JLECON

JOURNAL OF LIFE ECONOMICS

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E-ISSN : 2148-4139
DOI : 10.15637/jlecon

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ISSUE 3

VOLUME/CİLT: 10
YEAR/YIL: 2023

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Volume/Cilt: 10
Issue/Sayı: 3
Year/Yıl: 2023

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Journal of Life Economics

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Dergi; KIŞ (Ocak), BAHAR (Nisan), YAZ (Temmuz) ve GÜZ (Ekim) dönemleri olmak üzere yılda 4 sayı olarak yayımlanmaktadır.

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JLECON

Volume / Cilt: 10, Issue / Sayı: 3, 2023, pp. 127-140
E - ISSN: 2148-4139
URL: https://www.journals.gen.tr/jlecon
DOI: https://doi.org/10.15637/jlecon.2060

Received / Geliş: 13.04.2023
Acccepted / Kabul: 17.07.2023

RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

The impact of money supply on the real sector during the Covid-19 pandemic: Evidence from OECD countries

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Abstract

Declared as a pandemic on March 11, 2020, COVID-19 caused a "sudden stop" in the world economy, resulting in both supply and demand shock. Most of the countries responded by monetary expansion to tackle the global economic issue. In this study we aim to find the impacts of these economic policies during COVID 19 on global economy. Our sample includes 33 of OECD countries. We estimate the impact of monetary expansion on the real economy with a linear regression model. The results show that the monetary policy has positively and significantly impacted economic growth even after controlling for fiscal policies.

Keywords: Money Supply Shock, Health Crisis, Financial Markets, Real Economy, COVID-19, OECD countries

JEL codes: E44, I18, G01

Citation/Atıf: ALÇIN, S., HAMZAOĞLU, N. M., & ZAYİM, G. D. (2023). The impact of money supply on the real sector during the Covid-19 pandemic: Evidence from OECD countries. *Journal of Life Economics*. 10(3): 127-140, DOI: 10.15637/jlecon.2060

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1. INTRODUCTION

The Pandemic COVID-19 has generated a health crisis while posing a global threat to economic activity. The impact of Covid-19 on the economy was experienced precisely as a "sudden stop": a sudden stop in production and consumption and a rupture in supply chains. As a result, since the beginning of 2020, monetary expansion policies exceeding $ 20 trillion have been implemented by the central banks of developed countries.

While the Pandemic is a common problem facing all humans, the level of economic devastation seems heterogeneous across countries. All nations have taken action to cope with the Pandemic and mitigate the financial risks on their economies. We see several measures, including containment policies, improving R&D in the health system, financial supports for all businesses, households, and actions to preserve employment (OECD, 2020[a]). Globally, we have seen nationwide quarantine periods starting in developed countries (mainly EU countries) and extensions of the state of emergencies in many countries (IMF, 2020). The preliminary international reports highlight the fact that the impacts would not be the same across the economies. The potential impact of the Pandemic may be worse than an economic shock, and it can damage emerging economies and low-income countries more severely (World Bank, 2020). Even though the Pandemic spread had been slowing down in Summer 2020, we see a sharp increase in case number and deaths during the second wave. Starting from October 2020, many countries have restarted applying containment measures to control the spread of the virus. As the Pandemic spread, lockdowns have become mandatory to restore the health system. Thus, the COVID-19 outbreak alarmed OECD countries and force them to take emergency actions to support the economy due to temporarily frozen economic activities and income losses. Because of public health consideration, starting from December 2020, vaccination has started worldwide, mainly in developed countries.

On the economic front, several fiscal packages were adopted. We see similar financial supports for businesses such as tax payment deferrals (OECD, 2020[a]). In many countries, work schemes were designed for short-time in order to preserve employment. Different type of supports for households were implemented like direct cash transfers to low and middle-income households in US; expansion of the degree and the amount of income supports in EU; active monetary measures rather than fiscal packages in developing countries (OECD, 2020[a]). As a fast response expansionary monetary policies were quickly adopted by several Central Banks (CBs) at the beginning of the Pandemic. Additionally, Elgin et *al.* (2021) found that more independent CBs adopt smaller cuts and larger fiscal and macro-financial packages.

As the Pandemic has dynamically been affecting the global economy, it is essential to work on efficient policy responses on the Covid-19 in the near future. OECD reports that fiscal action can aid in stimulating the economy where it is necessary. Furthermore, the report proposes "*specific support for developing countries, including international coordination, financial support, and adaptation of tax rules"*; it states that all options, including public finance and CB actions, will be necessary to restore the economy (OECD, 2020[a]), not the way around.

Fewer number of studies focus on the monetary policies of OECD countries in COVID-19. On the other hand, OECD (2020[b]) published several policy briefs reporting member countries' new spending policies and immediate responses. Besides, studies are examining financial markets in specific countries, including OECD member countries. For instance, in Turkey, a limited number of studies analyze the impact of COVID-19 on the aggregate economy. We see Öztürk et *al.* (2020) conducting a sectoral analysis of the stock price index in the Pandemic. We see Çakmaklı et *al.* (2020) analyze sectoral supply shocks utilizing teleworking and physical job proximity and sectoral demand shocks with credit card purchases by conducting a SIR-multi-sector-macro model. Moreover, Kartal et *al.* (2020) discuss the main changes in the stock exchange index in Turkey during the Pandemic.

Given the immediate monetary actions of CBs to combat the Pandemic, our motivation, in this paper, is to provide an exploratory study that evaluates the effectiveness of money supply growth on the real economy. Our main reason for working with OECD data is the leading role of OECD countries in policy development. Furthermore, one of the OECD's main objectives includes "*establishing evidence-based international standards and finding solutions to a range of social, economic and environmental challenges*" (OECD). Therefore, OECD aims to provide an international standard for countries with different economic and geographical characteristics. Lastly, data availability can be problematic due to the dynamic nature of the Pandemic. For this reason, we chose OECD data sets as it offers researchers an opportunity to reach reliable data.

The structure of this study is as follows. The following section provides a literature review on monetary policies in a broad and wide range of studies focused on the economic impacts of COVID-19. Section 3 explains the data description, methodology, present econometric models, and discuss results. Lastly, in Section 4, we discuss our concluding remarks.

2. LITERATURE REVIEW

Monetary policies are commonly considered vital policy responses, especially in any downturn in the economy. In this regard, the monetary transmission mechanism showing the impact of monetary policies on the aggregate economy is worthy of attention. It can be in the form of different procedures, like monetary targeting of M3, inflation targeting, controlling interest rates (price control) (Juselius and Toro, 2005). As an unconditional monetary policy, quantitative easing (QE) is one of the standard tools that CBs apply to monetary expansion into the economy. It is noteworthy to mention that QE is not a newly discovered tool. We see that CBs used to apply it right after economic recessions like Fed in the 1930s, the Bank of Japan in 2001, the Bank of England, and the Fed after the recession in 2008 (Ricketts, 2011; Powell, 2002). As Haldane et al. (2016) denote, QE may have a significant macro-economic impact, and its effectiveness may vary over time. The vast literature on QE and monetary expansion also states them as one of the crisis causes. Furthermore, Horwitz (2012) already concludes that expansionary monetary policies formed a basis for the Great Depression. On the other hand, Krugman et *al.* (1998) recommended a monetary expansion policy as a solution in Japan's case of the economic crisis.

In OECD countries, we see empirical evidence of monetary policy practices by adopting inflation targeting during the 1990s, as Divino (2009) states. Dedola and Lippi (2005) show evidence on heterogeneous effects of unexpected monetary policy shocks in 5 OECD countries' industries (France, Germany, Italy, UK, and the USA). From another point of view, Ahrend (2010) discusses monetary ease in OECD countries between 2002-2005 and finds accommodating monetary policy as one factor behind financial imbalances triggering the 2009 recession.

In emergency cases, monetary policies may constitute a fast government response mechanism to any financial and economic threat. In the pandemic COVID-19, IMF has categorized the policy responses as monetary, fiscal, macro-financial, and exchange rate and balance of payment (ICMA, 2020). Indeed, COVID-19 has brought concerns on an upcoming crisis, and it is seen that 21 CBs announced QE programs on their local 10-year government bond yields right after the COVID-19 outbreak (Hartley and Rebucci, 2020). As Bonatti et *al.* (2020) state, the Pandemic caused stress on ECB's conventional monetary policies, whereby we see exceptional policies to smooth the impacts of such an economic crisis aiming to prevent an economic collapse. Moreover, they argue possible scenarios that the ECB may face regarding the exceptional monetary policies. As they denote, QE may be weaker in case of a rapid economic recovery. However, if any stagflation occurs, QE policy may be justified, but in case of a prolonged recession, ECB could face a dilemma supporting the debt of countries or causing a crisis in the euro area. The uncertainty of a possible hit by an impending economic crisis put CBs to announce for unconventional QE, but the situation could be problematic in the world economy in the long run. Zhang et *al.* (2020) discuss the unlimited QE

policies in the US and its impacts on financial markets. Bhar and Malliaris (2020) tackle the modeling of monetary policy and QE in the US. Finally, Benigno et *al.* (2020) focus on QE and its potential to support health and welfare expenditures and fiscal stimulus in emerging markets from a different perspective.

Literature covers a broad range of studies on COVID-19 and its impact on the economies. One branch of the literature deals with the pandemic-related consequences on the financial variables. For instance, drawing on the efficient market hypothesis, Narayan (2020) argues that pandemic-related shocks have a transitionary effect on the Yen-US dollar exchange rate, which is the most affected asset price during the Pandemic. On the other hand, the stock market and exchange rate nexus are investigated by Narayan et *al.* (2020) for the Japanese economy. The paper's main idea is that most firms in the Japanese economy benefit from the depreciation of YEN due to being more competitive and, therefore, stock market returns increase. Moreover, Haroon et *al.* (2020) suggest that under liquidity constraints, government interventions and flattening the curve seem to matter most for the emerging economies due to the aversion from uncertainty by investors. Finally, a refined analysis conducted by Pe et *al.* (2020) asserts that the impact of COVID-19 on the sectors such as transportation, mining, electricity & heating has been relatively more robust compared to manufacturing, information technology, education, and health care industries.

Due to the increased global risk, further studies investigate the impact of capital flows on the stock market prices in economies characterized by fragile financial markets (McKibbin and Fernando, 2020; Topçu and Gülal, 2020; Baker et *al.*, 2020). For instance, Prabheesh (2020) points out the financial instability in Indian stock markets due to the reversal of portfolio records and provides evidence on the causality running from foreign portfolio investment to stock prices in the COVID-19 period. The situation seems alarming for financial markets, as indicated by Gil-Alana et *al.* (2020), who argues that shocks are long-lasting rather than temporary in selected Asian countries. Furthermore, Ozili and Arun (2020) mention the impact of fast policy responses by several governments and states, and they highlight that these fast responses may deepen the global recession soon.

Several studies look into the impact of the Pandemic on energy markets. It is seen that uncertainty poses cause of volatility in the energy markets (Salisu and Adediran, 2020), above a certain level of oil price volatility, both oil price news and infection cases are essential predictors of oil prices (Narayan, 2020). Pandemic occurrence and the oil market are also studied by Qin et *al.* (2020), who concluded that oil prices had been negatively affected by the Pandemic. Devpura et al. (2020) also supported a similar argument who claim that the pandemic and oil prices are directly related. Huang & Zheng (2020) highlights the relationship between investor sentiment and crude oil futures price and found a structural change during the first quarter of 2020. Iyke (2020) found US oil and gas producers' heterogeneous responses to the Pandemic and stated that the Pandemic significantly triggered 28% of returns and 27% of return volatility. Similarly, Prabheesh et *al.* (2020) express that decreasing oil price is a negative signal for the stock market.

Moreover, Vidya et *al.* (2020) demonstrate to what extent the COVID-19 Pandemic deteriorates trade interconnectedness among the economies applying trade network analysis. From another perspective, studies are focusing on the impact of containment on economies and monetary transmission mechanisms –like supply and demand shocks, flight restrictions that limit the international mobility, social distancing, income per capita and consumption, emergency packages- (Baldwin and Tomiura; 2020; Thunström et *al.*; 2020; Ozili et *al.*, 2020; Sumner et *al.*, 2020; Bénassy-Quéré and Di Mauro, 2020).

3. DATA, METHODOLOGY, AND ECONOMETRIC MODELS

In this section, we firstly discuss data selection and methodology. Then econometric models and results are provided.

3.1. Data and Methodology

In this study, we used the pooled data of the OECD countries during the pandemic period. In the sample, we excluded Colombia, Iceland, Mexico, and Switzerland due to the lack of economic data for certain variables. Table A1 presents the list of sample countries. We exploited two databases to collect the data. First, we retrieved the selected macroeconomic variables from the leading economic indicators in the OECD database (OECD, 2020). We obtained Pandemic-related measures from Oxford COVID-19 Government Response Tracker (Oxford University, 2020). The economic variables that are used in the analysis are *quarterly growth rate (g), industrial production index (IP), the money supply in domestic currencies (MS), interest rate (R), the exchange rate (EXC)* And *fiscal stimulus package (FIS).* To include the health-related policies, we constructed *containment index(C)* and *health index (H)*[2] They were using daily indicators from Oxford data. The selected indicators for containment index are school closing, workplace closing, cancel public events, restrictions on gathering, close public transport, stay at home requirements, restrictions on internal movement, international travel controls. For the health index, we exploited the indicators of public information campaigns, testing policy, contact tracing.

Fiscal stimulus package as a percentage of GDP entered into the equation with cumulative values. However, the rest of the variables are in quarterly frequencies for the 2020Q1-2020Q4 period. Except for economic growth and industrial production index, the remaining variables are available monthly and therefore converted to quarterly frequencies. As the growth rate and interest rates are in percentages and may take negative values, we use them in levels. For the rest of the variables, we used logarithmic transformations. In the Appendix, Table A2 shows the variable description and provides summary statistics.

The standard approach in empirical works to deal with the output effects of unanticipated monetary shocks is to apply Vector Autoregressive Regression (VAR) as the model allows for the endogeneity in macroeconomic variables. However, due to the short period in this paper, we proceed with the simple linear regression and weighted linear regression models. Furthermore, to avoid the potential endogeneity of policy responses and gross domestic product (GDP), we use quarterly changes in economic growth rather than using GDP in level as the dependent variable.

Following earlier studies, we included two important financial market prices for monetary transmission; short-term interest rate and exchange rate, namely, into our model as independent variables (Taylor, 1995). However, later studies have focused on the inadequacy of traditional Keynesian perspective and interest rate channel due to zero lower bound problem (Fuhrer & Madigan, 1997; Krugman et *al.*, 1998; Summers, 1991). Indeed, what we see during the global financial crisis (IMF, 2013) and the COVID-19 period (Dabrowski and Dominguez-Jimenez, 2020) as monetary responses are unconventional tools in the form of quantitative easing rather than the tools that the monetary transmission framework suggested. Therefore, we included financial stock as an explanatory variable and introduced a financial market quantity into our model. Furthermore, to control the fiscal responses and their potential impact on the real economy, we took the fiscal policy package indicator of COVID-19 Economic Stimulus Index (CESI) created by Elgin et *al.* (2020); fiscal packages of the governments are measured as a percentage of GDP.

Moreover, the industrial production index is taken as a proxy to represent the sectoral structure in each economy. Detailed sectoral analyses conducted by the International Labor Organization (ILO) (2021) state that the impact of COVID-19 on the sectors are uneven, and sectors such as construction and service have been affected to a greater extend. Therefore, we might expect a higher negative effect on real economies as long as they are more dependent on sectors outside the industry. Furthermore, to control for the various policy measures, we included containment and health indices using the indicators of Hale and Wester (2020). Lastly, country dummies are included to capture

unobserved heterogeneity, such as different institutional and social norms.

3.2. Econometric Model and Results

We estimate Equation 1 to investigate the effect of monetary shock on the economies' short-run economic performance with OLS and feasible GLS. Our model is a simplified version of New Keynesian models (Gali, 2009; Fornaro et *al.*,2020), where output and employment are determined by aggregate demand. Our primary aim is to test whether the countercyclical monetary policy impacts aggregate demand and output in turn. The results appear in Table 1. In Model 1, we estimated the main equation with OLS and performed diagnostic tests to check for any potential misspecification. Added variable plots in Figure A1 demonstrate that the interest rate variable suffers from collinearity. Added variable plots decompose the multivariate relationship into a set of two-dimensional plots where e_1 is residuals from the regression of particular X_i on all X_{-i}, and e_2 is residuals from the regression of Y on all X_{-i}. The first residual, e_1, represents the nonlinear part of X_i and the second residual, e_2, represents the information on Y that X-i does not explain. Given this information, two extreme cases are essential. First, if the points are clustered through the e_2 axis, this implies perfect collinearity and the need to drop the variable, which is also the case for the interest rate variable in our model (Baum, 2006). Besides this technical explanation, we expect that the interest rate variable would not explain the variation in Y in our model as Eurozone countries have the same interest rate level.

Moreover, in the short run, due to the stickiness of prices, policy-induced change in money supply is closely linked to nominal interest rate, and the deterministic relationship implies that describing monetary policy actions through the monetary base or nominal interest rate is equivalent (Ireland, 2005) and therefore, endogeneity concerns might prevail. Thus, we proceeded with a model excluding interest rates. Variance inflation factors presented in Table A3 show that no multicollinearity problems exist among the remaining variables. For additional check for model specification, we apply Ramsey's RESET test, whose results are reported in Table A4. According to the results, we fail to reject the null hypothesis of the absence of omitted variable in the model. However, OLS estimates suffer from heteroscedasticity, as is shown in the Breusch-Pagan test in Table A5 in the Appendix. Therefore, we estimated Equation 1 (excluding interest rate) with the Feasible Generalized Least Square (FGLS) estimator. FGLS implements transformation in original data and runs a regression to the transformed data to deal with deviations from non-i.i.d errors (Baum, 2006). The logic behind FGLS is to give much weight to the residuals with fewer variances. Although in Model 1 and 2, we estimated the equation with heteroscedasticity robust standard errors, we also show FGLS results.

$$g_{i,t} = \alpha + \beta_1 logMS_{\,i,t} + \beta_2 R_{\,i,t} + \beta_3 logEXC_{\,i,t} + \beta_4 logFIS_{\,i,t} + \beta_5 logIP_{\,i,t} + \beta_6 logC_{\,i,t} + \beta_7 logH_{\,i,t} + \sum_{i=8}^{41} \beta_i FE_{\,i} + \varepsilon_{\,i} \quad (1)$$

Our ex-ante predictions to have a statistically significant positive impact of money supply and fiscal stimulus package on the growth rate of real GDP suggested by countercyclical policy framework Krugman and Wells, 2009). Considering the open-economy macroeconomic model of Fleming (1962) and Mundell (1963), we expect a significant negative relationship between exchange rate and output through the channel that exchange rate appreciation depresses net export and output in the short run. Additionally, a positive relationship between industrial production and growth rate is expected by economic insight. Lastly, we anticipate a significant negative relationship with containment measures in the short run and a significant positive relationship with health measures. For Model 1, we predict an insignificant effect of interest rate on output growth following the discussion above.

Regarding the regression results, monetary policy positively and significantly affects quarterly economic growth in all specifications. The positive and significant coefficient estimate of the logarithm of money supply asserts that in the COVID-19 period, monetary easing positively contributes to the growth rate of real GDP. FGLS coefficient estimates state that a 1%

money supply increase results in a 0.27% increase in economic growth. As expected, the interest rate variable is insignificant. Curdia (2020) stated that conventional monetary policy has a limited policy space because of the zero lower bound, most notably in the USA. Even though this is not the scope of this paper, COVID-19 measures also cover financial packages across many countries (IMF, 2020). When we control the cumulative value of the fiscal packages and several controls, significant monetary policy effect still prevails. Our result is in line with earlier empirical findings regarding monetary policy effectiveness even though it does not provide a specific mechanism due to the short period (Bernanke & Blinder, 1992; Taylor, 1995; Christiano et *al.*, 1998; Camarero et *al.*, 2002; Sun et *al.*, 2010).

Additionally, FGLS estimates show that a 1% increase in fiscal stimulus package results in a 0.43% increase in economic growth. In US, Castro (2020) investigated the potential fiscal channels and argues that unemployment insurance benefits can be considered as a crucial way in the stabilization of the economy. In an earlier study, Drautzburg et *al.* (2015) also provided a positive fiscal multiplier in the short run, where they studied fiscal policy in response to the American Recovery and Reinvestment Act (ARRA) of 2009. A statistically significant and positive result of the fiscal policy variable supports these studies.

The coefficient estimate of the exchange rate variable, on the other hand, stands negative and significant, which is also in line with our expectations and theory. In open economy macroeconomic models, a negative relationship

Table 1. Regression Results

	(Model 1)	(Model 2)	(Model 3)
Growth rate (quarterly)	OLS	OLS	FGLS
log (money supply)	57.21***	56.47***	62.94***
	(20.48)	(20.41)	(15.86)
interest rate	-0.979		
	(1.300)		
log (exchange rate)	-58.98***	-63.12***	-63.00***
	(18.59)	(17.72)	(15.59)
log (industrial production index)	28.07**	26.03**	27.84***
	(11.42)	(11.07)	(9.990)
log (fiscal stimulus package)	89.53***	95.36***	101.5***
	(29.72)	(28.62)	(25.23)
log (containment measure index)	-6.524***	-6.500***	-5.105***
	(1.771)	(1.766)	(1.533)
log (health measure index)	3.461*	3.556*	1.520
	(2.029)	(2.020)	(1.515)
Country fixed effects	YES	YES	YES
Observations	128	128	128
R-squared	0.53	0.53	0.53

Robust standard errors in parentheses.

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

postulates between the value of a domestic currency and net export or output levels (Fleming, 1962; Mundell, 1963; Dornbusch, 1976). Additionally, it is straightforward to expect a positive impact of the industrial production index on economic growth, not particularly for a pandemic period but regularly. We have this result in our model. Lastly, we find a negative and significant effect of containment measures and a positive and significant effect of health-related measures (only in FGLS, it is insignificant but still positive) on short-run economic growth. Recent study of Carlsson-Szlezak *et al.* (2020) claim that direct impact of social distancing measures was seen as reduced consumption of good and services, consumer confidence, and deteriorated production capacities. Mulligan (2020) states the cost of lockdown days and documents the offsetting effect of vaccine development and contract tracing. Our results also support these claims.

4. CONCLUSION

Since the beginning of the Pandemic, most governments have started to implement lockdown measures which caused a sudden and sharp decline in global production and supply chains, disrupted business activities, and an enormous uncertainty for the global economy. Concurrently, the COVID-19 outbreak depressed the aggregate demand due to quarantines, social life restrictions, and economic activities. As an immediate move, CBs around the world have reacted with similar responses. These are, in fact, the similar tools that the CBs used in financial turmoil in 2007-2009, even though the causes and the scopes were quite different.

In this study, we analyze the impact of monetary policy to stimulate the economy in the short run. We see a significant and positive impact of monetary policy on quarterly economic growth in all specifications. Our results justify QE measures of many CBs as sudden and immediate policy responses to the Pandemic (Bonatti et *al.*, 2020) by documenting the positive contribution of money stock on the quarterly growth rate of real GDP. Even after controlling the fiscal stimulus, our results suggest that monetary policy served its purpose, but its magnitude is relatively weak. The negative and significant impact of the exchange rate on economic growth is in line with existing literature (Fleming, 1962; Mundell, 1963; Dornbusch, 1976). The positive and significant coefficient of the industrial production index highlights the more substantial impact of the Pandemic on emerging economies that are primarily dependent on the service sector. These economies are expected to be exposed to a sharper slowdown in economic growth due to containment measures, shutdowns and restrictions. Additionally, we see a negative impact of containment measures and a positive impact of actions such as testing, vaccination, and contact tracing.

The current study provides empirical evidence of monetary and fiscal policies on the short-run economic growth in a pandemic context. However, our preliminary results should be interpreted with caution despite the data constraints and the dynamic nature of the Pandemic. Therefore, we evaluate our results to contribute to the emerging literature that deals with macroeconomic policy effectiveness in the Pandemic era. Future studies may develop this model by adding different variables and extend the time horizon as long as more data becomes available. The study shows how vital investment in industrial production and quick policy responses in monetary and financial packages are for economic growth. For this reason, such policies may be recommended for underdeveloped economies in the short term.

Notes

[1] In the OECD database, exchange rates are defined over the dollar value of the currencies, which means the exchange rate variable for the USA is 1.

[2] In the data of Oxford Coronavirus Tracker, the variables are recorded on an ordinal scale in which higher values indicate higher strictness of the measures. We follow the index methodology of Hale and Wester (2020) and calculate daily indices using the equation $Ij, = (vj,t - 0.5(Fj - fj,t)/Nj * 100$ to normalize the indicators with different scales. In the formula, I represents sub-index score for any given indicator at time t. v denotes the original score of the indicator and has a scale of 0-2,0-3 or 0-4. N is the maximum value that the indicator can take. F is the binary flag variable that exists only for particular indicators and captures

the geographical scope of the measure. For example, when the variable has a flag, Fj, it takes the value of 1 and fj, t takes the value of 1 or 0 depended on whether the policy has been implemented over the whole country or targeted to a limited geographical area. However, instead of daily indices, we transformed the daily data to quarterly by simple averaging and got unique values for each sub-index at the country level.

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Appendix

Table A1. List Of 33 OECD Countries in The Sample

Australia	Latvia	Denmark	Poland	Greece	Spain
Austria	Lithuania	Estonia	Portugal	Hungary	Sweden
Belgium	Luxembourg	Finland	Slovakia	Ireland	Turkey
Canada	Netherlands	France	Slovenia	Israel	United States
Chile	New Zealand	Germany	South Korea	Italy	United Kingdom
Czechia	Norway	Japan			

Table A2. Summary Statistics

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	Mean	SD	Min	Max
Quarterly growth rate	128	-0.560	7.405	-19	18.46
Money supply (billion currencies)	132	133,688	555,341	15.66	3184353
Exchange rate (USD=1)	132	74.89	243.7	0.757	1,220
Interest rate	132	0.205	1.938	-0.700	14.08
containment index	132	42.07	20.86	3.777	79.58
health index	132	69.10	22.83	8.791	100
Industrial production index (quarterly)	132	103.7	10.53	77.43	128.4
Fiscal stimulus (%of GDP) (cumulative)	132	14.16	6.897	3.780	42.20
Total number of cases per million (cumulative)	132	64,041	35,796	522	152,258
Country code	132	17	9.558179	1	33

Figure A1. Added Variable Plots

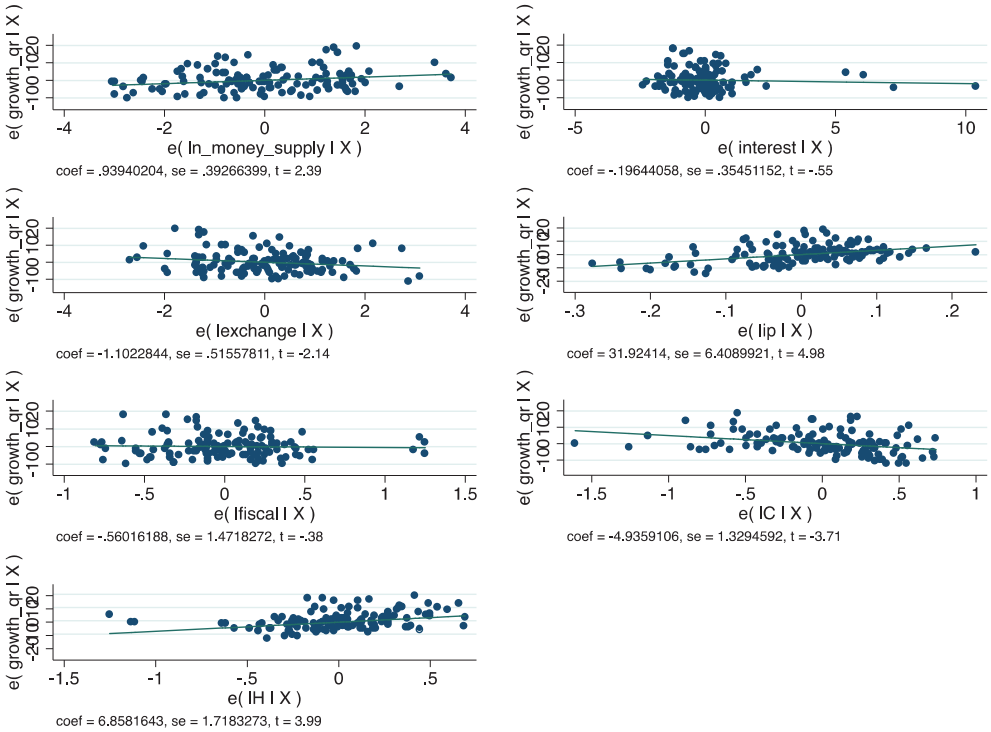

Table A3. Multicollinearity Test

Variable	VIF	1/VIF
log (money supply)	3.49	0.286716
log (exchange)	3.41	0.293609
log (containment measure index)	2.26	0.442170
log (health measure index)	2.16	0.462912
log (fiscal stimulus index)	1.16	0.861384
log (industrial production index)	1.35	0.861384

Table A4. Ramsey Reset Test Results For The Functional Form

Ho: model has no omitted variable	p-value
Model 1	0.2748
Model 2 (excluding interest rate)	0.2742

Figure A2. Residuals Normality

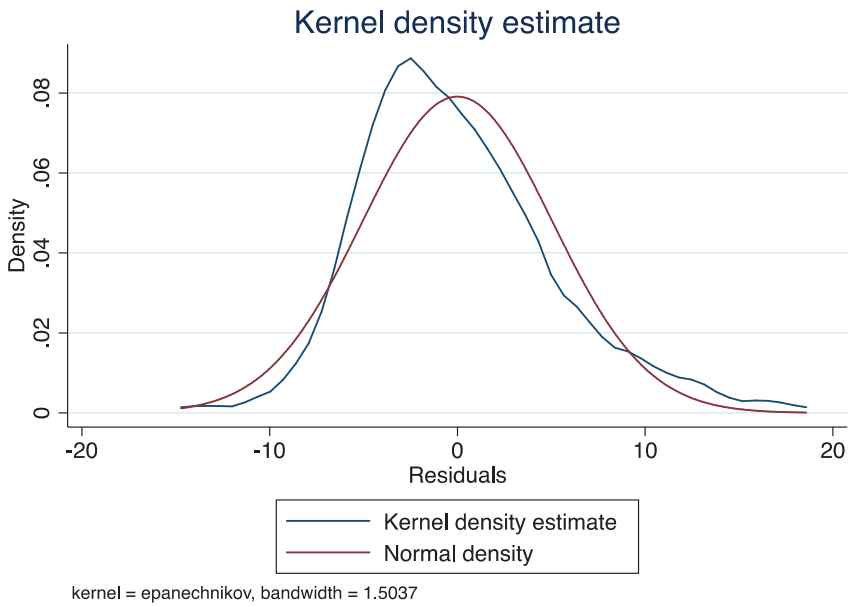

Figure A3. Residual Vs. Fitted Plot

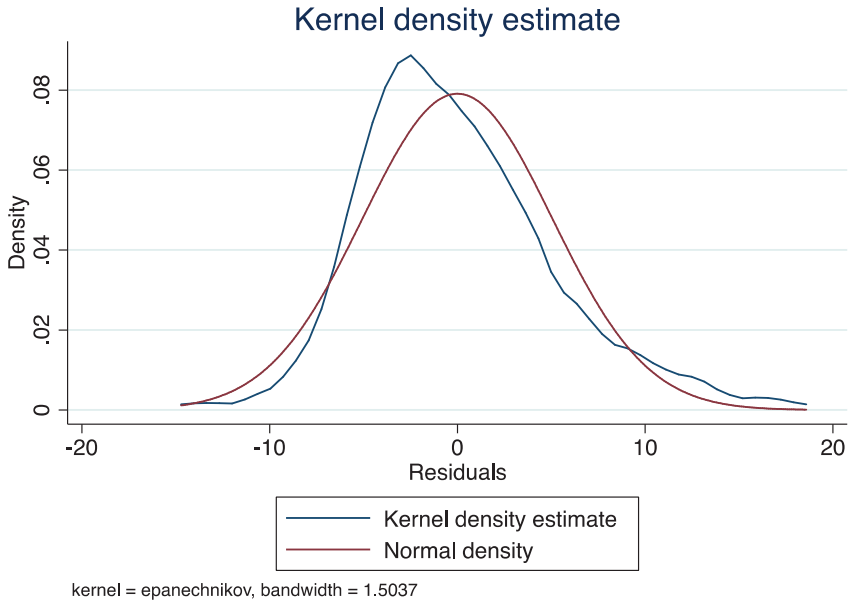

Table A5. Breusch-Pagan / Cook-Weisberg Test For Heteroskedasticity

Ho: Constant variance	p-value
Variables: fitted values of quarterly growth rate (model excludes interest rate)	0.0482

JLECON

Volume / Cilt: 10, Issue / Sayı: 3, 2023, pp. 141-156
E - ISSN: 2148-4139
URL: https://www.journals.gen.tr/jlecon
DOI: https://doi.org/10.15637/jlecon.2078

Received / Geliş: 23.05.2023
Acccepted / Kabul: 03.07.2023

RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Creating complexity matrix for classifying artificial intelligence applications in e-commerce: New perspectives on value creation

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Abstract

This research paper provides a comprehensive exploration of the role of Artificial Intelligence (AI) in value creation within the e-commerce sector, focusing on how task and information complexity affect AI deployment. It first outlines the historical development of value theory and value creation, highlighting the shift from traditional modes to modern interactive and co-creation models. Following this, the paper delves into AI's potential in various e-commerce dimensions including personalization, product recommendation, supply chain efficiency, and more. The centrepiece of the study is a detailed matrix classifying AI into Automated Intelligence, Assisted Intelligence, and Augmented Intelligence, based on the complexity of tasks they execute and the information they analyse. This research study engaged a panel of fifteen industry and academic experts to critically examine and assign complexity scores to various Artificial Intelligence applications within the e-commerce and similar sectors. The experts evaluated task and information complexity, thereby enabling a classification of the applications into a comprehensible matrix. This classification not only provides a guide for AI system design and evaluation but also enhances understanding of their functional dynamics. The paper contributes theoretically by advancing our understanding of AI as a value creator in e-commerce and practically by offering a roadmap for businesses to adopt and leverage AI technologies. As AI continues to revolutionize the e-commerce sector, the findings of this study provide invaluable insights for businesses seeking to gain a competitive advantage in the digital marketplace.

Keywords: Artificial Intelligence, E-Commerce, Value Creation, Ai In Marketing, Digital Marketing

JEL codes: M31, M37, D46

Citation/Atıf: BABAYEV, N. & ISRAFILZADE, K. (2023). Creating complexity matrix for classifying artificial ıntelligence applications in e-commerce: New perspectives on value creation. *Journal of Life Economics*. 10(3): 141-156, DOI: 10.15637/jlecon.2078

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1. INTRODUCTION

Artificial intelligence (AI) has become an integral part of the e-commerce value creation process, transforming the way businesses operate and interact with their customers. As a result, understanding how AI interacts with task and information complexity is critical. In light of this, the research paper attempts to explore the intricacies of the value creation process and the evolution of value theory within the context of e-commerce and AI technologies.

Firstly, the research explores the historical development and conceptualization of value creation and value theory, laying the groundwork for our subsequent exploration of AI in e-commerce. The paper highlights the paradigm shift from the traditional linear and localized modes of value creation to the modern interactive and value co-creation models, fuelled by advancements in technology and shifts in socio-economic factors. Additionally, it explores the evolution of the concept of value from its ancient philosophical origins to its contemporary significance in marketing, business, and economy, elucidating the intricate relationship between value creation and successful business endeavours.

Next, the paper transitions into an in-depth exploration of AI in e-commerce. The research describes the potential of AI to create value across various dimensions of e-commerce, including personalization, intelligent product recommendations, supply chain efficiency, advertising and sales, enhanced customer service, product content management, visual and voice search, and dynamic pricing optimization. It also touches upon the role of AI in augmenting human intelligence, presenting the concept of augmented intelligence.

The core of this research paper lies in understanding how task and information complexity influence the deployment and functionality of different types of AI in e-commerce. It also presents a comprehensive matrix that categorizes AI into Automated Intelligence, Assisted Intelligence, and Augmented Intelligence, based on the complexity of tasks they carry out and the information they analyse. This matrix will not only serve as a guiding framework for designing and implementing AI systems but will also aid in evaluating their performance and identifying areas of potential improvement.

The paper engages a panel of fifteen experts from various domains, including Marketing Managers, Market Intelligence Analysts, Senior Managers, and Digital Marketing Specialists, all providing their perspectives on the complexities of various AI applications in e-commerce. By employing a 10-point ordinal scale, these experts evaluated AI applications' task and information complexity, producing a comprehensive complexity matrix that offers an innovative method for understanding and strategizing the deployment of AI in e-commerce.

Overall, this research paper provides a holistic view of the value creation process, the evolution of value theory, and the role of AI in e-commerce. It is designed to enlighten readers on the transformative potential of AI in redefining the e-commerce landscape and fostering sustainable business growth through value creation.

2. LITERATURE REVIEW

2.1. The Value Creation Process and the Evolution of Value Theory

The primary objective of every business is to maximize profit, but achieving this without offering value is not a sustainable approach. Value creation is essential for the success and longevity of any firm, regardless of size. It involves developing and delivering products and services that consistently cater to customer needs, fostering brand loyalty. Value creation transforms work and assets into something that fulfils the needs of others, such as tangible goods or intangible offerings like software and innovative ideas (Garcia-Castro & Aguilera, 2015; Windsor, 2017; Chesbrough, Lettl & Ritter, 2018; Sjödin et al., 2020). Successful companies understand that the purpose of any commercial endeavour is to create value for customers, shareholders, and employees. Value creation does not involve selling or persuading; rather, it involves producing a product in its optimal form that caters to customer demands, making them want to purchase it.

The concept of value has been an essential element of marketing (Eggert et al., 2018; Kotler & Armstrong, 2020), business, and especially philosophy since ancient times (Halim, 2012). The value construct came to the forefront in marketing during the 1990s, although it had been discussed by philosophers for centuries prior. Aristotle was one of the first to explore the concept of value, distinguishing between value-in-use (a thing's functional purpose) and value-in-exchange (a thing's worth in trade) (Southerton, 2011; Halim, 2012; Eggert et al., 2018). This differentiation laid the groundwork for future thinkers, such as Adam Smith (Smith, 1776), who further explored the value paradox and introduced the law of supply and demand. However, the connection between the two value perspectives wasn't fully understood until the advent of Hermann Gossen's law of declining marginal utility (Gossen, 1854; Eggert et al., 2018).

Over time, the marketing discipline has also evolved, with the definition of marketing shifting from exchange-based to value-creation-focused. This change emphasizes the importance of customer relationships and the provision of value through these interactions. The American Marketing Association's definition of marketing, last updated in 2017, highlights the importance of creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large (AMA, 2017). As the field of marketing continues to change and adapt, the ability to analyse broad trends will be crucial to understanding and predicting how customer value will evolve in the future.

The evolution of value creation has been driven by technical developments and socioeconomic changes throughout history. Beginning with traditional methods focused on linear organization and localized production, value creation has evolved into interconnected networks, where businesses cooperate and interact with one another (Provan, Fish & Sydow, 2007). Further development led to interactive value creation (Prentice, Wang & Loureiro, 2019), where customers began to engage with companies, sharing knowledge and information. Specifically, the world wide web not only shaped customer views but also provided customers more control over marketing, resulting in a noticeable shift in customer behaviour over time. To conclude, the era of value co-creation emerged, in which consumers, known as "prosumers," actively participate in the production process (Ramaswamy & Ozcan, 2020). This shift necessitates innovative concepts, such as open innovation and crowdsourcing, as well as a bottom-up economics framework that emphasizes decentralization, interconnectedness, and collaboration between participants (Redlich & Moritz, 2016, Redlich, Moritz & Wulfsberg, 2019).

To put into perspective what has been addressed, the concept of value has been a fundamental element in philosophy, economics for centuries and marketing for decades. The evolution of marketing has led to a focus on value creation, emphasizing the importance of customer relationships and providing value through interactions. As the field continues to adapt, analysing trends will be crucial in understanding and predicting customer value's future development. Technical advancements and socioeconomic changes have driven the progression of value creation, leading to an era of value co-creation where consumers actively participate in the production process. Ultimately, successful businesses must prioritize value creation for customers, shareholders, and employees to ensure long-term growth and sustainability in an ever-changing landscape.

2.2. Artificial Intelligence as Value Creation in E-commerce

When most people think of AI, they automatically think of science fiction. Many might believe AI is something that belongs in the future, but in truth, most individuals come into contact with it multiple times each day. Research on artificial intelligence was indeed put on hold for several decades, a phenomenon known as "AI winter." In 1956, Artificial intelligence was coined by John McCarthy, father of AI (Andresen, 2002; McCarthy et al, 2006), has evolved over time and found its way into various business processes.

AI encompasses data mining, natural language processing (NLP), and machine learning (ML), including deep learning (Davenport, 2020; Nichifor, Trifan & Nechifor, 2021). Investment in AI startups has increased significantly, with AI expected to generate up to $15.7 trillion in the global economy by 2030 (Holmes, 2019; PwC, 2021). Therefore, artificial intelligence in e-commerce is a game-changing technology that is altering the face of online buying.

The adoption of AI technologies can lead to competitive advantages by enhancing customer experiences and engagement (Israfilzade, 2021). However, there are concerns about AI causing massive unemployment, though it is more likely that AI will augment human labour rather than entirely replace it.

Although some markets, industries, and businesses are further along in their development than others, AI as a whole is still in an extremely early stage of development at this point (Israfilzade, 2020; 2021). Emerging markets have the ability to overcome their more established competitors from a macroeconomic standpoint, which is an opportunity for these countries.

The combination of human and artificial intelligence is referred to as augmented intelligence (Webb, 2019). While AI applications, such as virtual assistants, bots, and machine learning, have disrupted various industries, the potential for collaboration between humans and machines is tremendous (Israfilzade, 2020; 2021). Technologies can create new tasks, expand existing sectors, and rearrange occupational tasks, rather than merely automating existing systems. As AI technologies continue to develop and integrate into society, the focus should be on leveraging the unique strengths of both humans and machines to create a more efficient and innovative future.

Therefore, it is evident that AI has emerged as a powerful tool for boosting sales and optimizing operations (Samek, Wiegand & Müller, 2017, Borges et al., 2021; Israfilzade, 2021). Even smaller online retailers have begun adopting technology with AI capabilities. According to PwC (2021), the most substantial economic benefits from AI in the coming years will likely arise from increased productivity in e-commerce, achieved by automating routine tasks and enhancing employee skills. Industries like manufacturing and transportation, which involve numerous operational processes amenable to automation, are expected to experience the most significant productivity gains from AI.

In light of the theoretical foundation that pertains to the co-creation of customer value in e-commerce, it is now understood that AI can act as a value-creation source within this setting (Samek et al., 2017; Melović et al., 2020; Soni, 2020; Huang & Rust, 2021a; 2021b; Panigrahi & Karuna, 2021; Nimbalkar & Berad, 2021; Moura, Reis & Rodrigues, 2021; Borges et al., 2021; Nichifor et al., 2021; Bawack et al., 2022). However, given the dynamic nature of this industry, it constantly evolves through the introduction of new e-commerce applications. Stated differently, two decades ago, AI-powered e-commerce apps were scarce and contributed minimally to value creation. Reflecting on the theoretical exposition, modern AI has started to diversify significantly. This paper reviews the literature thoroughly to discuss various modes of value creation attributed to the application of AI. These categories include AI Personalization, Intelligent Product Recommendations, Improved Products & Services, Supply Chain Efficiency, Advertising & Sales, Enhanced Customer Service, Product Content Management, Visual & Voice Search, and Dynamic Pricing Optimization (Table 1). Therefore, the table below shows the classification of these categories and the relevant studies supporting each category.

From the given table 1, it's evident that AI has a significant impact on various aspects of e-commerce, ranging from personalization to supply chain management. Here are a few key observations:

1. AI Personalization: In the era of customer-centric services, AI offers sophisticated personalization capabilities, enabling businesses to tailor their offerings to individual customer needs. This enhances the customer experience and boosts customer loyalty.

2. Intelligent Product Recommendations: AI can analyze user behaviour, preferences, and history to recommend products, leading to increased engagement and potentially higher sales.

3. Improved Products & Services: AI tools can analyze vast amounts of data to provide insights and make predictions, enabling businesses to optimize their offerings and improve conversion rates. This includes predicting customer churn, enhancing the user experience, and optimizing conversion rates.

4. Supply Chain Management: AI can streamline and automate various aspects of the supply chain, including demand prediction, route optimization, and task automation. This increases efficiency, reduces costs, and can lead to a more responsive and flexible supply chain.

5. Advertising & Sales: AI can help businesses to optimize their advertising efforts, including lead generation and campaign tracking. It also aids in customer segmentation and targeting, ensuring marketing efforts reach the right audience.

6. **Improved Customer Service**: With AI, businesses can provide timely and efficient customer service, such as through chatbots. This can help to improve customer satisfaction and loyalty.

7. Product Content Management & Visual and Voice Search: AI can help in improving content creation and optimizing search algorithms, including image search and recognition, which could potentially increase the visibility of products and improve customer experience.

8. Dynamic Pricing Optimization: AI can dynamically adjust prices based on a variety of factors, including demand, inventory, and competitors' prices, potentially increasing sales and profits.

The literature review has yielded an initial list of 32 items (refer to Table 2). These items have been categorized into nine areas of application for Artificial Intelligence: AI Personalization, Intelligent Product Recommendations, Enhanced Products & Services, Supply Chain Management,

Table 1. Classification of AI applications in forms of value creation

Forms of Value Creation	Relevant Studies
AI Personalization	Panigrahi & Karuna, 2021; Kumar & Kumar, 2021; Moura, Reis & Rodrigues, 2021; Israfilzade, 2021; Bawack et al., 2022
Intelligent Product Recommendations	Kumar & Trakru, 2020; Pallathadka et al., 2021; Nimbalkar & Berad, 2021
Improved Products & Services	Soni, 2020; Panigrahi & Karuna, 2021; Kumar & Kumar, 2021; Bawack et al., 2022
Supply Chain Efficiency	Pindyck & Rubinfeld, 2017; Kumar & Trakru, 2020; Nimbalkar & Berad, 2021; Yang, Feng & Whinston, 2022
Advertising & Sales	Pindyck & Rubinfeld, 2017; Shukla, 2019; Panigrahi & Karuna, 2021; Micu et al., 2021; Yang, Feng & Whinston, 2022
Enhanced Customer Service	Kumar & Trakru, 2020; Soni, 2020; Nimbalkar & Berad, 2021; Panigrahi & Karuna, 2021
Product Content Management	Soni, 2020; Kumar & Kumar, 2021; Micu et al., 2021; Barla, Cuneo & Nunzi, 2022
Visual & Voice Search	Kumar & Trakru, 2020; Pallathadka et al., 2021; Nimbalkar & Berad, 2021; Kumar & Kumar, 2021; Israfilzade, 2021
Dynamic Pricing Optimization	Shukla, 2019; Panigrahi & Karuna, 2021; Yang, Feng & Whinston, 2022

Advertising & Sales, Superior Customer Service, Product Content Management, Visual & Voice Search, and Dynamic Pricing Optimization.

This table 2 structure groups all applications under each AI dimension together. It provides a quick overview of the range of applications within each AI dimension.

3. METHODOLOGY

This research study primarily comprises two sections - the creation of a matrix for different types of Artificial Intelligence based on complexity, and the formation and consultation of an expert panel. Both sections hold pivotal roles in the research design and its execution.

The methodology for this research is designed to classify various AI applications in e-commerce based on complexity. An expert panel was constituted for the task. The experts were drawn from both academia and industry, and their selection was based on their specialized knowledge in the field of AI technologies. The process was designed to ensure a thorough and objective assessment of all value-creation measurement items within the domain of AI applications for e-commerce.

3.1. Creating Complexity Matrix of the Various AI Types

Task complexity and information complexity are essential dimensions for understanding the deployment and functionality of Artificial Intelligence in fields such as e-commerce. These complexities not only characterize the nature of tasks and information that AI processes but also help differentiate between various AI applications, elucidating their capabilities. Furthermore, understanding these complexities aids in the design and implementation of AI systems, and assists in estimating the necessary computational resources, level of algorithm sophistication, and human oversight required. Lastly, these complexities serve as key metrics in evaluating the performance of AI systems, helping to identify areas of potential improvement, thereby contributing to the continuous development and refinement of AI applications.

The three distinct types of Artificial Intelligence that are utilized in e-commerce, namely Automated Intelligence, Assisted Intelligence, and Augmented Intelligence, are largely determined by the complexity of the tasks they

Table 2. AI applications contributing to value creation in e-commerce.

Item No.	AI Application Dimensions	E-commerce AI Applications
1-3	**AI Personalization**	Personalized product and services through AI, Real-time content personalization, AI-personalized ads
4-6	**Intelligent Product Recommendations**	Recommendation Systems, New content suggestion, AI-powered email recommendations
7-12	**Enhanced Products & Services**	Conversion Rate Optimization, Retail Analysis, Product Description Analysis, Improved user experience, Customer churn prediction, User journey analysis
13-19	**Supply Chain Management**	Demand prediction, Optimizing future performance, Route optimization, Task Automation, Automated Order Placing System, Self-Checkout Systems, Automated Warehouses
20-23	**Advertising & Sales**	Lead Generation, Campaign Tracking & Analysis, Customer Segmenting and Targeting, AI-powered Display Retargeting
24-25	**Superior Customer Service**	Chatbots, Customer Feedback System
26-27	**Product Content Management**	Improved content creation, AI-generated keyword (SEO)
28-30	**Visual & Voice Search**	Improved search algorithm, Image search on e-commerce, Image Recognition
31-32	**Dynamic Pricing Optimization**	Price Optimization, Inventory Pricing

carry out and the information they analyse. Figure 1 provides a matrix illustrating this concept.

Information complexity refers to the organization and volume of the data. Some data might be well-organized, stable, and limited in volumes, such as budgeting or sales data. Conversely, other data may be unstructured, volatile, and high-volume, like social media, visual information, and sensor data.

Task complexity, on the other hand, could range from repetitive, predictable, and rule-based tasks such as credit decisions or recommendation engines to more complex, unpredictable tasks that require human judgment, such as tasks involving the judgment and creativity of research scientists, designers, and financial experts.

Consequently, table 3 provides a concise summary of the categorization of AI types based on their task complexity and information complexity. Automated Intelligence is characterized by low task complexity and low information complexity, as it focuses on automating routine and non-routine tasks without requiring new techniques. Assisted Intelligence, on the other hand, can handle tasks with either high information complexity or high task complexity, but not both simultaneously. It can manage tasks that involve either complex information or complex tasks, but not both together. Finally, Augmented Intelligence is associated with high task complexity and high information complexity, making it capable of handling complex tasks and analysing complex information. The following table presents a summary of the characteristics associated with each AI type:

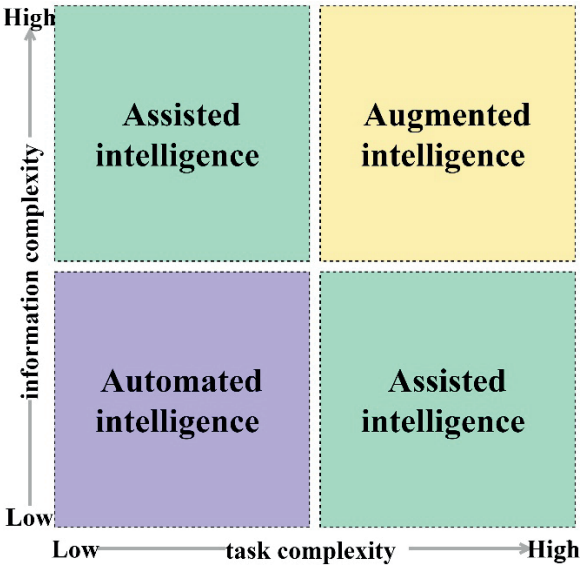
This classification offers valuable insights into the appropriate application of each type of AI in various e-commerce scenarios. It allows businesses to identify the most suitable AI type based on the complexity of tasks and information they need to handle, aiding in the design and implementation of AI systems.

3.2. Classifying the various AI Applications by the Expert Panel

A specially organized panel of experts was assembled for the task at hand. These experts, drawn from both academia and industry, were invited to serve as panellists in the content validation process through email invitations or dedicated meeting sessions. The selection was premised on their specialized knowledge in the field of AI technologies.

In establishing the size of the panel, there was a variety of perspectives to consider. Suggestions for the ideal number of experts to evaluate an instrument ranged between 2 and 20 (Zamanzadeh et al., 2015; Boateng, 2018).

Figure 1. Matrix of the various AI types in e-commerce based on complexity levels.



However, it is generally recommended that a minimum of 5 individuals be involved to ensure adequate control over unanticipated agreements.

Of the twenty-three experts invited, only fifteen responded. Thus, the content validity was evaluated by a team of fifteen experts, which included Marketing Managers, Data Analysts, Senior Data Scientists, and Digital Marketing Specialists, among others (See Appendix 1). In this study, all panel members provided informed consent to participate and independently assessed the validity of all value-creation measurement items.

Experts were prompted to examine the defined dimensions and their corresponding items with an objective lens before assigning a score to each. Panel members were also encouraged to provide feedback, either verbally or in written form, to enhance the relevance and significance of items within the domain of AI applications for value creation.

In academic discourse, the methodology for evaluating certain factors or variables is often as important as the results themselves. In this context, these factors--task complexity and information complexity of AI applications--are evaluated on a 10-point ordinal scale.

An ordinal scale is a scale that allows for rank order by assigning a value to a variable. In this case, the variable is the complexity of tasks and information associated with different AI applications. The use of a 10-point scale as opposed to a smaller scale, such as a 5-point scale, prevents a limited matrix of AI applications. This means that a larger scale allows for a more nuanced evaluation of the variables at hand.

The range of responses on this scale, from 1 to 5, signifies low complexity, while a range from 6 to 10 indicates high complexity. This dichotomy allows for a clear distinction between applications of lower and higher complexity, respectively.

Justification of the research. This bifurcated research methodology provides a comprehensive assessment system for understanding the complexity of AI applications in e-commerce. The complexity matrix allows for a systematic and detailed analysis, while the expert panel offers a range of perspectives to ensure reliability and validity. Consequently, this methodology facilitates consistent, reproducible, and interpretive findings crucial for academic research in this complex and fast-evolving field.

3.2.1. The Result of Classifying Various AI Applications

The complexity values assigned to each AI application help to plot them within a complexity matrix. Figure 2, as referenced in the text, is an illustrative representation of this matrix, where the horizontal axis represents task complexity, and the vertical axis represents information complexity. This visualization provides an accessible and comprehensive overview of how different AI applications are distributed based

Table 3. Categorization of AI Types based on complexity levels.

AI Type	Task Complexity	Information Complexity	*Example*
Automated Intelligence	Low	Low	Automates routine and non-routine tasks without the need for new techniques
Assisted Intelligence	Low (with high information complexity) or High (with low information complexity)	High (with low task complexity) or Low (with high task complexity)	Manages tasks with either high information complexity or high task complexity but not both simultaneously
Augmented Intelligence	High	High	Handles complex tasks and analyses complex information

on their relative complexities.

Table 4 provides a comprehensive evaluation of various AI applications in the e-commerce domain based on their information complexity and task complexity. Each application is assessed and categorized according to its suitability for different AI types: Augmented Intelligence, Assisted Intelligence, or Automated Intelligence.

The evaluations highlight the specific characteristics associated with each AI application. *For example*, AI Personalization involves tailoring e-commerce products and services to individual customer preferences, indicating a high information complexity (score: 8) and moderate task complexity (score: 5). This suggests that Augmented Intelligence, with its capability to handle complex tasks and analyze complex information, is the suggested AI type for this application.

The table 4 further evaluates a range of AI applications across different dimensions, including Improved Products & Services, Supply Chain, Advertising & Sales, Improved Customer Service, Product Content Management, Visual & Voice Search, and Dynamic Pricing Optimization. Each application is assessed based on its complexity levels, aiding in determining the most suitable AI type for its implementation.

By systematically evaluating and categorizing AI applications in e-commerce based on their complexity, businesses can make informed decisions regarding the deployment of AI technologies. This assessment provides valuable guidance in selecting the appropriate AI type for each application, ensuring optimal performance and value creation in the e-commerce sector.

Based on table 4, it is evident that Assisted, Augmented, and Automated Intelligence have distinct roles within the e-commerce industry.

a. Augmented Intelligence:

Augmented Intelligence involves AI systems working in collaboration with human intelligence to enhance cognitive performance, including learning, decision-making, and new experiences. In the table 4, it is noticeable that Augmented Intelligence is predominantly suggested for tasks with high complexity, both in terms of information and the tasks themselves. These

Figure 2. Visually classifying the various AI applications in e-commerce on complexity

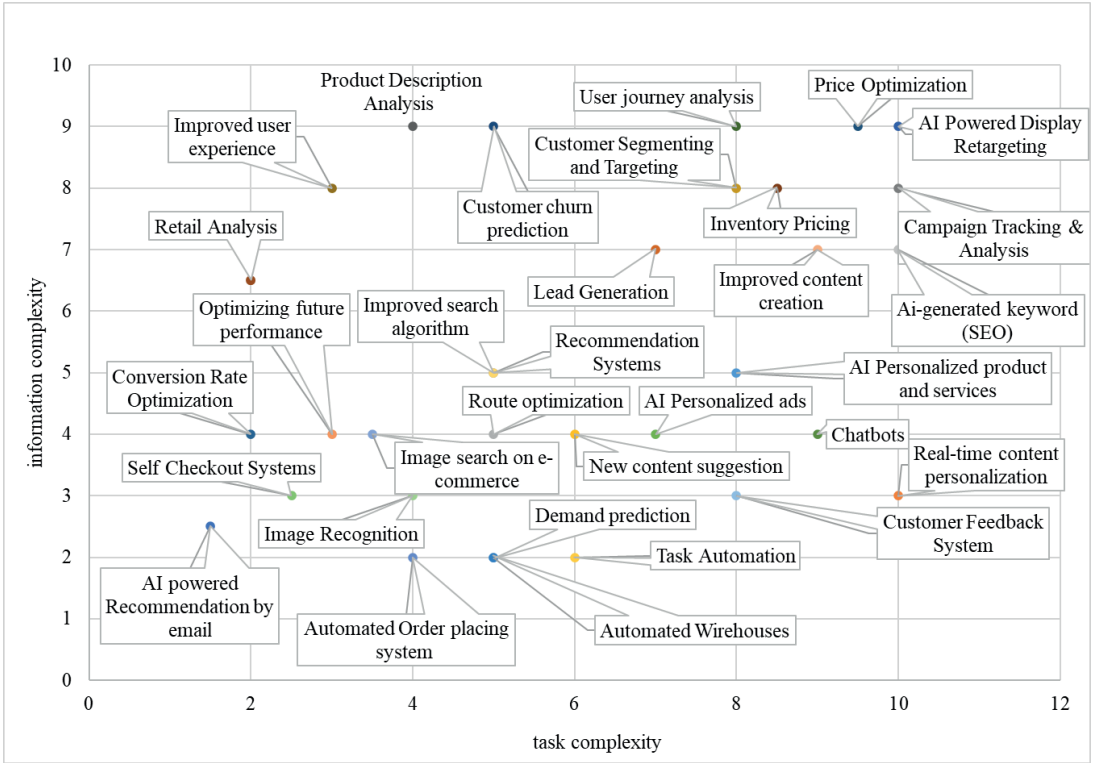


Table 4. The evaluations AI Applications in E-commerce provided by the experts

Dimensions	Items	Information Complexity	Task Complexity	Scope and AI Interpretation	Suggested AI Type
AI Personalization	AI Personalized product and services	8	5	AI tailoring e-commerce products/services to individual customer's preferences	*Augmented Intelligence*
	Real-time content personalization	10	3	Personalizing e-commerce content in real-time based on customer interactions	*Assisted Intelligence*
	AI Personalized ads	7	4	AI serving customized ads to users based on their behaviour and preferences	*Assisted Intelligence*
Intelligent Product Recommendations	Recommendation Systems	5	5	AI suggesting products based on user's past behaviour and preferences	*Augmented Intelligence*
	New content suggestion	6	4	AI suggesting new content based on user's interest and interaction patterns	*Assisted Intelligence*
	AI-powered Recommendation by email	2	3	AI generating personalized product recommendations via email based on user data	*Automated Intelligence*
Improved Products & Services	Conversion Rate Optimization	2	4	AI improving the rate of user conversion through optimization of sales funnels	*Automated Intelligence*
	Retail Analysis	2	7	AI performing analysis on retail data for insights and improvements	*Assisted Intelligence*
	Product Description Analysis	4	9	AI analyzing product descriptions to improve product understanding and categorization	*Assisted Intelligence*
	Improved user experience	3	8	AI enhancing the user experience through personalized interfaces and interactions	*Assisted Intelligence*
	Customer churn prediction	5	9	AI predicting customer churn to help in retention strategies	*Augmented Intelligence*
	User journey analysis	8	9	AI analyzing user journeys to understand and enhance the user experience	*Augmented Intelligence*
Supply Chain	Demand prediction	5	2	AI predicting product demand for better inventory management	*Automated Intelligence*
	Optimizing future performance	3	4	AI optimizing future supply chain performance based on past data	*Automated Intelligence*
	Route optimization	5	4	AI optimizing delivery routes for efficiency and cost reduction	*Automated Intelligence*
	Task Automation	6	2	AI automating routine supply chain tasks for efficiency	*Automated Intelligence*
	Automated Order placing system	4	2	AI system for placing orders automatically based on inventory status	*Automated Intelligence*
	Self-Checkout Systems	3	3	AI powered self-checkout systems for improved customer experience	*Automated Intelligence*
	Automated Warehouses	5	2	AI managing warehouse operations for optimized inventory management	*Automated Intelligence*

Table 4 (Continue). The evaluations AI Applications in E-commerce provided by the experts

Advertising & Sales	Lead Generation	7	7	AI identifying potential customers for targeted advertising	*Augmented Intelligence*
	Campaign Tracking & Analysis	10	8	AI tracking and analyzing advertising campaigns for optimization	*Augmented Intelligence*
	Customer Segmenting and Targeting	8	8	AI segmenting customers and targeting them with personalized ads	*Augmented Intelligence*
	AI Powered Display Retargeting	10	9	AI retargeting potential customers with personalized display ads	*Augmented Intelligence*
Improved Customer Service	Chatbots	9	4	AI powered chatbots for improved customer interaction and support	*Assisted Intelligence*
	Customer Feedback System	8	3	AI analyzing customer feedback for insights and improvements	*Assisted Intelligence*
Product Content Management	Improved content creation	9	7	AI aiding in the creation of enriched and optimized content for better user engagement	*Augmented Intelligence*
	AI-generated keyword (SEO)	10	7	AI generating effective keywords for SEO to enhance visibility and reach	*Augmented Intelligence*
Visual & Voice Search	Improved search algorithm	5	5	AI refining search algorithms for faster and more accurate results	*Assisted Intelligence*
	Image search on e-commerce	4	4	AI enabling image search functionality on e-commerce platforms	*Automated Intelligence*
	Image Recognition	4	3	AI recognizing and interpreting images for various applications such as product identification	*Automated Intelligence*
Dynamic Pricing Optimization	Price Optimization	10	9	AI dynamically adjusting prices based on demand, supply, and other factors	*Augmented Intelligence*
	Inventory Pricing	9	8	AI optimizing inventory pricing based on various influencing factors	*Augmented Intelligence*

tasks often require a nuanced understanding or advanced analytical capabilities, such as lead generation, campaign tracking, customer churn prediction, user journey analysis, AI-powered display retargeting, and dynamic pricing optimization. In conclusion, Augmented Intelligence is academically perceived as an effective way to tackle high-complexity tasks that benefit from human-AI collaboration.

b. Assisted Intelligence:

Assisted Intelligence is where AI systems help humans with tasks but without any self-learning or autonomous decision-making capabilities. Assisted Intelligence is commonly suggested for tasks with moderate information and task complexity. Examples from the table 4 include real-time content personalization, AI personalized ads, new content suggestions, and retail analysis. Assisted Intelligence also plays a crucial role in improving customer service through AI-powered chatbots and customer feedback analysis. Thus, academically, Assisted Intelligence is understood as a reliable AI application to enhance efficiency and effectiveness in moderately complex tasks without the necessity of autonomous decision-making.

c. Automated Intelligence:

This AI type appears primarily in supply chain applications such as demand prediction, performance optimization, route optimization, task automation, automated order placing, and in managing automated warehouses. It's also applied in generating product recommendations via email and conversion rate optimization. Automated Intelligence is typically engaged for tasks requiring high levels of automation, routine tasks, or those needing real-time responses based on predefined rules and parameters. This form of AI is designed to work autonomously, often without any human intervention, making it suitable for tasks that demand high efficiency and speed.

In assumption, the choice between Augmented, Assisted, and Automated Intelligence largely depends on the complexity and requirements of the task. While Augmented Intelligence tends to be employed for complex tasks requiring strategic decisions, Assisted Intelligence often aids in tasks that involve continuous learning from user behaviour and immediate decision-making based on these learnings. On the other hand, Automated Intelligence is primarily chosen for tasks that can be fully automated to increase efficiency and speed.

4. CONCLUSION

The expanding field of artificial intelligence has redefined the way we perceive and conduct business, with e-commerce being one of the industries where it has demonstrated transformative value. This study aimed to investigate AI as a source of value creation within the e-commerce sector. The paper began by providing a theoretical foundation, discussing the origins and evolution of AI, its importance in modern business processes, and the anticipated economic impact it holds for the future.

Through a detailed review of the extant literature, the paper identified various ways in which AI contributes to value creation in e-commerce, including personalization, intelligent product recommendations, product and service enhancement, supply chain efficiency, advertising and sales optimization, improved customer service, product content management, visual and voice search capabilities, and dynamic pricing optimization. These areas were supported by an extensive list of AI applications contributing to value creation in e-commerce, which was then classified according to the complexity of tasks and information they handle.

Consequently, the paper further identified three distinct types of AI - Automated Intelligence, Assisted Intelligence, and Augmented Intelligence - based on their capacity to process varying degrees of task and information complexity. This classification can help businesses in making informed decisions about the right AI applications to employ based on their specific requirements.

In the process of classifying the AI applications, research was leveraged by an expert panel drawn from academia and industry, who evaluated the complexity of tasks and information associated

with each AI application on a 10-point ordinal scale. This not only validated our proposed classification but also resulted in an insightful complexity matrix, providing a comprehensive understanding of how various AI applications are distributed based on their relative complexities.

The implications of this study are multifold. From a theoretical standpoint, it advances the current understanding of AI as a value creator in e-commerce, offering a comprehensive classification of AI applications based on their complexity. From a practical perspective, it offers a roadmap for businesses, particularly those in the e-commerce sector, to understand, adopt, and leverage AI technologies for enhancing their operational efficiency, customer experience, and ultimately, their bottom line.

Despite the significant strides made by AI in e-commerce, it's important to note that the field is still in its early stages. As such, businesses must be open to continuous learning, adaptation, and transformation as AI continues to evolve and revolutionize the business landscape. As we continue to explore the potential of AI in e-commerce, the focus should be on leveraging the unique strengths of both humans and machines to create a more efficient, innovative, and inclusive future.

In conclusion, the emergence of AI in e-commerce offers an exciting prospect for value creation. Businesses that are proactive in adopting AI technologies and aligning them with their business strategies stand to gain a competitive advantage in the ever-evolving digital marketplace. The findings of this study serve as a beacon, guiding businesses on their journey of AI integration and value creation.

4.1. Future Works and Limitations

The current paper presents numerous of opportunities for future research. Such studies will allow us to comprehend the complexity of AI applications in e-commerce and beyond in greater depth. These are the **future research directions**:

Cross-Sector analysis: Further studies could be conducted across different sectors to see if the complexity classification holds true beyond e-commerce.

Temporal assessment: Given the rapid advancements in AI technology, it would be beneficial to conduct this assessment over time to track the evolution of AI applications' complexity.

Comparative analysis: It would be insightful to conduct a comparative analysis using different complexity matrices, thereby potentially highlighting additional insights into the application of AI in e-commerce.

Inclusion of additional complexity factors: Future research could also aim to include other factors contributing to complexity, thereby providing a more comprehensive understanding of AI application complexity.

Similar to other academic endeavours, our research is not exempt from limitations. Acknowledgement of these factors is necessary in order to fully comprehend the extent and potential practicality of our findings. The study was subject to the following limitations:

Subjectivity in expert assessment: Despite efforts to reduce bias in expert evaluations, subjectivity could still play a role in the classification of AI applications' complexity. Each expert brings in their unique perspective and experience which might influence their ratings.

Expert panel size: Although the study included fifteen experts, which is within the acceptable range for such assessments, the conclusions drawn might still be limited due to the relatively small size of the expert panel.

Specificity of the domain: The panel was heavily drawn from individuals with specific expertise in AI and e-commerce. Therefore, the applicability of the findings may be limited in other sectors or disciplines.

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Appendix

Appendix 1. Background information on the expert panel's participants.

No.	Country	Sex	Occupation/ Position	Year of Experience	Sector
1	Azerbaijan	M	Marketing Manager	11	E-commerce
2	Ukraine	F	Marketing Manager	15	Retail
3	Georgia	M	Digital Marketing Specialists	10	E-commerce
4	Turkey	F	Marketing Researcher	12	Banking
5	Azerbaijan	M	Data Analyst	18	Logistics
6	Azerbaijan	F	Marketing Consultant	8	Banking
7	Ukraine	M	Senior Data Scientist	13	Banking
8	Georgia	F	Marketing Manager	14	Technology
9	Turkey	M	Ecommerce manager	12	E-commerce
10	Russia	F	Head of Innovation	14	Retail
11	Azerbaijan	M	Data Analyst	10	E-commerce
12	Ukraine	F	IT Project Manager	7	Banking
13	Azerbaijan	M	Senior AI Developer	9	Banking
14	Turkey	M	Ecommerce Strategist	11	E-commerce
15	Azerbaijan	M	Digital Marketing Specialists	8	Technology

JLECON

Volume / Cilt: 10, Issue / Sayı: 3, 2023, pp. 157-166
E - ISSN: 2148-4139
URL: https://www.journals.gen.tr/jlecon
DOI: https://doi.org/10.15637/jlecon.2091

Received / Geliş: 19.06.2023
Acccepted / Kabul: 26.07.2023

RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

The effects of PPI and CPI in prediction of interest rate value

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Abstract

Interest, which is as old as the history of humanity, is at the center of life today in parallel with the developments in technology and communication. Predicting the future values of interest, which is very important in every field from state administration to individual investments and expenditures, is very important for individuals/companies/states to continue their activities in a stable manner. In pioneering studies, it has been emphasized that the main components of interest are real interest and future inflation expectations. Over time, the effects of goods, money, and international markets on the formation of interest have been analyzed theoretically and empirically. The effects of Central Banks on monetary policies and their long-term reflections have been the aim of many studies in recent history. The fact that the expected inflation in interest studies does not reflect the truth for many times has prevented the right results from being found. For this reason, it is seen that the realized CPI is generally used in estimating the interest rate. In addition, when countries are examined, it is seen that there are significant differences between CPI and PPI. The aim of this study is to empirically investigate which of the CPI and PPI values realized in estimating the interest rate should be used and to what extent.

Keywords: Interest Rate, CPI, PPI, Panel GMM.

JEL codes: E43, E47, C33

Citation/Atıf: YÜZBAŞIOĞULLARI, A. (2023). The effects of PPI and CPI in prediction of interest rate value. *Journal of Life Economics*. 10(3): 157-166, DOI: 10.15637/jlecon.2091

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1. INTRODUCTION

The history of interest, which expresses the economic return or cost of using or lending a resource, dates to ancient times. It has emerged and evolved in different ways according to the needs of civilizations. It was considered a moral crime and banned until the Renaissance and Enlightenment period. Globalization and financial liberalization activities in the world economy in the last 50 years have highlighted the role and functioning of interest. Today, interest is at the center of our lives, including applications for blockchain, fintech, and future markets. In addition to the establishment of macroeconomic models, interest is also one of the basic concepts in the creation of the micro foundations of macroeconomics (Mishkin, 2012, p.459). At the core of financial decisions is the desire to maximize the income of individuals who invest. The main comparison and control point of investment decisions is interest rate (Fabozzi and Peterson, 2003, p.27).

Interest rate is one of the important factors in the formation of the value of exchange rates. In futures or spot markets, since the interest rate differences between countries create arbitrage opportunities, the changes in exchange rates continue until this arbitrage opportunity disappears. Today, due to the developments in communication and technology, this type of arbitrage opportunity is very limited as the markets react very quickly to these imbalances and maintain the balances. Increases in exchange rates, on the other hand, trigger inflation because of foreign trade on the economy. As stated below, one of the most important components of interest is inflation. Therefore, increases in exchange rates increase inflation and interest rates. In other words, there is a interaction between exchange rate, interest, and inflation. Any developments in exchange rate, interest, or inflation force others to change. For this reason, macroeconomic policies must include all three variables at the same time.

There is no optimal value for the interest rate that reflects the underlying macroeconomic conditions. The value of interest rates should be to ensure long-term growth, price stability and the resilience of financial markets (Executive Office of the President of the United States, 2015). For interest rates to be realistic, capital markets must have sufficient technological and legal infrastructure. Macroeconomic stability is the key to keeping interest rates stable and low.

In this study, it is aimed to determine the macroeconomic variables that affect interest rates. First, important studies on the determination of interest rates will be presented. Then, empirical studies to test the theoretical framework studies will be summarized. After specifying the basic features of the econometric method to be used, the results of the econometric study of 12 countries including the variables covering the period will be stated.

2. PIONEERING STUDIES ON THE DETERMINATION OF INTEREST RATES

Determining the future interest rate is very important in a very wide area, from taking any investment decision to bond markets. In this context, many studies have been carried out on the modeling of future interest rates. Handa (2009) emphasized that the traditional classical economists' full employment savings and investment, Keynesian economists' money supply and demand, modern classics money and bond supply and demand without being affected by inflation and post Keynesian economists' monetary policies affect real interest rates. Spahija (2016), on the other hand, examined the meaning and definition of the concept of interest, the independent variables affecting it, the hypotheses, and the proposed policies from four perspectives: Austrian School, Neo-Classical Theory, Theory of Liquidity and Theory of Loan.

The mathematical representation of interest was created with the book "Theory of Interest" written by Irwing Fisher, one of the founders of monetary economy, in 1936. Fisher mathematically explained many concepts such as nominal interest following inflation, the concept of real interest, the opportunity cost of money. He showed the relationship between nominal interest, real interest, and inflation in equation (1). In equation (1), i is r is real interest, nominal

interest, and π^* is inflation (Fisher, 1936, p.173).

$$r = i - \pi^* \quad (1)$$

Again, the relationship between money supply and inflation is shown by Fisher in equation (2). In equation (2), M represents the money supply, V represents the velocity of money, and PY represents the nominal GNP (Pressman, 1999, p.94).

$$M * V = P * Y \quad (2)$$

When equations (1) and (2) are considered together, the increase in money supply increases prices, and the increase in prices increases interest rates, which is called the Fisher effect (Mankiw a, 2003, p.90).

With the IS-LM model, which is one of the foundations of modern macroeconomics, the interaction of output in commodity markets and supply and demand with interest in money markets is presented mathematically and graphically. The IS-LM model, which was designed by Keynes for the closed economy, was adapted to open economies by Mundell-Fleming (Snowdon & Vane, 2005, p.123).

In money markets, supply consists of savings and demand consists of households and individuals' borrowing needs for consumption and investment. Interest rate ensures that supply and demand in money markets come into balance (Mankiw, 2003, p.278). IS-LM curves, which show the equilibrium state of goods and money markets in the macro economy, are also modeled with the help of real interest and real output (Hubbard & O'Brien, 2012, p. 357).

Mathematical representations of IS and LM curves are presented below.

$$Y = C(Y - \bar{T}) + I(r) + \bar{G} \quad (3)$$

$$\left(\frac{M}{P}\right) = L(r, Y) \quad (4)$$

As can be seen from equations (3) and (4), interest rates affect both investments and money markets. In other words, the rise in interest rates has a contractionary effect on investments, decreases expenditures on durable consumer goods, decreases the value of bonds held by households, and indirectly decreases consumption expenditures due to the income effect (Engen & Hubbard 2005). One of the most basic tools for the growth of countries is investment. Since investment is a function of interest, interest policies are extremely effective in the growth of countries. An increase in interest rates causes a decrease in investments.

Whelan (2020), on the other hand, obtained the interest equation specified in equation (5) by combining the Philips curve showing the relationship between inflation and unemployment, the IS curve showing the relationship between output and interest, and the Monetary Policy Rule.

$$i_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*) + \beta_y(y_t - y^*) \quad (5)$$

In the modeling of nominal interest in equation (5), the deviations in the natural value of inflation π^* and the natural value of national income y^* are included in the Fisher model specified in equation (1). Doepke et al. (1999) stated, many studies have been conducted on directing monetary policies according to the rules. It is preferred in terms of credibility and performance that monetary policy makers conduct monetary policy in accordance with these rules. Taylor (1993) has demonstrated how simple, algebraic formulations of such rules would play a role in a world where policy makers cannot and should not be followed mechanically.

Hördahl et al. (2006), on the other hand, modeled the short-term interest in equation (6) by including the Taylor-type short-term interest rate reaction function of the monetary authority in equation (5) by including expectations. In the equation, η_t represents the monetary policy shock.

$$i_t = (1 - \rho)(\beta(E_t[\pi_{t+1}] - \pi_t^*) + \gamma y_t) + \rho i_{t-1} + \eta_t \quad (6)$$

Patterson and Lygnerud (1999) emphasized that while short-term interest rates are determined by the transmission mechanisms of the rates announced by Central Banks, long-term interest rates are created by the markets. They stated that short-term interest rates, inflation expectations, expectations regarding the real economy (such as growth), international markets, exchange rate,

public sector borrowing rate and price/return rates of other assets and growth/demand are affected by the interaction of interest.

Based on modern monetary policies, economic activities are controlled with the help of interest. Interest is directed by Central Banks with the method also called Taylor rule. According to this rule, central banks minimize the movements in the inflation target and lack of production with the help of their policies. Central Banks with the help of policy interest; affect output/inflation/ expectations through interest, asset, credit, and foreign exchange channels. The specified Money Transfer Mechanism is carried out by the Central Banks in accordance with the monetary policy rules (Égert and MacDonald, 2008).

When the balance sheet of the Central Bank is analyzed, its assets include gold, foreign currency and government debts, and its liabilities include the money released to the market and the Central Bank's deposit. Since the central bank is the sole authority in the release of the money supply, it increases the money supply by buying bonds from the market, and decreases the money supply by selling bonds to the market. The central bank fulfills its function of influencing the market by changing the money supply, the amount of foreign currency or debt. The Central Bank uses open market operations to satisfy its monetary policy objectives, to ensure that short-term interest rates in the financial market are formed around the policy rate, and to regulate liquidity. It is not preferred to change the money supply directly, especially considering that it exerts inflationary pressure.

Individuals can react heterogeneously to developments in monetary policies due to reasons such as the failures and imperfections in the functioning of the market stated by the new monetarists and the stickiness in wages and prices emphasized by the new Keynesians. In this case, although the expected reactions are received in short-term interest rates, heterogeneous results occur in the long-term structure of the interest rate. The fact that the same interest rate has different effects on the economy in different countries and/or time periods is also due to heterogeneous changes in the long-term structure of the interest rate. Hur (2006) investigated the effects of changes in US monetary policies on bond markets with the help of impulse response function. He put the change in money markets into the model with M1. He found that the changes in M1 affect all the interests in the bond markets, but the severity of the effect is different, in other words, the returns do not change linearly by differentiation.

In monetary modeling of exchange rate, stable money demand function, balance in money markets, unsecured interest parity and Purchasing Power Parity are used. In other words, there is a significant relationship between the interest rate and the exchange rate. Equilibrium in international markets is provided by the unsecured interest parity and is shown in equation (7) (Heijdra, 2003, p 298).

$$r_t = r_t^* + e^{\cdot e} \tag{7}$$

In equation (7), $e \equiv lnE \;\; and \; e^{\cdot e} \equiv de^e/dt \equiv$ denote $\dot{E}^e$. As can be understood from equation (7), when the interest rate of one country changes, if the interest of other countries does not change, the exchange rate must change to provide the balance. With the help of uncovered interest arbitrage, countries intervene by changing the interest rate according to the developments in the exchange rate. Therefore, the correct calculation of the formation of interest plays an extremely important role in the formation of international monetary policies of countries.

Especially those of the developing countries that apply the fixed exchange rate regime have a serious dependence on the interest rates of the developed countries. A change in the exchange rate results in the developing country changing the interest rates and, in this case, it affects the GNP of the developing country. In their study, Giovanni and Shambaugh found that a 1 point increase in the interest rates of developed countries caused a decrease between 0.1-0.2 in the GNP of developing countries that implement the fixed exchange rate regime (Giovanni and Shambaugh, 2006).

Both developed and developing countries may experience extreme decreases in the value of financial assets due to financial crises caused

by the defense of the fixed exchange rate system, problems in the banking system, and the inability to rollover the debt stock. These crisis situations require quick action due to its self-feeding, uneven distribution of information to individuals, long duration with multiple balances and very costly to society. Some of the most important instruments of governments in crises are monetary and interest rate policies.

When the empirical and theoretical studies are examined, it is seen that the interest rate is affected by inflation. However, in the literature review, no study could be found on which or at what rate both producer and consumer inflation should be used. Since both inflation rates move differently over time, this issue is very important in interest rate estimations.

3. PIONEERING STUDIES ON THE DETERMINATION OF INTEREST RATES

Some studies on interest modeling and its components are presented Table-1.

When the empirical studies mentioned Table-1 are examined, it is seen that the relationship between inflation and interest rate has not been directly tested. In addition, when the literature review was examined, no study could be found on which of the CPI and PPI should be used in the estimation of interest rates.

4. ECONOMETRIC MODELS TO BE USED

The time series will be used to understand the changes in interest rates over time and to predict their future trends. Data from 12 countries will be included in the model with the Panel data method, as it contains more observations and provides statistically more reliable and higher degree of precision. A time series is said to be stationary if its mean and autocovariance do not change over time. Since the data to be used in the study is a time series, first, it is necessary to test its stationarity. Panel unit root test is performed by Levin, Lin and Chu (2002) with the help of the following equation.

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \quad m = 1,2,3. \tag{8}$$

In the least squares method, basic assumptions such as the normal distribution of error terms, the absence of variance and autocorrelation problems between the error terms, and the absence of multicollinearity between the independent variables should be provided. In cases where this assumption cannot be met, traditional methods do not give correct results. Since some of these assumptions could not be satisfied in our study, the Generalized Method of Moments (GMM) method was used. The GMM method is suitable for working with very different data structures such as linear and non-linear models, cross-sectional data, panel data and time series, and parameter estimates are obtained by matching a certain number of theoretical moments with observed moments, and then model validation and hypothesis tests are performed on these estimates.

$$E\left(Z_i' u_i\right) = E\left(Z_i'(y_i - X_i\beta)\right) = 0$$

$$\hat{\beta} = \left(X'Z\widehat{W}Z'X\right)^{-1}\left(X'Z\widehat{W}Z'Y\right) \tag{9}$$

In the equation, Z_i' is a $G * L$ matrix with observable instrumental variables. If the number of instrumental variables *(L)* is greater than the unknown *(K)* , a more general class of estimators is obtained by using a weighting matrix *(W)* in quadratic form (Wooldridge, 2002, p.190).

5. MODELING OF INTEREST RATE MOVEMENTS

Modeling of interest rate, which has a very important role in every moment of life both in the world and in Türkiye, is of vital importance in making economic decisions. Econometric study will be done with the help of equation (1). Panel GMM method was used with the 1995-2021 data of 12 countries (USA, England, Japan, Australia, Canada, Chile, India, South Korea, Singapore, South Africa, Brazil, and Mexico)[1] whose data can be accessed.

In the study, the deposit interest rates of banks (LENDINGINTERERESTRATE) were taken as the dependent variable. The independent variables are Consumer Price Index (CPI),

Producer Price Index (PPI) and Real Interest Rate (RIR). Actual values are used because there is not enough and accurate data on inflation expectations. The difference of this study from other studies is that PPI is included in the study as well as CPI. First, unit root tests were carried out with the help of equation (8) to investigate the stationarity of the series, and the results regarding the stationarity of the series are in Table-2.

Table 1. Some Studies on Interest Modeling And Its Components

Number	Writer	Dependent/Independent Variables	Methods	Conclusion
1	Aksoy and León-Ledesma (2005)	UK and US Treasury Bond interest rate, logarithm of GNP	Unit Root Testing, VAR and Cointegration	There is no long-term relationship between interest and production.
2	Beechey et al. (2008)	Short and long-term interest rates for 10 countries	Unit Root Testing, Cointegration	Nominal interest rates are stable in 10 countries, but cointegration is valid in some countries but does not give the same result for all 10 countries.
3	Kılcı (2019)	Central Bank interest rates and inflation data for Turkey for the years 2005-2017	Unit Root and Fourier Granger tests	The fact that the Central Bank interest rates affect inflation and there is a cause-and-effect relationship.
4	Browne and Manasse (1989)	Data from the USA, England, France, Germany, Italy, and Canada for the years 1971-1989 on interest rates and inflation between 3 months and 10 years	Linear and two-stage linear regression	Short-term interest rates (monthly-2 years) can be used for inflation expectations.
5	Chakraborty (2012)	India's 2006-2011 public deficit and interest data	Unit Root Testing and Asymmetric YES	The increase in the public deficit did not increase the interest rates.
6	Leuvensteijn et al. (2008)	Bank rates (deposit and loan) and Bond indicators of 8 EU countries for the period 1994-2004	Unit root testing, Cointegration and Error Correction Method	Increasing competition in banking reduces the gap between interest rates and increases social benefit.
7	Molefe and Mah (2020)	Budget deficit, GNP, inflation and interest rates of the BRICS countries for the years 1995-2019	Panel unit root, panel cointegration and panel vector error correction model	In the long run, the budget deficit increases the interest rates and creates a crowding out effect.
8	Bauer et al. (2014)	Inflation GNP growth with the bond yields of 10 countries covering the years 1990-2009	Gaussian dynamic term structure model	Presence of a forward premium model in long-term interest rates in developed countries
9	Rudebusch et al. (2007)	Between 1962 and 2005, 10-year and 3-month treasury bonds of the USA, and the growth of GNP	VAR	The finding that changes in the interest premium term have a significant correlation with future GDP growth has not been captured by macroeconomic models.
10	Sun (1992)	Between 1971-1986 US bond rates and CPI	MLE	The assumption of neutrality of money is not consistent.
11	King and Kurmann (2002)	US short-term and long-term interest rates between 1951-2001	VAR and cointegration	It was seen that the assumption of neutrality of money was not consistent and the expectations theory was rejected, and since short-term interest rates are determined by the CBT according to the interest and output gap, this interaction is important in determining the long-term interest rate.
12	Fama (1990)	TÜFE Bond interest rates from 1 to 5 years for the years 1952-1988 in the USA, CPI	Regression	That the real yield of inflation and bond interest rates move in opposite directions in the short run, but they move in the same direction in the long run.

Table 2. Unit Root Tests of Variables

	Levin, Lin & Chu t Sta.	Prob.
LENDINGINTERESTRATE	-2,2870	0,0111
CPI	-10,5505	0,0000
PPI	-8,2189	0,0000
RIR	-2,2255	0,0130

Null Hypothesis: Series have a unit root

In the study, Broadmoney/GDP (BROADMONEY), real interest (RER) and annual growth of GDP (GDPGROWTHANNUAL) are used as instrument variables.

Since the assumptions of the least squares method, such as the normal distribution of error terms, could not be satisfied, Panel GMM was used with the help of equation (9) and the results are presented in Table-3.

Table 3. Panel GMM Results

Variable	Coefficient	t-Statistic	Prob.
CPI	0,5144	3,2417	0,0014(*)
PPI	101,8927	2,5132	0,0127(*)
RIR	0,8632	5,5095	0,0000(*)

Dependent Variable: LENDINGINTERESTRATE

(*)The coefficients are significant at the level of α=0.01

The explanatory power of the study was found to be 0.95. When the results are analyzed, it is seen that the main variable affecting the bank rates is the Producer Price Index, while the effect of the consumer price index and real interest rates is relatively limited. The probability of the J test for the suitability of the instrument set was found to be 0.52, and the suitability of the instrument set is provided. The skewness of the error terms was found to be 0.22 and the kurtosis was 3.5, the Jarque-Bera test was 4.59 and the probability was 0.10. According to these results, it is seen that the error term is normally distributed.

6. CONCLUSIONS AND FURTHER RESEARCH

Interest, which has existed throughout the history of humanity, has been prohibited by religious provisions due to its negative effects. Since the enlightenment era, its use has become widespread in parallel with the economic, political, and technological developments in the world. Over time, with the establishment of institutional structures such as banking, it settled on a legal basis.

Estimating the future value of the interest rate, which is one of the most important determinants of many economic decisions such as investment, production and consumption for households, companies, government, and other countries, is of vital importance today. In addition, the reflection of the monetary policies of the state on the economy is extremely important for policy makers, households, entrepreneurs and other countries. Even a very small policy change regarding the interest rates of the Central Banks of the USA and EU developed countries has great effects in the world.

One of the focal points of today is the creation of projections for the future by modeling the interest rate. Therefore, many studies have been done to understand and model the interest rate. Theoretical and empirical studies have emphasized that interest includes expected inflation and risk premium. In the literature search, no adequate study could be found on which inflation rate or at what rate should be used due to the differences in the movements of CPI and PPI. In this study, it was aimed to determine their relative weights by including CPI and PPI in the same model.

The data of 12 countries whose data can be accessed, and the interest rate are modeled with Panel data. Although the correct result was determined by the least squares method after the stationarity test of the time series, the Panel GMM method was used because the assumptions about the model were not satisfied. Bank deposit rates are the dependent variable, and the independent variables are CPI, real interest and PPI, and the explanatory value of the model is 0.95. Although CPI and real interest have a significant effect on the formation of interest rates, the effect of PPI is relatively much more important.

According to the results obtained, it is considered that it would be appropriate for policy makers to attach importance to PPI in determining interest rates and in their efforts to keep interest rates low. It does not seem possible to expect a stable structure in interest rates without finding a solution to the problems experienced in the PPI within the country and throughout the world. As a result, it is considered that a permanent

decrease in the interest rate will only be possible by reducing the inflation and the real interest rate, which includes the uncertainty/risk premium.

Sufficient data could not be obtained for some developed countries, especially EU countries, and many developing countries. The establishment of the EU and the ECM and the joint publication of the data of these countries prevent the collection of long-term data on a country basis. This situation limits the number of countries to be included in the model. Since countries' studies on expected inflation differ and there is not enough data, actual inflation was used instead of expected inflation in the study. The effect of the policy rates of the Central Banks on the deposit rates could not be included in the study due to the lack of data.

In order to obtain more precise results, the number of countries included in the study should be increased. Due to the insufficient level of publicly available data, obtaining additional data from institutions may further increase the sensitivity of the study. Since countries' studies on expected inflation differ, sometimes healthy results are not obtained and there is not enough data, the results can be confirmed by conducting an econometric study on a country basis. Deposit rates are affected by short-term interest rates, primarily Central Bank rates, for reasons such as risk, return, supply/demand. In this context, due to the problems of accessing comprehensive data on the term structure of interest rates, examining the term structure of interest rates covering a limited number of countries will help to better understand interest rates.

Endnote

[1] Data are from the World Bank and International Financial Statistics (IFS).

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