p_i + 1$), [4]

$$y_{it} = u_i\phi_i(1) + \sum_{j=1}^{p_i+1} \phi_{ij} y_{it-j} + \varepsilon_{it} \; i = 1\ldots \text{N}, \text{t} = 1\ldots \text{T} \qquad (2.1)$$

which can be parameterized as

$$\Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \sum_{j=1}^{p_i} \rho_{ij} \Delta y_{it-j} + \varepsilon_{it} \; i = 1\ldots \text{N}, \text{t} = 1\ldots \text{T} \qquad (2.2)$$

where $\phi_i(1) = 1 - \sum_{j=1}^{p_i+1} \phi_{ij}, \;\; \alpha_i = u_i\phi_i(1), \beta_i = -\phi_i(1)$

[2] Kao and Chiang (2001) stress that despite the studies on unit roots and cointegration in time series data, the interest on testing unit roots in panel data analysis were limited.
[3] Since Im-Pesaran-Shin test is widely used in the literatura for heterogenous panels, we decided to deliver information on it, when compared to other unit root testing tools.
[4] We do not provide the details of AR in this paper, as it is not the main scope of the study.

$y.\rho_{ij} = -\sum_{h=j+1}^{p_i+1} \phi_{ih}$

The null and alternative hypotheses will be given by

$H_0: \beta_i = 0 \quad \forall i \text{vs} H_1: \beta_i < 0$ para $i = 1 \ldots N_1$ and $\beta_i = 0$ para i $= N_1+1, \ldots, N$ (2.3)

where the alternative hypothesis admits that β_i differs through cross sections. Small negative values will lead to the rejection of the null hypothesis.

It is crucial to note that the test does not provide perfect results in all conditions. Harris (2010) indicated that the researchers should be careful using IPS test when there is uncertainty concerning magnitude of initial conditions. The authors warned that the power of the test decrease when the magnitude of initial conditions is getting larger.

Pedroni's Cointegration Test

Various cointegration techniques have been extensively implemented in the empirical research recently. Orsal (2007) states that scholars started to create unit root and cointegration tests for the panel data because of the problems in finding low power of Augmented Dickey Fuller (ADF) and DF unit root test for the univariate cases and exploring long time series.

Im et al. (1995), Harris & Tzavalis (1996) and Phillips & Moon (1999) helped advances to occur in nonstationary panel analysis. As the number of time observations with large *T* and *N*, non-stationarity has become the matter for the researchers.

There are two major approaches for the panel cointegration tests have come to the forefront in econometrics of late years, which are residual-based (RB) and maximum-likelihood-based (ML). [5]

The scholars who have contributed to the residual-based panel cointegration test statistics were McCoskey & Kao (1998), Kao (1999), and Pedroni (1995, 1997, 1999). McCoskey & Kao (1998) developed tests for the null hypothesis of cointegration, which can be considered as a LM test extension developed in panel data. Kao (1999), on the other hand, derived DF and ADF type of tests and offered four variants of DF test stats within the framework of spurious regression for the panel data.

One of the most important residual-based panel cointegration test was developed by Pedroni (1999). It was in 1995 when Pedroni introduced first version of his residual-based panel cointegration tests. Pedroni (1996) proposed a fully modified estimator for heterogeneous panels. In 1997, he derived asymptotic distributions for residual-based tests of cointegration for both homogeneous and heterogeneous panels, while he extended his tests for the regression equations with two or more independent variables in 1999. Pedroni (1999) used 2 between dimension-based statistics (group-ρ and group-t) and 2 within-dimension-based (panel-ρ and panel-t) null of no cointegration panel. Phillips & Moon (1999) developed both sequential limit and joint limit theories for nonstationary panel data.

The scholars who introduced maximum-likelihood-based panel cointegration test statistics were Larsson & Lyhagen (1999), Larsson et al. (2001) and Groen & Kleibergen (2003). Grounding his research on cross-sectional independence, Larsson et al. (2001) proposed a panel cointegration test statistic. In addition, it was Groen & Kleibergen (2003) who introduced the estimation methodology for homogenous and heterogeneous cointegration vectors through a maximum-likelihood framework using the Generalized Method of Moments (GMM) procedure.

[5] In order to estimate nonlinear panel data models, maximum likelihood estimation is a frequently used method.

Arellano & Bond (1991) introduced GMM estimator relying on the small *T* panel estimation that is based on random and fixed effects estimators or on the combination of instrumental variable and fixed effects. The individual groups were pooled in this estimation while intercepts differ in the groups. [6]

As indicated, Pedroni (2003) introduced a set of statistics that allow testing the null hypothesis of non-cointegration in heterogeneous panels with multiple non-stationary regressors. Applying seven test statistics, Pedroni tested cointegration among the regressors for nonstationary heterogenous panels which are large as *N* and long as *T*. The test by Pedroni may involve unbalanced panels and common time dummies.

The statistical tests are constructed from the residues of the cointegration regression, as follows:

$$y_{it} = \beta_i + \beta_{1i}x_{1it} + \beta_{2i}x_{2it} + \cdots + \beta_{Mi}x_{Mit} + \varepsilon_{it} \quad (2.4)$$

on a sample of N cross sections observed in T time periods. It is admitted that the slopes $\beta_1, \beta_2, \ldots, \beta_M$ vary through the cross sections, with β_i the individual effects.

As specified, Pedroni developed seven statistics, four of them grouped according to what the author called within-dimension and the other three grouped according to what he called between-dimension. From the estimated residues of equation (2.4) the auxiliary regression is proposed

$$\hat{e}_{it} = \hat{\delta}_i \hat{e}_{it-1} + \sum_{k=1}^{K_i} \hat{\delta}_{ik} \Delta\, \hat{e}_{it-k} + \hat{u}_{it}^{*} \quad (2.5)$$

For within-dimension statistics the null hypothesis of non-cointegration and the alternative hypothesis are given by:

$$H_0: \delta_i = 1 \quad \forall i \quad \text{vs} \quad H_1: \delta_i = \delta < 1 \quad \forall i \quad (2.6)$$

on the other hand, for between-dimension statistics the null hypothesis of non-cointegration and the respective alternative hypothesis are given by

$$H_0: \delta_i = 1 \quad \forall i \quad \text{vs} \quad H_1: \delta_i < 1 \quad \forall i \quad (2.7)$$

this alternative hypothesis is less restrictive as it allows heterogeneity between panels; within-dimension statistics will be referenced as panel cointegration statistics and between-dimension statistics will be referenced as group mean cointegration statistics. We now introduce the explicit definition of each statistics:

1. Panel v-statistic

$$T^2 N^{\frac{3}{2}} Z_{\hat{V}\,N,T} \equiv T^2 N^{\frac{3}{2}} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \quad (2.8)$$

2. Panel ρ- statistic

$$T\sqrt{N} Z_{\hat{\rho}\,N,T-1} \equiv T\sqrt{N} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11\,I}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \quad (2.9)$$

[6] Some other techniques called the mean-group (MG) and pooled mean-group (PMG) estimators were introduced by Pesaran, Shin, and Smith (1997, 1999) in order to estimate nonstationary dynamic panels which have heterogeneous parameters.

3. Panel t- statistic (Non parametric)

$$Z_{tN,T} \equiv \left(\tilde{\sigma}_{N,T}^2 \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2\right)^{\frac{-1}{2}} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11\,I}^{-2}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t} - \hat{\lambda}_i\right) \quad (2.10)$$

4. Panel t- statistic (parametric)

$$Z^*{}_{t\,N,T} \equiv \left(\tilde{S}_{N,T}^2 \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2\right)^{\frac{-1}{2}} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11\,I}^{-2}\left(\widehat{e^*}_{i,t-1}\Delta\hat{e}_{i,t}{}^* - \hat{\lambda}_i\right) \quad (2.11)$$

5. Group p- statistic

$$TN^{\frac{-1}{2}}\tilde{Z}_{\hat{\rho}N,T^{-1}} \equiv TN^{\frac{-1}{2}} \sum_{i=1}^{N}\left(\sum_{t=1}^{T} \hat{e}_{i,t-1}^2\right)^{-1} \sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t} - \hat{\lambda}_i\right) \quad (2.12)$$

6. Group t- statistic (Non parametric)

$$N^{\frac{-1}{2}}\tilde{Z}_{tN,T} \equiv N^{\frac{-1}{2}} \sum_{i=1}^{N}\left(\hat{\sigma}_i^2 \sum_{t=1}^{T} \hat{e}_{i,t-1}^2\right)^{\frac{-1}{2}} \sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t} - \hat{\lambda}_i\right) \quad (2.13)$$

7. Group t- statistic(parametric)

$$N^{\frac{-1}{2}}\widetilde{Z^*}_{tN,T} \equiv N^{\frac{-1}{2}} \sum_{i=1}^{N}\left(\sum_{t=1}^{T} \hat{S}_i^{*2} \hat{e}_{i,t-1}^{*2}\right)^{\frac{-1}{2}} \sum_{t=1}^{T} \hat{e}_{i,t-1}^{*}\Delta\hat{e}_{i,t}^{*} \quad (2.14)$$

where $\hat{L}_{11i}^2$ is the estimation of the long run variance of the residuals and $\hat{\sigma}_i^2$and $\hat{S}_i^{*2}$ are the individual contemporaneous and long run variances respectively of the residuals.

All tests follow N (0,1) distribution. As for the rule of decision of the tests, for panel v-statistical large positive values of the normal distribution lead to the rejection of the null of non-cointegration, for the other six statistic very small negative values of the normal distribution lead to the rejection of the null hypothesis of non-cointegration.

Dynamic Ordinary Least Squares in Panel Data (PDOLS)

Pedroni (2001) developed a PDOLS technique to improve the DOLS method created by Stock & Watson (1993). Although there would be endogenous regressors, PDOLS estimators are normally distributed and asymptotically unbiased. As per Pedroni (2001), the group-mean PDOLS estimator has high robustness even to the omission of the variable.

Before this, a panel fully modified OLS test was introduced by Pedroni in 1996. Pedroni (1996) explored the asymptotic distributions and investigated three types of such estimators: The residual-FM, and the adjusted-FM, pooled the data along the within-dimension. The third one, which is the group-FM, pooled the data along the between-dimension. Kao & Chiang (1997) introduced a parametric DOLS based panel estimator pooled along the within-dimension, and proved that this had the same asymptotic distribution as the Pedroni's panel FMOLS estimator. In 1999, Kao (1999) worked on a spurious regression in panel data together with OLS estimator's asymptotic properties.

Pedroni (2000) identified that group-FM estimator (compared with the other two estimators) displayed minor size distributions in small samples.

Given the panel data model,

$$y_{i,t} = \alpha_i + \beta_i x_{i,t} + u_{it} \quad (2.15)$$

the PDOLS estimator is based on the following DOLS regression for each cross section

$$y_{i,t} = \alpha_i + \beta_i x_{i,t} + \sum_{j=-P}^{P} \gamma_{i,j} \Delta x_{i,t-j} + u_{it}^* \quad (2.16)$$

where i = 1, 2,…, N is the number of cross sections, t = 1, 2,…, Tis the number of time periods, P is the number of lags and leads of the DOLS regression, β_i is the slope and $x_{i,t}$ are the explanatory variables.

Estimators of β coefficients and t-statistics are obtained by averaging over the cross sections with Pedroni's group mean method. The estimators are the following:

$$\hat{\beta}_{GM}^* = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\sum_{t=1}^{T} z_{i,t} z_{it}'\right)^{-1}\left\{\sum_{t=1}^{T} z_{i,t}(y_{i,t} - \bar{y}_i)\right\}\right] \quad (2.17)$$

$$t_{\hat{\beta}_{GM}^*} = \frac{1}{\sqrt{N}}\sum_{i=1}^{N} t_{\hat{\beta}_i^*} \quad (2.18)$$

$$t_{\hat{\beta}_i^*} = (\hat{\beta}_i^* - \beta_0)\left\{\hat{\sigma}_i^{-2}\sum_{t=1}^{T}(x_{i,t} - \bar{x}_i)^2\right\}^{\frac{1}{2}} \quad (2.19)$$

where $z_{i,t}$ is the regressor vector that includes the lags and leads of the explanatory variables in differences and $\hat{\sigma}_i^2$ is the long-term variance of the residues u_{it}^*.

PDOLS estimator is averaged along the between-dimension according to the null hypothesis of the Pedroni cointegration test H_0: $\beta_i = \beta_0$vs H_A: $\beta_i \neq \beta_0$, which allows estimating a long run relationship for each cross section.

2.4. Single Equation Error Correction Model

As mentioned, Pedroni's cointegration test is a 2-step residual-based test based on Engle-Granger methodology, which is predicated on an investigation of residuals through calculating I(1). At this juncture, we think it is important to provide the basics of Engle-Granger's Error Correction Model (ECM) which has become one of the foundations of modern econometrics in terms of model development, among other things because it solves the problem of how to integrate into a dynamic model both long-run information contained in variable levels (cointegration) and short-run information contained in variables in differences (stationarity).

Engle & Granger (1987) were the formalizers of the error correction model, whose formulation for the simple case of two variables y_t and x_t both with order of integration I (1) and cointegrated would be the following:

$$\Delta y_t = \alpha(y_{t-1} - \beta x_{t-1}) + \sum_{i=1}^{n} \delta_i \Delta y_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta x_{t-i} + \varepsilon_t \quad (2.20)$$

with Δ denoting the first difference of the variable. Certain considerations are relevant:

Note that since all variables are expressed in first differences and y_t and x_t are I(1) the first difference defines a stationary variable. On the other hand, since y_t and x_t are cointegrated, the linear combination (y_{t-1}-βx_{t-1})

will also be stationary, hence in an error correction model with integrated variables of order one and cointegrated all variables will be stationary and therefore the estimation through OLS is valid[7].

Specifically, the term (y_{t-1}-βx_{t-1}) defines the ECM and picks up the information of the variables in the model that is lost when applying the first difference; on the other hand, it also allows capturing the impact on Δy_t generated by imbalances between y_t and x_t. This type of imbalance can arise due to errors of economic agents in past decisions and the presence in the model of the linear combination (y_{t-1}-βx_{t-1}) reflects the attempts of the agents to correct such errors in the current period through the variable Δy_t, therefore, the α adjustment coefficient must be negative; at the same time, it is the reason why the Equation #2.20 is called "Error Correction Model".

Strictly speaking, the estimation of an error correction model requires that the study of the stationarity of the variables have been previously carried out through some unit root test as well as the cointegration analysis of those variables, because its formulation includes at least one error correction mechanism and variables in differences.

3. CONCLUSION

Although panel data econometrics is a very broad field, and it will not be possible to include all methods in this study; this article focuses on analyzing the basic framework of how to construct econometric analysis based on heterogenous non-stationary dynamic panel datasets. In this study, we aim introduce details of the specific selected of highly used panel data tests and estimations (Im-Pesaran-Shin unit root testing, Pedroni's cointegration test, panel data ordinary least squares) for standard empirical research and explain why and under which conditions these methods are applied. We represent theoretical formulations of these tests and estimations along with Engle and Granger's error correction mechanism in order to determine the order of integration and long-run relationship between the variables. By this, we are hoping to commentate the basic steps for a straightforward empirical panel data research process for junior researchers in different branches of social sciences.

The types of panel data, number of variables included in the analysis, weighting issues are very decisive in determining which methods to apply in panel data research. In this framework, we provide information on the definitions of panel data types, and sorts of investigations that should be applied depending on these types, in addition to foundations of selected tests and estimations for heterogeneous panels.

To be able to perform an established panel data analysis, applying valid unit root tests, checking for cointegration, and following the most appropriate estimation methodology are the keys. In order to choose the best performing tools, scholars first should determine whether panel data analysis may be applied in investigating the economic issue under consideration. The limitations shall be considered to understand if specific econometric tools to analyze panel data might be meaningful, in addition to the assumptions underlying the statistical inference procedures and the data generating process which may not be always fully compatible. The scholars shall also brainstorm on how to surge the efficiency of the estimators.

Despite its various advantages, it should be kept in mind that the strength of the panel data to isolate impacts of particular treatments and actions, is very much related with the data generating process and compatibility of the assumptions of statistical tools.

One major limitation of our research might be strong focus on the basics of the panel data research, which might have caused us to miss the details on panel data econometrics, although the major scope of this paper is not to convey all technicalities regarding panel data research in social sciences.

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7 Among other things due to the fact that all stationary variables prevent the possibility of spurious regression.

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REVIEW ARTICLES

A Discussion on Representing Organizations and Teams as Cognitive Systems

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Abstract

Viewing organizations/work-groups/teams as cognitive systems that process information is either a prevalent perspective or a tacit assumption in many management studies with a long history (Hayek, 1949; Simon, 1945). In this research, first, ontology of cognitive system (or cognition) will be discussed in the context of organizations and organizational behavior. It will be exhibited in the light of the literature that different approaches on this subject affect research methods, findings and interpretations of these findings in management sciences, especially in the organizational behavior literature. The two main distinctions in this regard are as follows. 1- Cognition as information processing and symbol manipulation and organization is the information processor. In other words, the mental representation of the world is based on symbols (representationalist perspective). 2- The anti-representationalist: the external world is not a collection of given facts independent from the individual minds of agents or collective mind of groups, but merely a construction by our given or emerging knowledge structures, the environment and the action are situational/contingent. Accordingly, there is a conflict between the notion of tacit knowledge and the representationalist symbol-processing cognitivist view (Tsoukas, 2005). Another distinction emerges when we analyze the activities of teams/work-groups as information processing and knowledge production activities, below the organizational level of analysis, at the group level. As a consequence of the assumption, considering team cognition as *information content*, a product/output, and investigating as such, is a specific ontological attitude. However, grounding the team cognition as an emergent phenomenon, of collection of processes and actions during collaboration is an alternative approach and research paradigm, which considers the cognition as the *process* of collaborative interaction (Cooke et.al 2012). At the organizational level of analysis, this second approach is consistent with focusing on "organizational knowing" rather than organizational knowledge (Cook & Brown, 1999; Orlikowski, 2002).

Keyword

Team cognition, Collective Intelligence, Organizational cognition, Organizational knowledge, Cognitive science

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1. INTRODUCTION

The "cognitive revolution" that heralded the birth of cognitive science as an interdisciplinary field is retrospectively traceable as early as mid-20th century. This development is also contemporaneous with the start of the organizational theory and behavior literature on information processing, and/or the literature on cognitive characteristics of organizations and their subsystems. This overlap is no accident, and it was not however, just a result of influx of cognitivism to peripheral scientific fields. Rather, intellectual scientific and technological developments of the first half of the 20th century caused both cognitive revolution in general, and notion of organizations, societies, economies as information processing systems. After defining/discussing the "cognition" and what is "cognitive" in organizations, this overlap will be explained further.

What are "cognition", the adjective "cognitive" and the term "cognitive system"? All three will be defined in a unified terminological discussion. "Cognition" is the set of mental activities related to knowledge and knowing. Etymologically, co-, meaning "with" in Latin and gnosis "knowing" from Ancient Greek, 'gignoskein', to know, the process of acquiring knowledge (Gomez-Marin & Mainen, 2016); underlies the notion as an act of knowing. However, as a noun, it refers to the perception, sensation, idea, or intuition resulting from the process of cognition; so to the knowledge content itself (Lexico, 2022). As a contribution to terminological discussion in Turkish scientific literature, cognition might had corresponded to "idrak", "derk etmek" in classical Ottoman Turkish, if it had introduced to Turkish scholarship before the language reforms of the republic. Currently the generic translation as "biliş" (cognitive, bilişsel) in modern Turkish is gaining its specific sense and connotation, as the academic audience using the term is creating this technical sense as a terminological convention.

A more technical, cognitive scientific, or cognitive psychological definition of cognition on the other hand, further specifies the mental activities that yields this "knowing": Perception, manipulation/processing of sensory input and memory content in order to recognizing and remembering, decision making, problem solving, planning, any kind of adaptive, *knowledge using behavior*, for individual adaptation or social adaptation and survival. Processing is usually transformation of one modality of input into another. For example, visual sensory input to conceptual when looking at a scene and labelling the scene as for example, 'a tree and apples in the branches' by means of recalling the concepts of tree and apple from the long term memory. Or, phonological input to verbal or lexical and then conceptual (heard sounds to words and then concepts, then meanings). Another case is from mental to visual imagery, thinking about something and the visually representing it in the mind, imagining etc. Another type of processing is inference, using the knowledge available to the mind (the cognitive system), establishing relationships between prepositional statements and concluding a new one, namely, starting from known truths and on the basis of logical operations, attainment of previously unknown (new) truths about reality, by just using mental power, in contrast with learning by observation/experience.

Both of these two types of processing, namely, transformation and inference, requires dealing with the notion of "mental representation": internal, symbolic knowledge structures. So cognition as a process, actually is, to operate on representations and create new symbolic knowledge structures out of the former. This centrality of notion of representation is called as 'representationalist view'. Mental representations are internal pictures, reflections in the mind, of external reality, of entities of outside world, not only in the form of images but symbols or concepts. This is also the way that we can imagine and reason about things that are not only physical, three dimensional or visual. The analogy is that you can represent an image of an apple in a computer's memory in terms of strings of zeros and ones, as well as you can represent a melody, or a music file. Similarly; in addition to visual ones, human mind can represent some entities in terms of language-like or descriptive representations. (Block, 1983). Mental imagery is only partially visual.

"Mental states" are derived from the above mentioned representationalist view of mind: when mind is actively operating on a certain configuration of mental representations, this is a mental state, when this operation processes and/or transforms this representation to a new one, now, the mind is in a new mental

state, or when the previous one is completed or quitted, and a totally new task is at the center of focused attention, this is also a new mental state. Mental activity is depicted as a continuous transition from one to another mental state. During a single cognitive task of problem solving that entails several mental steps, before discovering or reaching to a solution, different representations of the problem as phases, are examples of mental states.

Another significant point on the term 'cognitive' is its demarcation or distinction from the 'affective'. Affective domain of human mental activity entails emotional, attitudinal, motivational and empathy related dimensions (Baker, 2012). As a side note, most of the "cognitive" studies in organizational context, regardless of their being in the individual, group or organizational/societal level of analysis, struggle to confine their research paradigm to the cognitive domain when they want to particularly focus on knowledge related processes. The struggle is of course about controlling affective domain related variables, and they concede the exclusion of constructs from affective domain as a limitation or as being outside the "scope of the research problem".

2. COGNITIVE REVOLUTION AND ORGANIZATIONAL SCIENCES

Notions of cognitive process, mental representation and states are foundations of the representationalist view of mind and relates to the computational theory or mind, which in addition, depicts all transitions from a mental state to another, as computations. Unsurprisingly all these notions and views of mind are reminding us computers; a central processing unit operating on internal symbols, recalling data from and writing onto a long term memory module and actively using a working memory (i.e. RAM) containing the current computational state. This computer metaphor and view of mental activities as series of computations is the core of cognitive revolution which focused on the information processing to understand human psychology. This novel paradigm challenged and replaced the dominant behaviorist and psychoanalytic schools around the end of second world war in United States and Europe. Behaviorism was extremely positivist and relying only on observable behavior and environmental conditions, deeming mental activities and mental phenomena (being inaccessible to third person) as scientifically irrelevant. On the other hand, cognitive revolution started a new research paradigm that launches an expedition in the human mind:

"The cognitive revolution'' in psychology, which was really more of a counterrevolution against the revolution of behaviorism, was stimulated by the introduction of the high-speed computer. With input devices analogous to sensory and perceptual mechanisms, memory structures for storing information, control processes for passing information among them, transforming it along the way, and output devices analogous to behavior, the computer provided a tangible model for human thought. Perceiving, learning, remembering, and thinking were reconstrued in terms of ''human information processing,'' performed by the software of the mind on the hardware of the brain. Artificial intelligence, simulated by the computer, became both a model and a challenge for human intelligence." (Kihlstrom & Park, 2002)

3. EARLY POLYMATHS OF COGNITION IN THE SOCIAL: H. SIMON AND F. HAYEK

The above mentioned analogies about workings of human mind and psyche went beyond psychology and permeated into administrative, organizational sciences and economics. For example, Herbert Simon in his early 1945 work *Administrative Behavior: A Study of Decision Making Processes in Administrative Organizations*, envisions these organizations as decision making systems. In his analysis of the psychology of administrative decisions, he refers to the formal decision theory of von Neumann (founder of game theoretic economics and modern computer architecture) and Morgenstern, and adopts their notions of representing possible future as the nodes of a "decision three", applies notions of tree data structure or tree search algorithm to human organizational decision making. Another notion derived from von Neumann and

Morgenstern was the min-max calculations of optimal choice with the best outcome at minimum cost (p.120-121).

In addition to adoption of information science to study organization, in his seminal paper "The Architecture of Complexity", Simon brings about another novel perspective on the notion of "hierarchy" in organizations. Rather than a stratified structure of power relations, Simon pictures hierarchy as a feature of complex systems, relation between parts and the whole, higher level systems and subsystems, "to refer to all complex systems analyzable into subsystems" (Simon, 1962). Social/organizational hierarchy is only a version of this systemic feature which is also universal for biological, physical and artificial systems. All systems are organized into hierarchical layers of parts, parts of these parts and so on. Any (sub) system at some specific layer in a hierarchy are not only interdependent but can be decomposed into (which means easily understood, explained in terms of, or reduced into) the nearest, one level down or horizontally neighboring, simpler subsystems. The most intense interactions and information exchange occurs among these neighboring subsystems and we can see this systemic feature in the divsionalization of organizations, and in division of knowledge related tasks, (similar to the notion of division of labor). This systemic feature is characterized as "division of labor, and can be considered a problem solving activity where the recursive division of problems into sub-problems is a property of both organizations and computer programs" (Egidi & Marengo, 2004). Simon's notion of this close relation to, and interaction with closer subsystems is called "near decomposable architecture" or "near decomposability".

Friedrich Hayek, articulated similar but alternative ideas when he tried to explain the reasons of the economic institutions, in his book The Sensory Order (1952). His understanding of cognition is different from the computationalist/symbol processing/representationalist view based on computer metaphor. What Hayek thinks that human sensory experience and thinking happens through the network of connections among the similarly structured nerve cells of the brain. As we can empirically verify, there is no central processing unit, or a biologically different long term memory module or working memory cells in human brain, what we see is a sea of seemingly identical neurons which are connected to each other via synapses that carry electrical current from one to another neuron. Human cognitive system cultivates and is structured as a result of interaction of this network with sensory information pouring from external world, action-perception couplings and adaptive behavior selects and reinforces the best configuration of the synapses and patterns of flow of signals among the neurons. All of the mental systems of processing and storage (of information) must be implemented on this biologically uniform structure by means of different configurations of synaptic connections and specific flow of electrical impulses among the neurons (neural networks). This perspective is called "connectionism" and is a reaction against the computationalist/representational view, which was criticized to be counterproductively reliant on the computer metaphor to understand human cognition. Connectionist view of a cognitive system is bottom up, networked, adaptive, emergent and relational. The connectionist movement was named and gained traction in 70's and 80's but Hayek's view that all aspects of human mental activities can be explained by a system of connections of specific groups or patterns of nerve-excitations (in 1940's terminology of psychology and brain anatomy), captures the whole idea and predates the connectionist movement itself. What is interesting about his approach on human mind is that this connectionist conception is applied to the field of economics and societal level to explain market process. Neurons are replaced by simple individuals with trivial market information:

But, while the latter has been one of the main subjects of investigation ever since the beginning of our science, the former has been as completely neglected, although it seems to me to be the really central problem of economics as a social science. The problem which we pretend to solve is how the spontaneous interaction of a number of people, each possessing only bits of knowledge, brings about a state of affairs in which prices correspond to costs, etc., and which could be brought about by deliberate direction only by

somebody who possessed the combined knowledge of all those individuals. Experience shows us that something of this sort does happen, since the empirical observation that prices do tend to correspond to costs was the beginning of our science. But in our analysis, instead of showing what bits of information the 'different persons must possess in order to bring about that result, we fall in effect back on the assumption that everybody knows everything and so evade any real solution of the problem (p. 50-51)

Here, Hayek characterizes the price system as a mechanism for information flow. Similar to the mind, as also in the market system, surprisingly only a very little explicit (conscious) knowledge is required by the agents in order for them to respond the signals in the market and to the changes in his circumstances. In the mind as in the market, the most essential information is passed on in the form of simplified 'signals' (as contextually situated nerve impulses or prices, respectively). (Smith and Barry, 1997) Network of individuals are receiving and passing simple market signals to each other without any central control and design, and this connectionist system decides upon a prices that enables the functioning of the price system.

Both Simon and Hayek relies on their own view of human cognition (computationalist vs connectionist) to analyze organizational and economic institutions, but their distinct positions create a theoretically complementary system. Hayek considers the market as the exceptional institution that can coordinate the actions of atomic individuals with very limited, local information, Simon on the other hand adds elements of division of knowledge (in reference to division of labor) and specific institutions of coordination as complementary mechanisms explain evolution of organizations in addition to markets (Egidi and Marengo, 2004). A witty side note is that,, due to his genius, Hayek created such an early connectionist view which was contemporary with computationalist view of the cognitive revolution, but this did not chronologically match the succession of computationalism by connectionism as two schools of cognitive science. The practitioners of cognitive science had never been aware of Hayek's relevant works of whom known merely as an economist (Feser, 2006).

4. ORGANIZATIONS AS COGNITIVE SYSTEMS IN THE THEORY OF ORGANIZATIONAL KNOWLEDGE

Simon and Hayek were early polymaths and generalists who applied their novel perspectives into broad areas of scientific disciplines from economics to administrative sciences and computer science. In this section, in a more focused way, the notion of 'organizations as information processors', hence as 'cognitive systems' in the specific discipline of *organizational theory and behaviour* will be illustrated. The main theme of classification of varieties of employing this notion is the representationalist/computationalist vs. connectionist duality. Secondly, this section will elaborate on how this duality influenced the construction of theories and how different theoretical approaches preferred one side of this duality.

Simon envisioned organizations as decision-making systems and proposed organizational level complementary mechanisms to overcome limitations of bounded cognition of its individual members working under conditions of uncertainty and limited information. Similarly, the studies on organizational knowledge envisioned organizations as knowledge possessing and processing entities and as higher-level cognitive agents, beyond and above its indivual members, as these members possess individual information and knowledge. This ontology of 'knowledge as possession' (Cook & Brown, 1999) is compatible with the definition of cognition as a representation and an information content, which also entails assumptions about how knowledge is the outcome of logical rule based operations where both the rules and the outcome are stored in the mind as entities. This approach extends into the organizational level of analysis, and to the theories on knowledge production, on knowledge transfer within and between organizations. These theories are constructed on rule based procedural knowledge handling organizational processes. According to this representationalist view, organizational knowledge represents a pre-given world, is universal and objective,

knowledge results from information processing, is transferable, and enables problem solving (von Krogh and Roos, 1996).

However, the discussion on the nature of knowledge, tacit vs explicit knowledge, and on the duality of "knowledge used in the action" and "knowing as part of action" causes the questioning of depicting organizations as representationalist/computationalist cognitive systems. Previously existing, planned, explicit rules, procedures cannot explain the existence of tacit knowledge and can't produce it, cannot account for its activation in the relevant context. In his 2005 book "Complex Knowledge: Studies in Organizational Epistemology", H. Tsoukas characterizes this representationalist/computationalist view:

"in terms of propositional knowledge and logical if-then operations on them: "is the formulation of conditional 'if, then' statements relating a set of empirical conditions ('If X __' - the factual predicate) to a set of consequences that follow when the conditions specified in the factual predicate obtain (' . . . then Y'—the consequent)" (p. 71).

This side of information processing view works best for to handle patterns and regularities, squeezes them into simple, general observational statements and a limited set of rules to activate when they are observed, this process is called "codification" but also unsurprisingly termed as 'algorithmic compressibility' by Tsoukas and organizational knowledge literature preceding his work. This is a rule based algorithmic, hierarchical (in Simon's sense), top down cognitive system, compatible with the computer metaphor.

On the other hand, the problems of tacit knowledge are categorized along with 'narrative knowledge'. In contrast with propositional knowledge, narrative knowledge is anecdotal, context, practice/action dependent, dynamically constructed and provides adaptation to unforeseeable conditions. Both tacit knowledge and narrative knowledge create the problem of codification, namely putting organizational knowledge into generalizable, context independent propositional statements and both are irreducible to simple coding schemes. For example, basic steps of decision making for routine tasks with and pre-determined number and types of actions can be codified into expert systems. However in the case of codifying a "repair" task for any system, the final stage (system repaired, problem source discovered and treated) cannot be achieved by guessing previous steps (backtracking), instead there is a constant use of previous experience coupled by trial and error to extract new transitional, information required for the intermediate mental states of the agent. Therefore, the knowledge that really works and practically used is context and action dependent, dependent on the continuous change of the state of the problem, environment requires specific knowledge and action at each step and instance of repair (Cowan, 2001). This example is illuminating for an organizational analysis about how it can provide and present knowledge in such non-deterministic contingent problems, and how organizations are able to handle and create this kind of knowledge. The quest for explanation requires the changing the paradigm of cognitive system that is used to characterize organizations, and recourse to view of an organization as connectionist cognitive system, previously described as bottom up networked, emergent, relational (Biggiero, 2008). When an explicit propositional formula for action cannot be created, the necessary knowledge and expertise is created by action reaction cycles that trains the cognitive systems of the members of the organization and the organization itself. Therefore, only recollections of past experiences are implicitly imprinted on the individual and organizational memory in the forms of heuristics, instincts or intuition, i.e. tacit knowledge. Tacit knowledge is both acquired by practice/action, and activated-realized during practice/action. This distinction of knowledge from knowing: a perspective on knowing in practice which highlights the essential role of human action in knowing, i.e. knowing as part of action, how to get things done in complex organizational work (Orlikowski 2002). Where knowledge as a static content residing in the heads of cognitive agents, is compatible with representationalist computationalist view;

"knowing as a part of action" is only possible in this second connectionist interactionist view of organizations as cognitive systems.

After the illustration of the duality of connectionism vs. computationalism for organizations, the following question is still unanswered. How can an organization, as being a mere collectivity of agents, or sometimes just an abstract entity, be construed as a cognitive system i.e. a knowing agent itself? Where does the ontological justification come from? What is the solution to the problem of elevating cognitive agency to the collectivity? This question will be discussed in the following section of team cognition and group minds.

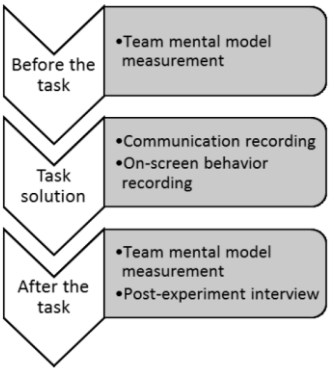
5. TEAM COGNITION

When activities of teams/work-groups are studied with some attention on an ongoing actions of information processing and/or knowledge production, there are two discernible pillars of the research paradigm, first is the level of analysis: it is at the group level, below organizational level of analysis, and above the individual level. Second pillar is that the group's or its members' *cognitions of* tasks, environment, members, procedures, experience, roles and any other kind of knowledge or information that the group deals with, is conceptualized as *group cognition* or *team cognition* depending on the terminological choice. As a result of this second pillar of research paradigm, any of group related object of inquiry in the cognitive realm, is rendered to information or knowledge *content*. So team cognition is the knowledge content that teams knows, produces and uses to make sense of the world and solve problems.

The first pillar is easily justifiable, studying how individual inputs are translated into group outputs, or how individual information inputs are combined into group knowledge, how group judgments can be predicted from individual preferences (McGrath et al., 2000) requires a group level of analysis of knowledge, judgement, and performance. Moreover, when teams are studied, it can be realized that the totality of the team knowledge and performance cannot be reduced into the aggregation of individual knowledge and skills. Human collectivities manage tasks in such level of complexity that no member can have a clear, all-encompassing and detailed ownership or understanding of the teams' actions and knowledgebase. All these aspects places the group performance, judgements and knowledge as the object of inquiry.

Second pillar has significant consequences in research design in team cognition related studies. The result is an input output (I/O) research paradigm where cognitive activity is perceived in terms of its product or precedent, as knowledge content, and the studies are carried out by making initial measurements of these content and team related constructs. Then hypotheses are tested by means of post experimental measurement. In the following figure of the research model, basic elements of team cognition are team mental models (i.e. the information structures, knowledge that the members have about the task and the task environment). They are measured at the individual level and then overlap, complementarity or inconsistencies on individual mental models among the members are used to make group level characterizations of a collective mental model, named as team mental model. To underline the assumptions again, while studying the group activity of collaborative problem solving all of the measurements are made for the inputs and outputs.

Fig. 1 An example for I/O research paradigm: Team mental models (Geszten et al. 2017)



The change in the individual mental models in terms of consistency or overlap is considered to be the dependent variable. Usually performance is also measured, and correlated with efficient team collaboration, in other words collective intelligence. The problem here and the focus of criticism from alternative paradigms, is that the middle part, where the actual collective efforts had taken place is left unattended as a black-box. What kind of knowledge processing and producing activities and interactions happened, as a result of overlap or inconsistencies of members' mental models? How these actions, interactions and events contributed to the chance of individual mental models therefore team mental models, what kind of different team mental states realized during all the tasks were carried out? Similar questions and their answers are not central in this I/O paradigm of research. The critics point out the notion of "cognition as knowledge content" as the source of this neglect of internal workings of the *black-box of team cognition* and viewing the system only in terms of inputs and outputs.

Interactive Team Cognition (ITC) theory criticizes and diverges from existing I/O paradigms (Cooke et.al 2012, 2009, 2004) and considers team cognition is an activity, not a property or a product; proposes that team cognition should be measured and studied at the team level and team cognition is inextricably tied to context. Teams engage in cognitive activity as a single cognitive agent/unit, and this activity extends beyond the knowledge and skills that each team member carries within his or her head. As a cognitive function, team cognition is located in the interactions among team members rather than the static properties of their shared knowledge structure. Team member interaction, is typically in the form of explicit communication (e.g., e-mail, phone, talking face-to-face), is team cognition. The research paradigm of ITC focuses on interaction analysis and uses specific patterns of interaction to explain its conjectures about dependent variables.

This recurring duality (or dichotomy) of diverging conceptions of cognition in organization sciences once again presented. I/O research paradigm focuses on cognition as knowledge (internal representations or reality), and ignores the action in the black box of cognition. ITC on the other hand, establishes cognition of the team around the semi-structured, context dependent and dynamic interactions of the agents under minimal central control of previously calculated, long-term general instructions. We observe this same duality in the Hayek's dynamic information flow between interacting players of the market (connectionism) and the Simon's administrative organizations as decision-making agents, while performing rule based information processing (representationalism). Similar duality was also portrayed in the theories of organizational knowledge.

6. ONTOLOGY OF TEAMS AS COGNITIVE SYSTEMS AND GROUP MIND

An important dimension of examining cognitive dimensions of organizations and organizational units like teams, is the assumptions about ontology of a cognitive system where agent is not an individual person or

animal. In the cases of individual agents, we have an autonomous sentient individual with some level of recognizable intelligence, which actually is the stereotypical base of the notion of cognition. How can we attribute cognition and the functions/features of cognitive systems (i.e. being a knowing agent) to a collection of individuals, to a group which might be considered an abstract entity resulting from and aggregation of individuals? Where does ontological justification come from? What is the solution to the problem of elevating cognitive agency to the collectivity?

One of the ontological approaches to solve this problem is compartmentalization of mental features of sentient/autonomous entities and demarcating cognition from unrelated mental functions. Features like consciousness of external entities, self-consciousness, free will, emotions and affection are not necessarily to be attributed to organizations or teams. But the act of knowing/knowledge related features like judgements, information processing, memory and collective attitudes may be attributed to collectivities. An administrative organization can make decisions but this does not require attribution of a "self" to an organization. So here, attributing cognition to collectivities (organizations or teams) entails propagation, processing and possession of information (or knowledge) by the collectivity above the individual level, but does not entail construing the collectivity as a person with a self, consciousness or sentience. For example, a decision making committee may exhibit its unique and idiosyncratic qualities and behavioral outcomes (decisions) as a result of the unique arrangement of its member, structure, specific rules and task constraints that the committee exposed to in a certain context. When analyzing or observing a decision making task the level of analysis can't be individual cognitive agent, event their collectivity is short of explaining what is going on. Amalgamation of each members' mental models into team mental models, organizational constraints at that unique time point, and combination of contingent personal contributions to collective activity creates a contingent and time and context dependent outcome. All these parameters cannot be implemented or realized in any of the members or even in the totality of the members, this collective attitude of the group is unique and sometimes idiosyncratic combination of the views, skills and knowledge about the task and the context, and can be realized only through their collective action and interaction, when the collective action and the existence of the collectivity, the group ceases, the attitudes and the knowledge base attributed to the group vanishes into oblivion.

In the context of modern business world, (technological or organizational) systems become more and more complex, and they scale to larger and larger systems, so that an individual will no longer have complete control over it, rather, it requires multiple individuals to collaborate in order to accomplish a goal, Therefore when the focus of analysis is propagation of a representational state (dissemination of knowledge) through the system, the cognitive system cannot be construed at the individual level. In his theory of 'distributed cognition', Hutchins expemplifies by means of decks of ships or cockpits of modern planes as such systems, pilots, captains, navigators, engineers, co-pilots, instruments like maps or flight control computers all together forms the cognitive system that navigates these vessels. And a very limited and simplified portion of ongoing information processing is realized in the actual minds of members, (even in the minds of leaders, captains or coordinators); it's distributed across the individuals and the organizational technical systems and realized during collaborative actions. When the interactions cease only a very partial and imperfect traces of information and procedures remains in the individual memories. The above discussions and examples from the literature concludes the argument that there is an ontological ground for cognition by collectives on the condition that cognition must be stripped and isolated from general mental functions and features, and should be attributed to groups and organizations as an isolated feature. Group mind in this sense, is a limited, one dimensional mind without self and soul.

One problem of boundary conditions for attributing cognition to other than sentient individuals is about the definition cognition as 'the source adaptive behavior in the face of environmental stimulus and constraints'. This is a lower boundary. If any adaptive behavior that entails some mechanism for reacting a stimulus is considered to be a result of cognition or information process, then bacteria and plants may be considered to be equipped with a cognitive system but not with a mind (Allen, 2017), like we assume for groups. To overcome this fallacy, the following definition and assumption must be taken in consideration all the time:

Cognition entails internal representations of external reality by means of symbol systems, inside the cognitive system and behaviors as outcomes of operations on, or processing of these internal representations can be outcomes of cognitive activity. So this requirement of internal representations is the explanation of why computational-representational understanding of mind is such indispensable in every theoretical standpoint even it is under continuous attack from more interaction and process focused views of cognition.

7. CONCLUSION

In this study, recurring duality of computational-representational (CR) view of cognition vs. connectionist, interactionist, process based (CIP) view is observed at societal (Hayek, 2005), organizational (Simon, 1945), (Tsoukas, 2005) and team level (Cooke et.al 2013) analysis human collective action in the context of cognitive tasks. As illustrated in the previous sections, adoption of CR view involves an organizational or team cognition view of collective creation and sharing of structured knowledge content and focuses on the analysis, observation and measurement of these knowledge content or knowledge structures. Adoption of CIP on the other hand urges a focus on the processes and interactions and the making of these knowledge contents and ontologically grounds collective cognition on these processes and interactions. As another result of this study, which is a discussion of a very narrow scope and a very selective review of the literature, CR / CIP demarcation corresponds to and overlaps with the 'cognition as content' vs. 'cognition as process' duality.

Then what is the significance of this dualities and overlap of these two dualities? The awareness of the duality may guide researchers and the audience of the research in organizational cognition field about the issues of conceptualization of their object of inquiry as cognitive system. If the organization as cognitive system is conceived as a location for information content then CR view will be expected to guide the research about detecting rule based, computational structures, or (sometimes metaphorical) algorithms for processing this information. Similarly, as a consequence of CR, the most possible oversight is the neglect of the actual processes and interactions where these computations, rules of processing were at work. These processes are also the opportunities for illuminating how rules were generated for the first time or evolved from an earlier version, or how they actually fit the external reality of the organization. Same awareness of the duality may help to guide CIP based research to be able to detect internal representations of the collectivity, where the way these representations are structured may constrain and even determine the patterns of interaction and process of collaboration.

In conclusion, this duality not being a dichotomy, may serve as complementary paradigms to have multi-dimensional picture of the instances of organizational cognition.

One for the limitations of the study is, the problematic of metaphorical use of cognition related vocabulary. This is not addressed in the discussion of ontology and the history of cognitive view in organizational sciences. To articulate their theoretical arguments researchers, may recourse to metaphorical and analogical use of cognition related terminology, characterizing organizations, teams and groups as intelligent, learning, innovative, creative, etc. without making or being aware of any ontological assumptions. This may create ambiguity for the audience and sometimes confusion for the researcher themselves in the research design. Nonetheless, use of cognitive system or intelligence as a metaphor in the organizational behavior and theory was out of the scopes of this study and beyond the intellectual resources of the author.

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RESEARCH ARTICLE

Modeling The Dependence Structure of Financial Data with a Copula: Electricity Index – An Example of The Dollar Exchange Rate

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Abstract

The Copula method is used to reveal the dependency structure between random variables. In both parametric and non-parametric cases, the measurement of dependency with copula functions, alternatives to many methods, and methods that allow much simpler calculation of these calculations have been proposed. In this study, the dependency structure between the electricity index and the dollar rate was examined using the copula function. The relationship between the two indices was compared with MSE, AIC and BIC values. As a result of these calculations, it was determined that the most suitable modeling according to MSE could be done with Clayton, and the most suitable modeling according to AIC and BIC could be done with Gumbel.

Keyword

Copula, dependency structure,index, Electricity Index

1. INTRODUCTION

Copulas were proposed by Abe Sklar in 1959. The history of the copula theory dates back to the work of Hoeffding in the 1940s. Copulas reveal the dependency structure between random variables. Copulas are functions whose univariate marginals are uniformly distributed within the range [0,1] and relate multivariate distributions to their univariate marginals. Capulas are a powerful method used to model the distributions of variables with a common marginal distribution. The main purpose of the capula functions is to obtain the most appropriate multivariate distribution for the studied data by revealing the dependency structure. In the first stage of this study, the definitions of Copulas, their basic features, Archimedean Copula families and the characteristics of these Copula families are explained. In the next section, the estimates of the copulas explaining the dependency structure between the BIST electricity index and the dollar rate between 01.10.2015 and 01.10.2019 and the results obtained from the applications are included. "Copula" is a Latin word and was first used by Abe Sklar in 1959. As a word meaning, copula means to relate (associate), commitment. Copulas, in a broader sense, are the explanation of multivariate distribution functions with the help of univariate marginals. Copulas do this by using a common marginal distribution function to model the distribution of

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variables. The basis of copulas is that they can be used in non-parametric dependency measures, that is, the assumption of normality is not sought and a large number of marginal distributions are determined. The main purpose of the capula functions is to reveal the multivariate distribution, which is suitable for the observed data, with the dependency structure. That is, it expresses the dependency structure between random variables. Copulas are widely seen in finance, economics, actuarial, financial time series, survival analysis and medical statistics, and its popularity is increasing day by day.

2. LITERATURE REVIEW

According to Hafner and Reznikova (2010), in their study on the portfolio they created from stocks based on the 30 Dow Jones index, showed that the stock model effectively measures the asymmetric correlation and is at least as successful as the parametric methods in creating a portfolio. Paletier (2006) used the dynamic conditional correlation method as Engle and Sheppard (2001) applied to the data set in the regime variable structure, and the model showed successful performance especially in detecting sudden and high volatility. Cuaresma and Wojcik (2006) used dynamic conditional correlation, which takes into account the joint correlation of both variables, to test the effect of interest rates on the monetary policies of the Czech Republic, Poland and Hungary. Bautista (2006) examined the change in time between exchange rates and interest rates. In addition, the performance of the model, which takes into account the varying correlation, was tested with data from six different Asian countries. Wang and Thi (2007) used a conditional correlation model to dynamically detect the time-varying correlation between Taiwan and USA stock markets. Lanza et al. (2006) used a conditional correlation model to model the volatility of prices in oil markets. Lee (2006) used the dynamic conditional GARCH model to determine the relationship between inflation and production before the Second World War. The assumption of the time-varying correlation between the variables was established as the basis for the studies on detection. Sklar (1959) used the term copula to indicate the dependence between variables. It is based on a common marginal distribution of variables expressed by the copula method. Copula in the literature is a very powerful tool for modeling. The most basic feature underlying the copula function is related to the common distribution among the variables. The Copula method is very useful for determining the distribution of the marginal number for the assumption of normality and the n-dimensional joint distribution. In this way, the marginal distributions of a copula function can be multidimensional. It allows detecting the varying co-correlation volatility by combining it with the distribution over time and calculating the dependence between the variables. Due to its listed features, the copula method is used in modeling the portfolio distribution. stated that it can be used. In this study, MSE, AIC and BIC values were calculated to determine the most suitable copula family in modeling the dependence between the BIST electricity index and the dollar rate. As a result of these calculations, it was determined that the most suitable modeling was with Clayton according to MSE, and with Gumbel according to AIC and BIC.

3. SKLAR THEOREM

The theorem at the beginning of this chapter is central to the theory of the copula. The theorem that relates the multivariate distribution functions and their one-variable marginal distribution functions is called the sclar theorem. Let $H(x,y)$ be a common distribution function with marginals $F(x)$ and $G(y)$. For each x,y ϵ $\overline{\mathrm{R}}$

$$H(x,y) = C(F(x), G(y))$$

It has a C copula. This equation can be converted to an equation expressing the copula using the inverse of the common distribution function and marginal distribution functions. But if the marginal distribution function is not strictly increasing, the function cannot be inverted. In this case, the quasi-inverse concept will be examined.

3.1. Semi-Inverse Function

Let F be a distribution function.

i) If t F is member of the value set of F, then $F_{(t)}^{-1}$ is equal to any value of x in $\overline{\mathrm{R}}$ such that $F(x) = t$

$F(F_{(t)}^{-1}) = t$

ii)If t is not in the value set of F

$F_{(t)}^{-1} = ebas\{x \backslash F(x) \geq t\} = ek\ddot{u}s\{x \backslash F(x) \leq t\}$

If F is a strictly increasing function, then F has only one known semi-inverse. This is shown as F^{-1}, which is known as the inverse of F (Nelsen, 1999).

Common distribution function $H(x, y)$ with marginals $F(x)$ and $G(y)$ and C

Let $H(x, y) = C(F(x), G(y))$ be a copula function. Let F^{-1} and G^{-1} F ve G be semi-inverses of F and G, respectively. Then for any (u, v) in the domain of C'

$C'_{(u,v)} = H(F_{(u)}^{-1}, G_{(v)}^{-1})$

3.2. Frechet - Hoeffding Limints

Suppose we have any variable m with its univariate marginals. Let the distribution function $F(y_1, y_2, \dots, y_m)$ and its marginals be in the range $F_1, F_2, \dots, F_m$ $[0,1]$.

If we denote the Frechet-Hoeffding lower and upper bounds with F_u and F_v

$F_u(y_1, y_2, \dots, y_m) = max\ [\sum F_{j-m+1,}\ 0] = W$

$F_v(y_1, y_2, \dots, y_m) = min\ [F_1, F_2, \dots, F_m] = M$

$W = max[\sum F_{j-m+1,}\ 0] \leq F(y_1, y_2, \dots, y_m) \leq min[F_1, F_2, \dots, F_m] = M$

In the case of univariate marginals, in the term Frechet - Hoeffding class, m denotes the class of variable distributions$F(F_1, F_2, \dots, F_m)$ marginals are constant and given. (F_{12}, F_{13}) refers to the classes $F(F_{12}, F_{13}, F_{23})$ when it is bivariate or given in higher dimension.
More precisely, the Frechet-Hoeffding lower bound copula is smaller than any copula, and the Frechet-Hoeffding upper bound copula is greater than any copula.

3.3. Survival (Life) Copula

Whether the random variables of interest represent the lifetimes of individuals or objects in a heap, the probability that an individual or object will live longer than x time is called the survival function or life function (or reliability function).

$\bar{F}(x) = P[X > x] = 1 - F(x)$

form is also displayed. The value range is $[0, \infty)$. Survival function for pair of random variables (X, Y) with common distribution function H

$\bar{H}(x, y) = P[X > x\ , Y > y]$ is expressed in the form.

$\bar{H}(x, y) = 1 - F(x) - G(y) + H(x, y)$

$= \bar{F}(x) + \bar{G}(y) - 1 + C\big(F(x), G(y)\big)$
$= \bar{F}(x) + \bar{G}(y) - 1 + C(1 - \bar{F}(x), 1 - \bar{G}(y))$

It is written in the form. $\hat{C}: I^2 \to I$

$\hat{C}(u,v) = u + v - 1 + C(1-u, 1-v)$ survival function
$\bar{H}(x,y) = \hat{C}(\bar{F}(x), \bar{G}(y))$
The form is also obtained. $\hat{C}$ is the survival copula X and Y

4. THE PROPERTY OF SYMMETRY IN THE COPULA

The joint distribution function of X and Y is H, the marginal distribution functions are F and Let G be continuous random variables with capula C. If C(u,v)=C(v,u) for all (u,v) pairs in I^2, then the random variables X and Y are interchangeable, and C is simply called symmetric (Nelsen, 2006)

4.1. Archimedean Copulas

It was first put forward by Kimberling. Archimedes' copulas are very preferred as they provide us mathematical convenience and flexibility and are used to model the insufficiency structure between two variables.
This approach allows a multivariate capulan to be reduced to a simple univariate function. $C: [0,1]^2 \to [0,1]$ let's consider a bivariate capula.
$\varphi: [0,1] \to [0,\infty)$ let be a continuous, decreasing and convex function such that
$\varphi(1) = 0$
$u, v \in [0,1]$ for $C(u,v) = \varphi^{-1}\big(\varphi(u) + \varphi(v)\big)$

Your format can also be expressed. φ is called the generator of the gate C. For this, let's first define the function $\varphi^{(-1)}$

$\varphi: [0,1] \to [0,\infty)$ 'let a be a continuous, strictly decreasing function such that
$\varphi(1) = 0$. The function $\varphi^{(-1)}$,defined as the set of definitions of the inverse function of φ $[0,\infty)$ and the set of values [0,1] is as follows,

$$\varphi^{(-1)} = \begin{cases} \varphi^{(-1)}, & 0 \le t \le \varphi(0) \\ 0 \quad , & \varphi(0) \le t < \infty \end{cases}$$

the function $\varphi^{(-1)}$ and not increasing on $[0,\infty)$ and $[0,\varphi(0)]$ is the exact reduction on Moreover, in the range of [0,1], $\varphi^{(-1)}(\varphi(u)) = u$, and

$$\varphi\big(\varphi^{(-1)}(t)\big) = \begin{cases} t, & 0 \le t \le \varphi(0), \\ \varphi(0), & \varphi(0) \le t < \infty, \end{cases}$$

$$= min(t, \varphi(0))$$

Finally, if $\varphi(0) = \infty$, then $\varphi^{(-1)} = \varphi^{-1}$. (Nelsen, 2006)

Let C be an archimedean copula whose manufacturer is φ. The properties of archimedean copulas are given below.There:
i)Let $C(u,v) = C(v,u)$ be symmetric if and only if
ii) If u,v,w ∈ I, then $C(C(u,v),w) = C\big(u, C(v,w)\big)$ such that
iii) any constant c>0 is the generator of C' at c φ.

4.2. Some Archimedean Copulas

Ali-Mikhail-Haq Copula Family

$$C_\theta(u,v) = \frac{uv}{1-\theta\,(1-u)(1-v)}\,,\theta\,\epsilon\,[-1,1)$$

Where $\theta = 0$ and $C_\theta(u,v) = uv = \prod(u,v)$ forms the independence copula. This kapula also belongs to an Archimedean copula family.

It is the copula of the joint distribution function, the marginals of which have a standard logistic distribution, $\theta\,\epsilon\,[-1,1)$. As is known as the Ali-Mikhail-Haq copula, it is also known as the copula of the Gumbel bivariate logistics distribution.

Clayton Copula Family

The Clayton capula family is an asymmetric archimedean capula. The Clayton kapula is defined as follows:

$$C_\theta(u,v) = max([u^{-\theta} + v^{-\theta} - 1])^{-1/\theta}, 0)\,,\theta\,\epsilon\,[-1,\infty)\backslash\{0\}$$

Manufacturer function,

$$\varphi = \frac{1}{\theta}(t^{-\theta} - 1)$$

Where $\theta \to 0$, the $\lim_{\theta\to 0} C_\theta(u,v) = uv = \prod(u,v)$ forms the independence capula. It implies perfect dependence, while $\theta \to \infty$ (Nelsen, 1999).

Frank Copula Family

The Frank capula family is a symmetric Archimedean kapula. The Frank capula is defined as follows:

$$C_\theta(u,v) = -\frac{1}{\theta} In[1 + \frac{(e^{-\theta u}-1)(e^{-\theta v}-1)}{e^{-\theta}-1}], \theta\,\epsilon\,(-\infty,\infty)\backslash\{0\}$$

Manufacturer function,

$$\varphi(t) = -ln\frac{e^{-\theta t}-1}{e^{-\theta}-1}$$

Where $\theta \to 0$ iken, $\lim_{\theta\to 0} C_\theta(u,v) = uv = \prod(u,v)$ forms the independence copula. When $\theta \to \infty$, Frenchet-Hoeffding becomes equal to its upper limits.
The Frank capula family is preferred more than other capulas in practice because it allows negative dependence among marginals, unlike other capulas (Nelsen, 1999).

Gumbel Hougaard Copula Family

The Gumbel capula family is an asymmetric Archimedean capula. The Gumbel hood is defined as follows:

$$C_\theta(u,v) = \exp\{-[(-lnu)^\theta + (-lnv)^\theta]^{1/\theta}\}$$

Manufacturer function,

$$\varphi(t) = (-lnt)^\theta$$

with an increase in the parameter θ, the deciency between observations increases.
When $\theta \to 1^{+}$, that is, the $\lim_{n\to\infty} C_{\theta}(u,v) = uv = \prod(u,v)$ becomes equal to the independence capula. While $\theta \to \infty$, it shows perfect dependence (Joe,1997).

5. COPULA ESTIMATION METHODS

The problem of statistical modeling of kapulas is also studied in two stages:
i) determination of marginal distributions
ii) identification of the appropriate copula function (Cherubini et al., 2004).

The Exact Method of Maximum Likelihood (MLE) ve The Method of Inference on Marginals (IFM).

5.1. The Exact Maximum Likelihood Method (MLE)

Multidimensional density function,

$$f(x_1, x_2, \dots, x_n) = c(F_1(x_1), F_2(x_2), \dots, F_n(x_n) \prod_{j=1}^{n} f_j\,(x_j)$$

is also expressed.

Multidimensional capula function,

$$C(F_1(x_1), F_2(x_2), \dots, F_n(x_n)) = \frac{\partial^n C(F1^{(x1)}, F2^{(x2)}, \dots, Fn^{(xn)})}{\partial F1^{(x1)} . \partial F2^{(x2)} \dots \partial Fn^{(xn)}}$$

The order partial derivative, the c-capula density, and the fi's are univariate marginal probability density functions. We can trace the solutions of the statistical model problem of capulas in two steps as mentioned below:
i) determination of marginal distributions
ii) identification of the appropriate copula function.

let be our sample data matrix. From here, the log-likelihood function

$$l\,(\theta) = \sum_{t=1}^{T} ln\; c\;(F_1\,(x_{1t}), F_2(x_{2t}), \dots, F_n(x_{nt}) + \sum_{t=1}^{T}\sum_{j=1}^{n} In\; fj^{(x_{jt})}$$

It can be expressed as. Where θ is the set of all parameters related to the capula and the marginals. If the set of marginal probability density functions and the capula are known, it can be written to the log-likelihood function mentioned above, which maximizes this equality $\hat{\theta}_{MLE} = max\; l\;(\theta)$ the maximum likelihood estimator can be obtained. (Cherubini et al., 2004)

5.2. The Inference Method for Marginals (IFM)

Since it is not always possible to use the most likelihood estimation method or it requires very intensive calculations, the two-stage IFM estimation method is preferred in multivariate kapula estimation methods. These stages are:

Step 1: The parameters of the marginals were estimated by estimating the marginal distributions with a variable.

$$\theta_1 = ArgMax\theta_1 \sum_{t=1}^{T}\sum_{j=1}^{n} Iog\ fj^{(xjt\,;\,\theta 1)}$$

is also obtained.

Step 2: The obtained θ1 estimate is substituted into the log-likelihood function and the capula parameter θ_2 is estimated.

$$\theta_2 = ArgMax\theta_2 \sum_{t=1}^{T} ln\ c\ (F_1\ (x_{1t}), F_2(x_{2t}), \dots, F_n(x_{nt}); \theta_2, \theta_1)$$

This method is called the Inference Method for Marginals (IFM).
The estimator,

$$\hat{\theta}_{IFM} = (\theta_1, \theta_2)'$$

is also expressed.

IFM estimator can be calculated more easily than MLE estimator. Therefore, it will be easier to compare the asymptotic covariance matrices of the IFM estimator compared to the MLE estimator.

It is proved that IFM estimators, like MLE estimators, which gave the IFM estimator for the first time (joe, 1997), have the property of asymptotic normality under favorable conditions.

$$\sqrt{T}(\theta_{IFM} - \theta_0) \rightarrow\ N(0, G^{-1}(\theta_0))$$

Where $G(\theta_0)$ is the Godambe cognitive Matrix. ˪ Let the logability function . Here is the Skar fan

$$s(\theta) = (\frac{\partial l_1}{\partial \theta_{11}}, \frac{\partial\ l_2}{\partial \theta_{12}}, \dots, \frac{\partial l_n}{\partial \theta_{1n}}, \frac{\partial l_c}{\partial \theta_2})'$$

The Godambe information matrix is;

$$G(\theta_0) = D^{-1}V(D^{-1})'$$

Here,

$$D = E[\frac{\partial\ s(\theta)}{\partial \theta}]\ \text{ve}\ V = E[s(\theta)s'(\theta)]$$

Many derivative calculations are required for the estimation of this covariance matrix. (Joe, 1997), It has been stated that IFM method is very effective in comparing with MLE method (Cherubini et al.,2004).

6. Application

In this study, between 1.09.2015 and 01.09.2019, the electricity index of the Istanbul Stock Exchange and the dollar exchange rate received from the Central Bank were used. Here, an analysis has been made using the returns of the data. The return is calculated by the formula:

$$ln\left(\frac{P_t}{P_{t-1}}\right)$$

The following 3 methods were used in the selections of models for copulas:

- ❖ MSE (Mean Error Squared)
- ❖ AIC (Akaiki Information Criterion)
- ❖ BIC (Bayesian Information Criterion)

Mean Error Squared Criterion (MSE)

$$MSE = \frac{1}{N}\sum(F_{ei} - F_i)^2$$

$F_{ei}: Empirical\ \ Probability$

$F_e: Theoretical\ Probability$

$N: Number\ of\ \ Observations$

Akaiki Information Criterion (AIC)

The Akaiki Information Criterion is one of the measures of goodness of fit that is often used in practice.

$$\mathrm{AIC} = 2\mathrm{k} - 2\ln(\mathrm{L})$$

- k is the number of parameters in the model,
- ln L the log likelihood value of the model

shows.

When choosing a model, the smallest AIC value is preferred.

Bayesian Information Criterion (BIC)

Bayesian Information Criterion is another measure of goodness of fit that is mostly used in practice.

$$BIC = k\ln(N) - 2\ln(L)$$

• k is the number of parameters in the model
• ln(L), the likelihood value of the model
• N is the sample size.
Descriptive statistics are given in Table 1.

Table 1. Descriptive statistics are given in Table 1.

DESCRIPTIVE STATISTICS

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
BIST_elektrik	996	-,097030	,070207	,00028637	,014312605	-,476	,077	3,762	,155
USD	996	-,064757	,147066	,00068965	,010509434	3,197	,077	47,399	,155
Valid N (listwise)	996								

The graphs of BIST Electricity Index and USD Logarithmic Difference Series are given below.

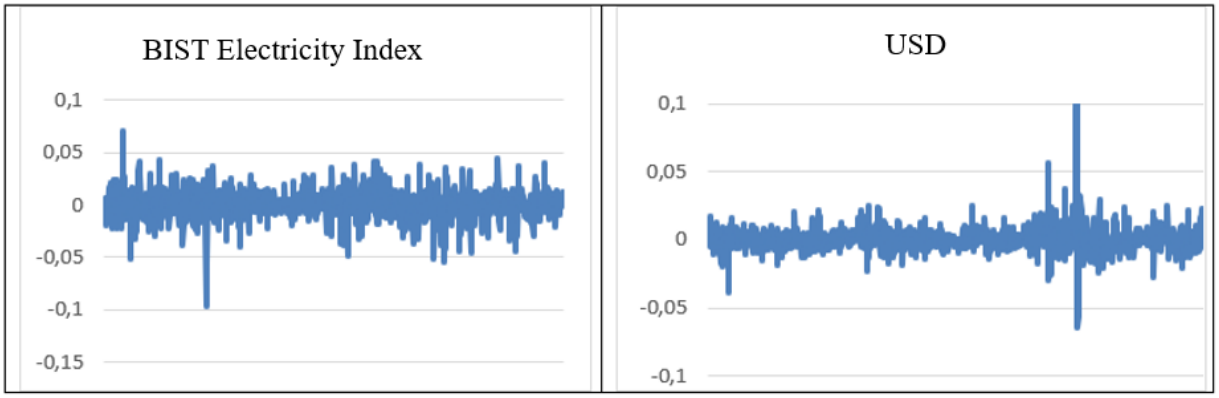

Figure 1. BIST Electricity Index and USD Logarithmic Difference Series

AIC, BIC and MSE values are given in Table 2. According to the results given in Table 2, it was determined that the most suitable modeling according to MSE could be done with Clayton, and the most suitable modeling according to AIC and BIC could be done with Gumbel.

Table 2. AIC, BIC and MSE values

	$\widehat{\theta}$	LL	AIC	BIC	MSE
Frank	-0.2489	-0.8433	3.6866	8.5903	0.000062362
Clayton	-0.0110	-0.0695	2.1390	7.0427	**0.000013402**
Gumbel	0.9987	-0.0103	**2.0206**	**6.9243**	0.000159600

AIC, BIC and MSE values are given in Table 2. According to the results given in Table 2, it was determined that the most suitable modeling according to MSE could be done with Clayton, and the most suitable modeling according to AIC and BIC could be done with Gumbel. Frank, Clayton and Gumbel BIST Electricity Index and USD Distribution Diagram are given in Figure 2.

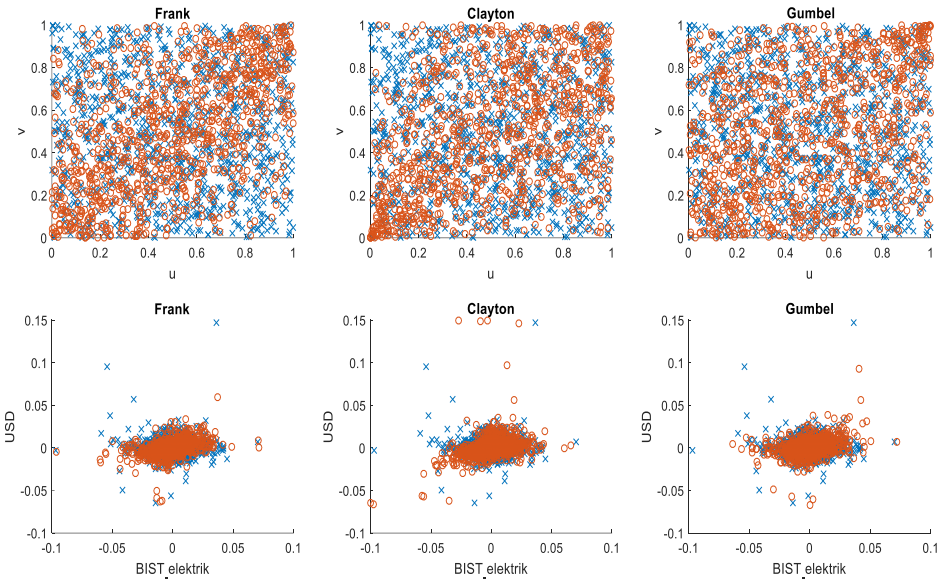

Figure 2. Frank, Clayton, and Gumbel BIST Electricity Index and USD Scatter Diagram

RESULT

In this study, the applications of the theory of copulas in finance are discussed. For this reason, Frank, Clayton, and Gumbel copulas used especially in finance have been examined. In addition, the properties of Archimedean copulas, which are the most important class of capsules, were examined and their advantages over the dependence measure were emphasized. In the application part of this study, to determine the most appropriate scapula family in modeling the dependence between the BIST electricity index and the dollar exchange rate, the following calculations were performed: MSE, AIC, and BIC. In the results of these calculations, it was determined that the most appropriate modeling according to MSE is with Clayton, and according to AIC and BIC, it is with Gumbel.

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RESEARCH ARTICLE

Analysis of The Factors Affecting The Profitability of Banks In Turkey By Lasso Regression

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Abstract

In the article examining the factors affecting the profitability indicators of the banking sector, which has a large share in the financial sector in Turkey, the analysis of the factors affecting the return on assets and return on equity ratios of the top 10 deposit banks in 2020, ranked according to their asset size in 2020, was made with the lasso regression method. As a result of the analysis, separate models were established for return on assets and return on equity. Among the independent variables, only the deposit variable was excluded from the model and it was seen that the effect on profitability was not as much as the variables of securities portfolio, equity, NPL ratio, asset share, inflation and gross domestic product.

Keyword

Profitability in Banking, Return on Assets, Return on Equity, LASSO regression method

1. INTRODUCION

Banks, whose main task in the financial sector is to carry out financial intermediation transactions between fund suppliers and fund demanders, have an important share in the financial sector. Banks working for profit, like many financial institutions, play an important role in the smooth running of the economy in the transactions they make for this purpose, while ensuring the stable functioning of the financial structure. Interpreting the profitability indicators of banks that provide information about the state of the financial structure in Turkey and in the world; It provides general information about the financial sector.

As of the end of 2020, the share of banks in the financial sector in Turkey is over 90 percent. For this reason, the profitability indicators of the banks examined in Turkey should not be seen only as a sectoral size, but rather as a sector in which the changes in the country's economy can be monitored due to its large share in the financial sector.

Among the profitability indicators in the article, return on equity (ROE) and return on assets (ROA) variables were selected as dependent variables, and the effects of the variables of securities portfolio, deposit, equity,

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NPL ratio, asset share, inflation and gross domestic product were examined. LASSO regression method was used in the analysis part of the article. When we look at the literature, it has been seen that more than one study has been done on the profitability of banks, it has been observed that panel data analysis and regression methods are used more in the analyzes, while LASSO regression method is not used as widely as panel data analysis.

In the article, the data of the top 10 deposit banks with the largest asset size as of December 2020, from the banks in Turkey between the years 2011-2020 were obtained. The application results were obtained and interpreted using the R programming language.

According to Article 3 of the Banking Law No. 5411, banks; It is divided into 3 as Deposit Banks, Development and Investment Banks and Participation Banks. Banks are supervised and regulated by the Banking Regulation and Supervision Agency (BRSA).

Financial statements are the tables in which the transactions of commercial enterprises in a certain period are monitored. Financial statements; It consists of balance sheet, income statement, cash flow statement and statement of changes in equity. The data to be used for the article are taken from the income statements and balance sheets of banks.

The balance sheet is the tables that show the financial situation of the banks in a certain period. In the banks balance sheet, the assets and resources of the bank are accounted for in accordance with their fair values under active and passive accounts (Akgüç, 2011). Active accounts include the bank's receivables, passive accounts include equity and the bank's debts, which consist of foreign resources. Bank balance sheet is based on the principle that active and passive accounts are equal to each other (Takan, 2001). Loans in active accounts are among the items with the largest share in the banks balance sheet. Foreign resources (syndication loan, etc.) are mainly used as a source of funds in passive accounts, apart from the shareholders' equity (Tunay, 2005).

Income statement, on the other hand, is the financial statement that shows the income of the bank within an operating period (usually 1 year) and the expenses, costs and profits or losses they have obtained as a result of their activities. The income statement, which expresses the accounting equivalent of net income, shows the summary of the bank's performance (Takan, 2001). The main items that make up the income statement are interest income-expenses, non-interest income-expenses and net profit for the period. Interest income-expenses, the interest paid by the banks on their deposits and debts and the interest income they receive from the loans they extend, the income part of the non-interest income-expenses; net fees and commissions, foreign exchange income, expense from money market and capital market transactions; personel expenses, provisions, foreign exchange expenses consist of tax and depreciation expenses, and the net profit for the period consists of the sum of the items that have been counted in general terms. Net profit for the period is one of the most important profitability indicators showing the profit obtained as a result of the activities of the bank in an operating period.

Financial statements of banks are disclosed to the public quarterly. Financial statements disclosed to the public cause competition among banks. The resulting competition enables banks to diversify their products, see the effects of efficient use of resources on their performance, and evaluate their own performance within the sector.

Profitability is an indicator of the success of an enterprise in carrying out its activities. The main purpose of banks and financial institutions is to make a profit, as in other enterprises. Making a profit is very important in order to sustain the existence of banks, increase their market value and meet the expectations of their shareholders. Profitability in banking, on the other hand, expresses the profits of the banks in a certain period as a ratio, not as an amount (İskenderoğlu et al., 2012). Profitability rates are calculated on the basis of the financial statements (income and balance sheet) announced by the banks. Some ratios are calculated by taking related items and some ratios are calculated by bringing together the relevant amounts. (Akguc, 2011). Profitability indicators used as dependent variable in the article; return on assets (ROA) and return on equity (ROE).

Return on assets is an indicator of how effectively the assets used by the bank in its activities are used and how much return is obtained on the assets. It is accepted as an efficiency criterion that informs the

shareholders of the banks about the management efficiency of the bank they are a shareholder of (Şıklar, 2004). The formula for return on assets:

$$\text{ROA} = \frac{Net\ Profit\ For\ The\ Period}{Average\ Total\ Assets} \quad (1)$$

Return on equity shows the degree of profitability of the capital in the bank, it is a performance criterion that measures the return on the investment they make, in other words, maximizing the profit, which is the main goal of the bank's shareholders (Şıklar, 2004). The formula for return on equity:

$$\text{ROE} = \frac{Net\ Profit\ For\ The\ Period}{Average\ Total\ Equity} \quad (2)$$

2. LITERATURE

Yıldırım et al. (2021), applied LASSO (Least Absolute Shrinkage and Selection Operator) regression, LARS regression and multiple linear regression models from penalized regression models to the dataset of 442 patients diagnosed with diabetes. As a result of the analysis of LASSO regression and LARS regression, it was seen that the same variables were found to be significant and had a higher R2 and mean square error than the multiple linear regression model.

With the LASSO method seen in the Financial Stability Report published by the CBRT in May 2020, it was investigated whether the variables on the credit default swap (CDS) were significant in the model. In the research, it was seen that the effect of exchange rate, exchange rate changes, GDP ratio, VIX index, indebtedness rate of financial institutions, foreign exchange reserves, loan interest rate, foreign exchange reserves, dollar and local currency interest difference on CDS. Since the downward movement of the risk premium is known to have a positive effect on profitability, it has been taken into account in the study while scanning the literature.

While it is seen that multiple regression method and panel data analysis method are used when examining the data explaining profitability in banking in the studies in the literature, it is seen that LASSO regression is not used as widely as panel data analysis in economic data. When we look at the studies on LASSO regression, it is seen that this method is mostly used in the analysis of data related to health sciences and in studies on machine learning, but it has not been encountered as often as in other study areas in the analysis of economic data. The use of the LASSO regression method in the article offers an alternative to the other analyzes in terms of using the LASSO regression method in economic data.

3. MATERIAL AND METHOD

The data used in the article; It is the year-end data included in the financial statements of banks announced to the public as of 2011 - 2020. The banks subject to the analysis are the top 10 deposit banks with the largest asset size as of the end of 2020. The data of the variables were obtained from the financial statements of the banks and the information on the websites of the CBRT, BRSA, TURKSTAT and The Bank Association of Turkey.

In the application part of the article, the LASSO regression method, which has a lower estimation error compared to other regression methods and makes the selection of the variable at the same time while analyzing the independent variables that explain the dependent variables, is seen to be more successful than the least square method, ridge regression method and panel regression method. Evaluation was made in the conclusion part. The R program was used while performing the LASSO regression method analysis.

4. LASSO REGRESSION METHOD

LASSO (Least Absolute Shrinkage and Selection Operator) regression method is a regression method that reduces the non-significant coefficients in the model towards zero and provides meaningful variables. The method was first introduced by the statistician "Robert Tibshirani" in 1996, by using punishment in model selection in the field of geophysics, and was later developed.

In the LASSO method, by using the penalty term in the L1 norm, the regression coefficients are reduced. Among the shrinking variables, there are also independent variables with a zero coefficient. These variables with zero coefficients are excluded from the model and the independent variables that explain the dependent variable in the model remain. In the LASSO method, by excluding the variable that is not suitable for the model, variable selection is made at the same time. Thanks to the excluded variable or variables, it becomes easier to interpret the model as the variables that better explain the model remain in the model. (Kayanan et al.,2019)

In the regression analysis, while all variables remained in the model, forward selection, backward selection and stepwise selection methods were used before the LASSO method was used. Since these methods do not take into account the relationship of the variables with each other, they cause misleading estimations. In the LASSO regression method analysis, the significant variables explaining the dependent variable remain in the model. With this feature, it has been seen that the LASSO method, which helps in the estimation of the regression coefficient and the selection of the compatible variable to be included in the model, is more successful than the ridge regression method when the number of observations is larger than the number of independent variables and the independent variables are related to each other. (Zou and Hastie, 2005).

In the LASSO method, the LASS estimator is reduced by the penalization method to obtain a smaller mean of variance and error squares. The variables to be included in the model are standardized and the transformation is made so that the mean is 0 and the variance is 1.

Penalized function for linear regression method:

$$Q_N = \left(y_i - \sum_j x_{ij}\beta_j \right)^T \left(y_i - \sum_j x_{ij}\beta_j \right) + \lambda \sum_{j=1}^{p} |\beta_j| \qquad (3)$$

When it is desired to make parameter estimation and variable selection from this objective function,

$Q_N = -lnL(\boldsymbol{\theta}) + \lambda \, \Sigma \, |\beta j|$

The likelihood function in the form is minimized and used for parameter estimation and variable selection.

$\sum_{j=1}^{p} |\beta_j|$: L1 norm penalty term

λ: setting parameter ($\lambda > 0$)

$\boldsymbol{\theta}$: parameter vector

$lnL(.)$: log-likelihood function

The LASSO method equation was developed with the aim of minimizing the mean squared error by forcing the sum of the absolute values of the regression coefficients to be less than a fixed value. The λ value is the parameter that adjusts the shrinkage of the coefficient estimates. If λ=0, the equation becomes the same as the classical regression method model estimator, the EKK method, while the model turns into a multiple

regression model. (If λ is large, it means that all units are penalized, and small means that penalization is not done much.)

LASSO regression method is also included in machine learning algorithms. In machine learning, an inference is made from the data consumed and prediction results are obtained. A high λ causes over-learning, i.e. memorizing the data on the training data in the used model, resulting in success only on that data, while a λ of 1 causes all variables to be excluded and the bias to increase due to the low coefficient values. In this case, incomplete learning, that is, the model used does not fit the training data and the model is not suitable for new data. In overlearning, the model has high variance and low side, while incomplete learning has low variance and high side. LASSO regression method used to obtain the highest efficiency with the least variable; It increases the quality of the trained data by finding the best λ value describing the model and making coefficient estimations with the best λ found, and ensures that the coefficients of the most significant variables remain in the model.

5. ANALYSIS

5.1. Variables Used in the Scope of Analysis and Their Definitions

The variables used within the scope of the analysis belong to the top 10 deposit banks, which have the highest share in the banking sector as of the 4th quarter of 2020, among the banks in Turkey. The data on the variables were obtained from the financial statements of the banks, which were announced to the public, and from institutions such as TURKSTAT and CBRT between the years 2011-2020. Variables taken from banks balance sheets are called microeconomic variables, and economic variables that are not determined by banks that are not included in banks' balance sheets but affect the performance of financial institutions are called macroeconomic variables.

Table 1: Banks included in the analysis

The Name Of The Bank			
1	T.C. Ziraat Bankası A.Ş.	**6**	Yapı ve Kredi Bankası A.Ş.
2	Türkiye İş Bankası A.Ş.	**7**	Türkiye Vakıflar Bankası T.A.O.
3	Türkiye Garanti Bankası A.Ş.	**8**	QNB Finansbank A.Ş.
4	Akbank T.A.Ş.	**9**	Denizbank A.Ş.
5	Türkiye Halk Bankası A.Ş.	**10**	Türk Ekonomi Bankası A.Ş.

Table 2: Variables included in the study

		Variables	**Ratios Taken For Analysis**
Dependent Variales	**Micro Variables**	Return on Assets	(Net profit for the period / Average total assets) (ROA)
		Return on Equity	(Net profit for the period / Average total equity) (ROE)
Independent Variales		Securities Potfolio	(Securities portfolio / Total assets) (SP)
		Deposit	(Total deposits / Total assets) (DEP)
		Equities	(Total equity / Total assets) (EQU)
		Asset share	(Bank's assets / Total assets) (AS)
		NPL ratio	(Non-performing loans (Gross) / Total loans) (NPL)
	Macro Variables	Inflation	Inflation (INF)
		Gross Domestic Product	Gross domestic product quarterly growth rates (GDP)

The dependent variables used in the application are the performance indicators of the banks.

- Return on Assets (ROA)
- Return on equity (ROE).

Among the independent variables used in the analysis, microeconomic variables specific to the bank are equity, deposits, NPL ratio, securities portfolio and asset share, while macroeconomic variables are inflation

and gross domestic product. Microeconomic variables taken from banks' balance sheets were made suitable for analysis by dividing each variable by total assets due to the size of the amounts in the financial statements. Macroeconomic variables were included in the analysis by taking annual percentage rates.

While the data obtained from various sources were obtained, the dependent variables of microeconomic variables, return on assets and return on equity, were used by annualizing according to the end of the year, while the amounts valid as of the end of the year were taken into account in the independent variables. The descriptions of the variables used in the application are as follows:

Return on Assets (ROA): It is a ratio showing the profit from the bank's assets. It is one of the important profitability indicators as it gives information about the effective use of the assets of the banks.

Return on Equity (ROE): It is a ratio showing the profit obtained from the equity of the bank. It is one of the important profitability indicators as it gives information about the efficient use of banks' equity and is also used to measure the return on capital of the bank's shareholders.

Assets: These are the total assets of the bank.

Equity: It is included in the bank's resources and refers to the resources provided by the bank's partners. It is a source that shows the soundness of the bank in times of crisis.

Deposit: These are the funds that the bank receives from the savers.

Credit: It is the purchasing power provided by the bank to real or legal persons, provided that they are bought back.

Non-performing loans: Loans are classified as non-performing loans if the loan payments given to real or legal persons exceed 90 days. While the ratio of non-performing loans gives information about the solvency of the persons or institutions to which the loan is given, it also gives information about the asset quality of the bank.

NPL ratio: It shows the rate of return of the loans provided by the banks. (Sarıtaş et al.: 2016)

Securities Portfolio: It consists of government debt securities, and other papers (bonds, bills...).

Inflation: It expresses the increase (decrease) in the general level of prices.

Gross Domestic Product (GDP): It is the market equivalent of the products produced within the borders of the country in a certain time period.

While analyzing, the explanatory variables of return on assets and return on equity, which are profitability indicators, were examined within the scope of the model. LASSO regression method was applied for the created model and the best variables explaining the dependent variables, return on assets and return on equity, were obtained in the analysis. The interpretation of the variables was made according to the results of the analysis.

5.2. LASSO Regression Analysis

During the application, the dependent variables were modeled separately. Before starting the application, in order to obtain unbiased and consistent results, the distribution tables of the variables explaining both dependent variables, correlation analysis table, and assumption tables were examined separately in accordance with the LASSO regression method. The change distribution of the microeconomic and macroeconomic independent variables specific to banks used in practice by years is as follows.

Models:

$$ROA = \ y_i + \beta_1 SP + \beta_2 DEP + EQUoz + \beta_4 AS + \beta_5 NPL + \beta_6 INF + \beta_7 GDP + \mathcal{E}_{it}$$

$$ROE = \ y_i + \beta_1 SP + \beta_2 DEP + \beta_3 WQU + \beta_4 AS + \beta_5 NPL + \beta_6 INF + \beta_7 GDP + \mathcal{E}_{it}$$

Descriptive statistics:

Table 3: Descriptive statistics of variables in the LASSO regression method

	ROA	ROE	SP	DEP	EQU	AS	NPL	INF	GDP
Minimum	0,06	0,23	0,06	0,48	0,06	0,03	-0,03	0,25	0,13
Maximum	0,16	0,54	0,43	0,68	0,15	0,19	0,07	0,45	0,22
1. quarter	0,11	0,34	0,12	0,55	0,10	0,05	0,03	0,29	0,14
3. quarter	0,13	0,42	0,19	0,60	0,12	0,14	0,06	0,35	0,17
Mean	0,12	0,38	0,16	0,57	0,11	0,10	0,04	0,32	0,16
Median	0,12	0,38	0,15	0,57	0,11	0,11	0,05	0,31	0,16
Variance	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Standard Deviation	0,02	0,06	0,06	0,04	0,02	0,04	0,03	0,06	0,02
Skewness	-0,31	0,22	1,56	0,41	-0,10	-0,19	-1,20	0,85	0,64
Kurtosis	0,22	0,83	4,34	-0,35	-0,08	-1,17	0,73	0,00	-0,17

Table 4: Correlation matrix for the variables in the LASSO regression method

	ROA	ROE	SP	DEP	EQU	AS	NPL	INF	GDP
ROA	100%								
ROE	89%	100%							
SP	26%	28%	100%						
DEP	-10%	1%	11%	100%					
EQU	56%	15%	7%	-19%	100%				
AS	24%	17%	63%	-11%	17%	100%			
NPL	-13%	-14%	4%	6%	-12%	0%	100%		
INF	-24%	-14%	-19%	3%	-15%	-3%	-29%	100%	
GDP	13%	-5%	4%	9%	52%	-3%	-2%	33%	100%

In the correlation analysis table; It is seen that the highest positive relationship among the variables is between ROA and ROE variables with 89%, and the lowest negative relationship is between inflation variables with -24%. When the relationship of ROA, which is one of the dependent variables subject to the analysis, is examined, it is seen that it has the highest positive relationship with the equity variable with a rate of 56% and the lowest relationship with the inflation variable with a rate of -24%. When the relationship between ROE, which is the other dependent variable, is examined, it is seen that it has the highest positive relationship with the securities portfolio with a rate of 28%, the lowest relationship with the NPL ratio and inflation variables with a rate of 14%.

5.3. Assumptions

In practice, the variables affecting the profitability of deposit banks, which were among the top 10 banks in Turkey as of 2020, were analyzed using the LASSO regression method. The ratios obtained from the financial statements of the year-end data between the years 2011-2020 were used. For the LASSO regression method; It was seen that the data did not provide the assumptions. In order to eliminate the problem in the data, the square root transformation was applied to the dependent variables, return on assets (ROA) and return on equity (ROE), and the independent variables, the inflation variable, and the analysis continued. The test values obtained as a result of the analyzes are as follows.

5.3.1. Assumptions for LASSO Regression Analysis

For LASSO regression analysis assumptions, normality, autocorrelation and varying variance assumptions, which are the assumptions used to determine the suitability of the data for analysis in the regression equation, were examined separately for the dependent variables return on assets and return on equity. The null hypotheses of the assumptions to be tested for return on assets and return on equity are as follows:

H_0: There isn't autocorrelation problem.

H_0: The model provides the assumption of normality.

H_0: There isn't problem of changing variance.

Table 5: Assumption test values for return on assets

ROA								
Assumptions	**Test Name**							
Autocorrelation Test	**VIF**	mdc 1,98	mev 1,14	oz 2,11	akpay 1,99	tdo 2,19	enf 1,78	gdp 1,21
Normality Test	**Shapiro-Wilk Testi**	0,19						
Heteroskedasticity	**Breusch-Pagan Testi**	0,21						

Table 6: Assumption test values for return on equity

ROE								
Varsayım	**Test Name**							
Autocorrelation Test	**VIF**	mdc 1,98	mev 1,14	oz 2,11	akpay 1,99	tdo 2,19	enf 1,78	gdp 1,21
Normality Test	**Shapiro-Wilk Testi**	0,07						
Heteroskedasticity	**Breusch-Pagan Testi**	0,11						

In the regression analysis, the assumption, also known as the autocorrelation or multicollinearity problem, was tested with the VIF values, which are the variance inflation factors. The fact that the VIF values used to measure the relationships of the independent variables with each other are greater than 10 indicates the existence of an autocorrelation problem. Looking at the test results, it was seen that the test values of the variables were less than 10, so there was no autocorrelation problem. When the normality test and the varying variance tests were examined, it was seen that their values were greater than the significance value of α=0.05. The test values being greater than α=0.05 significance level means that the null hypotheses cannot be rejected. Considering the undeniable hypotheses and the VIF coefficient, it is seen that the variables are normally distributed and they do not have the problem of varying variance and autocorrelation.

5.3.2. Model selection and estimation results for the LASSO regression method

In the LASSO regression method, the most suitable variables for the model are found by the penalization method as a result of the analysis. The selection of models to be found separately for ROA and ROE variables is as follows.

Table 7: LASSO regression method estimation results

Variables	Coefficients of ROA	Coefficients of ROE
Intercept	0,07	0,28
SP	0,09	0,26
DEP	0,00	0,00
EQU	0,67	1,03
INF	-0,05	-0,05
GDP	-0,12	0,80
NPL	-0,04	-0,01
AS	-0,09	-0,47
R Square	**0,90**	**0,96**
Best Lambda Value	**0,001**	**0,005**

For ROA and ROE dependent variables according to the LASSO regression method, when the independent variables used in the application explain the model, it is seen that the independent variables in the model explain the ROA model by 90% and the ROE model by 96%. The most suitable lambda values for the models are 0.001 for ROA and 0.005 for ROE. While choosing the model, a selection was made by considering the a priori expectations (all the independent variables used in the application to be meaningfully included in the model) and the most appropriate lambda values.

In the LASSO regression method, the coefficients of the variables that do not explain the model as significantly as other variables are reduced to 0 and removed from the model. Considering the compatibility of the independent variables with the model according to the estimation results of the models established for profitability, it is seen that the coefficient of the deposit variable, which is one of the explanatory variables for the models of ROA and ROE variables, is 0. In this case, it is seen that the deposit variable does not explain the model as well as the other variables, and the model continues with the SP, EQU, INF, GDP, NPL and AS variables other than deposits.

When the variable coefficients for two different models are examined, it is seen that while the relationship between the dependent variables and the dependent variables is the same, except for the GDP variable, only the GDP variable has a negative relationship with the ROA variable and a positive significant relationship with the ROE variable.

In the ROA model, it is seen that the variables other than the DEP variable remained in the model. While the relationship between SP and EQU variables and ROA is positive, the relationship between INF, GDP, NPL and SP variables and ROA is negative and statistically significant. Looking at the coefficients in the model, it is seen that a one-unit change in the independent variables of EQU and GDP are the variables that will affect ROA the most positively and negatively, respectively.

In the ROE model, it is seen that the variables other than the DEP variable remain in the model. There is a positive relationship between SP, EQU and GDP variables and ROE, and a negative and statistically significant relationship between INF, and SP variables and ROE. Looking at the coefficients in the model, it is seen that a one-unit change in the independent variables of EQU and SP are the variables that will affect ROE the most positively and negatively, respectively.

While there is a positive relationship between the SP variable, which expresses the financial assets of the banks, and ROA and ROE, it is seen that the ROE variable is more affected by the SP variable and will be more positively affected by the changes that will occur in the securities. As of 2011, due to the decrease in the demand for GDDS (Government Debt Securities), the decrease in the share of SP in the balance sheet, together with the increase in the demand for credit usage and the financing of the public finance deficit with money market instruments such as bonds and bills, have a positive contribution to profitability.

When the DEP variable, which expresses the deposits of the banks, is examined, it is seen that the ROA and ROE variables are not included in the models. Considering the DEP variable, when the pressure of the interest given to the deposit on the profitability of the bank is taken into account, it is seen that the

profitability affects negatively and when it is considered together with the other independent variables in the model, the DEP variable is the variable that is excluded from the variables that explain the model.

It is seen that the EQU variable, which expresses the equity of the banks, is the independent variable that affects the ROA and ROE variables positively. It is seen that the positive effect seen in the balance sheet has a positive effect on profitability, with the reflection of the positive effect on the income statement due to the fact that the strong capital structure increases the usage area of the equity capital within the legal restrictions in the transactions made by the bank.

There is a negative relationship between the NPL variable, which expresses the NPL ratio of the banks, and the ROA and ROE variables. The increase in the NPL variable indicates an increase in cases where banks do not take their loans on time or do not take them at all, considering the significant ratio of loans extended to customers in the balance sheet. It is seen that it has a negative effect on profitability as it significantly affects the asset quality of banks and causes the asset-liability balance to deteriorate.

It is seen that there is a negative relationship between the AS variable, which expresses the share of banks in the banking sector, and the ROA and ROE variables in the article. The fact that the AS variable has a negative effect on profitability shows that the profitability of banks varies depending on the transactions they make and the effective use of these transactions, not economies of scale.

It is seen that the inflation variable, which is one of the macroeconomic variables that affect the profitability of banks, is negatively related to ROA and ROE variables, and it affects both dependent variables negatively at the same rate. It is considered that the negative effect of the INF variable is due to the negative effects of the increase in the general level of prices, such as the increase in borrowing costs, financial uncertainty and dollarization, and the deterioration of the asset-liability balance on the profitability of the banks.

There is a negative relationship between the GDP variable, another macroeconomic variable that affects the profitability of banks, and the ROA variable, and there is a positive relationship with the ROE variable. Looking at the GDP variable, the changes in the balance sheets of banks with the increase of the GDP variable are not the same in the ROA and ROE models, the ROE variable is more sensitive than the macroeconomic variable GDP, the positive contribution of growth while increasing the macroeconomic activities and stability makes a positive contribution to the ROE variable and positively affects the profitability. It is seen that negative effects such as increasing cost and decreasing demand have a negative effect on the ROA variable and have an effect on the profitability not increasing as expected.

6. CONCLUSION AND EVALUATION

In the article, the factors affecting the profitability of the top 10 deposit banks, which are in the banking sector, which has a large share in the financial system in Turkey as of December 2020, and selected according to their asset size as of December 2020, between 2011 and 2020 are examined. Securities portfolio, deposit, equity, NPL ratio, asset share, inflation and gross domestic product data were used as independent variables for profitability, which was examined through the return on assets and return on equity criteria.

While obtaining the results, separate models were established for the dependent variables, return on assets and return on equity, and while analyzing the model to see the effects of the independent variables on the dependent variables, the LASSO regression method, which excludes the variables with the penalization method and leaves the best independent variables in the model, was used.

In the LASSO regression method, the deposit variable was excluded from the models. In terms of the relationship of the coefficients, it is concluded that the GDP variable is negatively related to the return on assets, positively related to the equity variable, and the coefficients of the other independent variables with different values are in the same direction in both models.

In the LASSO regression method, it was concluded that the EQU and GDP variables affected the most in the ROA model, the EQU and GDP variables affected the most in the ROE model, and the SP the least.

In the LASSO regression method, the variables that reduce the significance of the model were examined and it was concluded that the absence of deposit variable in the model for the return on assets and return on equity variables would help in obtaining more meaningful estimations.

When the profitability in banking data is compared with the panel data analyzes in the literature, it is considered that almost all of the independent variables in the model are found to be significant, since no dummy variable is added to reduce the degree of freedom in the LASSO regression method and therefore there is no variable that restricts the acceptance region of the model.

As general evaluation; When the profitability indicators of banks are examined, it is seen that having a strong equity structure, solid asset structure and decrease in NPL have a positive effect on profitability. However, it is observed that the increase in gross domestic product and inflation, which are macroeconomic variables, creates a risk environment and accordingly causes an increase in uncertainty, thus having a negative effect on profitability. In this situation, where profitability is adversely affected due to the decrease in demands as a result of prudence, banks should take action especially considering the problems that may arise in macroeconomic conditions. In this case, it is considered that the operational studies carried out by the internal systems of the banks to protect and move forward the current situation against the risks that may arise will contribute positively to the profitability of the banks.

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