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Abstract

In the midst of the rapid development of the digital economy in Indonesia, Indonesia continues to strive to keep domestic prices stable. One of a part of digitalization development is the presence of e-commerce, which has the potential to reduce the inflation rate through various channels. Changes in producer and consumer behavior that shift to online markets create a more competitive and transparent market environment. The development of e-commerce is also inseparable from innovations in the financial sector, especially digital payment systems, which are an important component in contributing to the fluidity of e-commerce transactions. However, the behavioral changes that occur can cause bias in the calculation of the consumer price index. We analyze the impact of digitalization through e-commerce on inflation in Indonesia on a national and regional scale. This study also analyzes the impact of payment systems on e-commerce and seek out the possibility of bias in the calculation of inflation. The method used is GMM (Generalized Method of Moments) with a panel data range of 34 provinces from 2018-2023 with monthly frequency. The results of the quantitative analysis are also supported by the findings of the field study. The results of this study show that digitalization through e-commerce consistently has a significant negative effect on national and regional core inflation. The study also finds a positive impact of payment systems on e-commerce transactions and finds bias in inflation calculation. In-depth regional analysis from the representative provinces of North Sumatra, East Java, and South Sulawesi also supports the findings of this study. Based on the results of this study, it is important for Bank Indonesia as a monetary policy maker to strengthen its strategic plan in utilizing digitalization through e-commerce as an effort to control inflation in Indonesia.

Keywords: Digitalization, Inflation, E-Commerce, GMM

JEL Classifications: E31, O33, L81

Disclaimer: The conclusions, opinions, and views expressed by the authors in this Working Paper are those of the authors and do not represent the official conclusions, opinions, and views of Bank Indonesia.

1. Introduction

1.1 Background

The rapid development of technology and digital adaptation has changed the consumption and production behavior of Indonesia's economy activities to become more efficient. The rapid transmission of information between individuals is one of the important aspects in changing consumption and production patterns to be cheaper and to be more efficient. Digitalization will reduce the costs of information transmitted by individuals (Goldfarb & Tucker, 2017). The development of digitalization has provided a new phenomenon in economic activity, especially through the emergence of e-commerce as a utilization of technological innovation. In the span of 2020 to 2023, the growth of e-commerce adoption in Indonesia has consistently recorded a growth of 10% per year.¹ This rapid growth streamed to the value of Indonesia's digital economy, which reached USD 82 billion in 2023 and is expected to increase to USD 210 to USD 360 billion by 2030. About 70% of Indonesia's digital economy share in 2023 was contributed by the value of ecommerce transactions (USD 62 billion).² The large value of the digital economy and the growth of e-commerce transactions are supported by the expansion of internet access that reached 66.48% of the population in 2022.3

E-commerce rapid growth and digitalization in financial sectors are inseparable. The Digitalization in payment systems is considered as an important component in contributing to the success of e-commerce transactions (Alzoubi et al., 2022). Digital payment transaction products in Indonesia are also increasingly diverse such as BI-FAST, QRIS (Quick Response Code Indonesian Standard), Electronic Money, and Internet Banking. The ease of transaction using digital payment instruments encourages people's preference to switch from cash to digital payment instruments. The factors of convenience, ease, and cost savings are the most beneficial aspects of the digital payment system (Ranjith et al., 2021). Amidst the rapid development of digital transactions and payment system innovations, Indonesia still strives to maintain a stable domestic price environment. In the past decade, Indonesia has recorded a significant decline in inflation. This can be seen from the decline in annual inflation from 8.38% in 2013 to 2.61% in 2023.⁴

The development of e-commerce as a sign of digitalization has a significant effect in reducing the inflation rate (Calson-Ohman, 2018). The negative effect of e-commerce on inflation can be explained through the digital transformation in the production, distribution and consumption processes carried out by economic actors. In terms of production and distribution, e-commerce platforms integrate supply chains that reducing operational costs (Kulakov and Vinogradov, 2020; Djuranovik, Puspitasari and Kuntoaji, 2021). These reduced operational costs granting consumers a lower price level (Couture et al., 2018). In addition, e-commerce expands market access and increases price transparency which will further reduce price levels (Lacuesta, Roldan and Serrano-Puente, 2020).

E-commerce, through the expansion of its market share as an implication of digitalization, has the potential to reduce the inflation rate through increased productivity and market competition (Willis, 2004; Charbonneau et al., 2017; Coffinet and Perillaud, 2017). These studies explain that e-commerce will reduce market entry barriers and create a more competitive market structure, allowing

¹ A Data from Badan Pusat Statistik Indonesia 2020-2023

² Google, Temasek, and Bain & Company

³ Badan Pusat Statistik. 2023.

⁴ Badan Pusat Statistik. 2024.

producers to compete in offering low prices to attract consumers. Furthermore, the decline in inflation due to the widespread presence of e-commerce is also confirmed by various studies, not only limited to developed countries, but also developing countries, which shows the global scale and significance of this phenomenon (Calson-Ohman 2018; Kulakov and Vinogradov, 2020; Coban, 2022).

The development of e-commerce is certainly inseparable from innovations in the financial sector, especially digital payment systems, which are considered an important component in contributing to the growth of e-commerce transactions (Alzoubi et al, 2022). An advanced and fast digital payment system can stimulate investors and increase the pace of e-commerce expansion (Asian Development Bank, 2023). In the context of regional cooperation, countries in the Southeast Asian region have released the ASEAN Agreement on Electronic Commerce in order to encourage an integrated digital economy through cross-border e-commerce. The convenience of mobile payments has a significant impact on consumer behavior, which shows that the more convenient mobile payments are, the greater the incentive for consumers to make purchases.

Changes in the behavior of producers and consumers who switch to online markets have the potential to produce bias in the calculation of the inflation rate. The phenomenon of inflation bias is confirmed by several studies. Lunneman and Wintr (2006) found that products traded online have smaller price changes than the price changes listed in the Consumer Price Index (CPI) data. In Indonesia, Anugrah, Irmasari and Iskandar (2019) found that there is a CPI bias in the range of 0.7 - 0.81% amid the development of the digital economy. The findings from these studies show the importance of measuring inflation that also reflects the reality of the growing digital market and online transactions.

Although previous studies imply the important role of digitalization on inflation, especially with the rapid development of e-commerce, most of these studies focus on the context of developed countries such as Europe (Calson-Ohman, 2018; Kulakov and Vinogradov, 2020; Lacuesta, Roldan and Serrano-Puente, 2020), Japan (Jo, Matsumura and Weinstein, 2022), South Korea (Yim et al., 2022) and Turkey (Kazak et al., 2023). However, in the case of Indonesia, there is still a gap that specifically uses e-commerce transaction data to see its impact on the inflation rate. This study will explore the strategy of utilizing digitalization, including digital payment transactions through e-commerce presence for inflation control.

There are several other aspects that are also discussed in this study, such as inflation bias and regional analysis. This study reviews the possibility of inflation bias as an implication of e-commerce development because the price level on online platforms that is lower than offline may reflect a declining price movement of goods and services or a price gap between goods included in the CPI basket and those traded online. Furthermore, this study will also include a review in the regional scope represented by the provinces of North Sumatra, East Java and South Sulawesi. Therefore, the rapid development of e-commerce can be utilized by policy makers to make policies in an effective inflation control strategy, especially in the midst of current global uncertainty.

1.2 Research Objectives

We analyze the impact of digitalization, including digital payment transactions, through e-commerce on reducing the inflation rate in Indonesia and strategies to optimize the role of digitalization, especially e-commerce, in realizing inflation stability in Indonesia. Therefore, several research questions can be analyzed in depth to explore the effects of digitalization through e-commerce on inflation in Indonesia, such as:

- 1. How does digitalization through e-commerce affect the reduction of inflation in Indonesia, both nationally and regionally?
- 2. Is there a bias in the calculation of inflation in Indonesia caused by the shift in consumer and producer behavior due to digitalization?
- 3. What are the strategies in optimizing the role of digitalization, especially ecommerce, to encourage inflation stability in Indonesia?

2. Literature Review

2.1. Theoretical Framework

The theory used as a foundation in this study includes three main parts. First, the theory of inflation and the factors that drive it. Second, the concept of e-commerce as a component of digitalization and its influence on inflation. Third, the potential bias in measuring inflation. The presence of e-commerce causes a difference between prices on online and offline platforms, which in turn will contribute to the occurrence of bias in the measurement of inflation.

2.1.1. Core Price Index

The inflation calculation used by the Central Bureau of Statistics (BPS) can be derived from the Consumer Price Index (CPI) indicator by substracting the CPI in a period (CPI_t) and the CPI of the previous period (CPI_{t-1}), then it is divided by the CPI of the previous period (CPI_{t-1}), and multiplied by one hundred percent or as shown in the following formula:

$$Inflation_{t} = \frac{CPI_{t} - CPI_{t-1}}{CPI_{t-1}} \times 100\%$$

Inflation behavior is influenced by changes in aggregate demand (demand pull inflation) and aggregate supply (cost push inflation). Global and national economic conditions drive the dynamics of aggregate demand and supply which then have implications for the inflation rate (Syarifuddin 2006; Cadarajat, Permata and Prasmuko, 2008; Mankiw, 2018; Anugrah and Pratama, 2018).

2.1.2 The Phillips Curves

In the study of inflation determinants conducted by Yanuarti and Hutabarat (2006), the factors that determine the inflation rate are depicted in the Traditional Phillips Curve model. It illustrates that price dynamics is a backward-looking phenomenon, where the current price level results from market participants' consideration of the price level in the previous period. The Traditional Phillips Curve explains that inflation is a function of cyclical indicators of economic activity represented by the output gap and the lag of inflation. The traditional Phillips Curve equation is formulated as follows:

$$\pi = E\pi + \beta(y - y^*) + \nu \tag{1}$$

where π is inflation, $E\pi$ is adaptive inflation expectations, $(y - y^*)$ is the output gap, and v is supply shocks. Adaptive inflation expectations are positively related to actual inflation because they generate price adjustments by looking at past inflation. Then, the output gap (the difference between actual output and potential output) positively affects the inflation rate. A positive output gap means that actual output is greater than potential output (strengthening aggregate demand). This condition will push up the wage rate and other input costs. This increase in production costs pushes up the selling price. It can be seen that the output gap can go through both demand and supply channels in shaping the inflation rate.

Meanwhile, the New Keynesian Phillips Curve (NKPC) developed by Gali and Gartler (1999) refers to the study conducted by Taylor (1980) and Calvo (1983) explaining the price level is a forward-looking phenomenon. In this model, firms operate in a monopolistically competitive market and the decision to set the selling price is optimal. The behavior of each firm in setting the optimal price in aggregate produces a short-term relationship between inflation and inflation expectations and average real marginal cost as a measure of real economic activity (Yanuarti and Hutabarat, 2006). The relationship between inflation and inflation expectations and average real marginal cost in the NKPC baseline model can be formulated as follows:

$$\pi_t = E\pi_{t+1} + \beta(y - y^*) + v \tag{2}$$

Where $E\pi_{t+1}$ is the forward-looking inflation expectation, π_t is the expectation operator and $(y - y^*)$ is the difference between actual output and potential output. In the NKPC baseline model, current inflation is not affected by inflation in the previous period. However, empirical findings found that current inflation is also affected by the previous period's value. Fuhrer and Moore (1995) showed that the pure baseline NKPC model does not match the empirical findings of inflation characteristics, so they derived a model that incorporates backward-looking inflation and forward-looking inflation into the inflation determinant variables. This model is then referred to as hybrid NKPC, which is formulated as follows:

$$\pi = \pi_{t-1} + E\pi_{t+1} + \beta(y - y^*) + \nu \tag{3}$$

where $E\pi_{t+1}$ is forward-looking inflation, π_{t-1} is backward-looking inflation, $(y - y^*)$ is output-gap, and v is supply shocks.

In the Calvo model, a firm tends to maintain a price equal to marginal cost plus a fixed markup over marginal cost. If the ratio of marginal cost to the aggregate price level increases, then on average, price reviewing firms will raise their selling prices to maintain the fixed markup. The result is inflationary pressure.

Empirically, using marginal cost variables is constrained by data limitations. Some studies have used real unit labor cost as real marginal cost proxy (Gali, Gertler, Lopez-Salido, 2003) and real labor income share (Gali & Gertler, 1999). As explained by Yanuarti and Hutabarat (2006), an alternative proxy for real marginal cost is the output gap. This choice is based on the fact that the output gap is procyclical. When production levels are higher than potential levels, there is increased competition among the available factors of production. When the production cycle is high, it often requires overtime work where the labor cost per unit of product (unit labor cost) during overtime is higher than that during regular working hours. As a result, there is a significant increase in the marginal cost of labor. The significant increase in labor cost is then transmitted to the increased selling price level of the product.

Csonto, Huang and Tovar (2019) elaborate the route by which digitalization, including e-commerce, affects inflation by modifying the New Keynesian macroeconomic model developed by Gali and Gertler (1999). This model allows us to express inflation as a function of past inflation and inflation expectations, output-gap, technology, real returns to factors of production (i.e. real wages) and cost-push shocks (captured by mark-ups over marginal costs and labor mark-ups). Formally, if the firm minimizes its price deviation from the optimal price level, inflation (π_{-t}) can be formulated as follows:

$$\pi_t(d) = \left(1 - \frac{\beta}{1 - \alpha}\right) \pi_{t-1}(d) + \frac{\beta}{1 - \alpha} E_t \pi_{t+1}(d) + \frac{\alpha(1 - \phi)}{(1 - \alpha)\phi} \tilde{y}_t(d)$$

$$-\frac{\alpha}{1-\alpha\phi}\tilde{a}t(d) + \frac{\alpha}{(1-\alpha)\phi}(\tilde{w}_t(d) - \tilde{p}_t(d)) + \frac{\alpha}{1-\alpha}[\mu_t(d) + \nu_t(d)]$$
(4)

Where α is the degree of price rigidity, β is the intertemporal discount factor, and ϕ is the demand elasticity of substitution of various goods with the respective values of α , β , and ϕ ranging from 0 to 1.

Equation (4) above formulates the process to find out how digitalization can affect inflation with various channels. Csonto, Huang and Tovar (2019) divide the effect of digitalization on inflation into three channels. First, digitalization leads to lower expectations of future inflation which in turn lowers the actual inflation rate, although in this study the result is not significant. Second, the decline in price response to output gap or demand pressure due to digitization (which is reflected in the change of Phillips curve slope). Third, the decline in marginal cost as an implication of increased productivity or tighter market competition that will eventually suppress the inflation rate.

The second channel that explains how digitalization, including e-commerce, affects inflation is by reducing the price response to changes in the output gap (Csonto, Huang and Tovar, 2019; Djuranovik, Puspitasari and Kuntoaji, 2021). As explained in the previous inflation theory in the New Keynesian model, the output gap has a positive relationship with the inflation rate. This means that when actual output is greater than its potential level, producers will adjust production levels to accommodate the strengthening demand. An increase in production leads to an increase in wages and production costs which then results in an increase in prices.

Third, through lower cost levels. Digital platforms that directly connect sellers and buyers can eliminate some costs such as physical store rent, employee salaries and others. Market integration also implies lower logistics costs. In addition, online marketplaces also allow producers to offer more frequent discounts and continuous promotions, which in turn reduce price levels.

The effect of digitalization on inflation through the cost channel can also be explained by tighter competition and higher productivity. E-commerce that utilizes the digital landscape provides an almost no entry-barriers to the market. This open market access reduces entry barriers and changes the market structure to become more competitive. This competition then reduces the monopoly power or price markups that can be set by producers. In addition, one of the characteristics of a competitive market is that the high elasticity of demand indicates the weak ability of companies to set prices (price makers). It appears that higher competition prevents producers from increasing prices.

2.2 Inflation Determinants in Indonesia

Aginta (2021) explores the inflation-output dynamics within the Phillips Curve framework. The estimation results show that a one percentage point increase in the output gap is associated with an increase in inflation of about 40 basis points. Inflation persistence or backward-looking inflation is significant in the formation of current period inflation in Indonesia. In addition, Indonesia's inflation is driven by demand pressures, exchange rate movements, international oil price inflation, global price dynamics and domestic rainfall conditions.

Aginta (2021) also examines the relevance of the mining industry for output gap measurement at the regional level in relation to Indonesia's output gap-inflation dynamics and divides the analysis more specifically between Eastern Indonesia and Western Indonesia. The assessment of the output gap by excluding the contribution of the mining sector was based on the findings of previous studies that the prevalence of extractive businesses has a large impact on local economic activity statistics, but a much smaller impact on local social welfare.

The gap between total GRDP and non-mining GRDP occurs because the main revenues from the extractive sector do not go straight to provincial government revenues, but are transferred directly to the central government and both foreign and domestic controlled mining companies (Hill et al., 2008). Thus, the exclusion of the mining sector in GRDP is expected to better reflect provincial demand conditions that influence price dynamics. This becomes relevant when exploring the proportion of the mining sector in the total GRDP of provinces in Eastern Indonesia; such as East Kalimantan and Papua which lose up to 50% of GRDP if the non-mining sector is excluded. Aginta (2021) found that Indonesia's inflation rate is more responsive to non-extractive economic activities, at least at the local level. Furthermore, the response of the output gap - both GRDP and non-mining GRDP - to inflation is higher in the western region compared to the eastern region. In other words, inflation in the western region of Indonesia is more sensitive to the dynamics of local economic activity than inflation in the eastern region. This finding is similar to that in Chinese provinces (Mehrotra et al., 2007).

2.3 Previous Studies

Digitalization as the foundation of e-commerce growth stimulates fundamental transformation in the economic system and ultimately affects macro indicators, such as inflation. Various previous studies have found a significant negative effect of digitalization and e-commerce on inflation, meaning that an increase in digitalization and e-commerce has led to a decrease in inflation rates in various countries (Yi and Choi, 2005; Charbonneau et al., 2017; Coffinet and Perillaud, 2017; Calson-Ohman, 2018; Kulakov and Vinogradov, 2020; Lacuesta, Roldan and Serrano-Puente, 2020).

Yi and Choi (2005) examined the effect of the internet on inflation using panel data of 207 countries in the world for the period 1991 - 2000. They applied pooled OLS and random effects model. They found that 1% increase in the proportion of internet users in a country's population can reduce the inflation rate by 0.04 - 0.13%. Another study conducted by Charbonneau et al. (2017) found that digitalization significantly affects inflation in Canada through three main channels. First, the direct impact on the consumer price index is decreasing due to the declining prices of goods related to Technology, Information and Communication (ICT) as an implication of technological maturity. Second, e-commerce, as a form of technological development in the business world that lowers barriers to market entry and improves competition among producers. Companies have the same opportunity to expand their market and reach potential customers faster through lower prices. Third, digitization influences lower inflation through lower operating costs due to increased efficiency and productivity from automation and new business models. All three channels lead to lower inflation as a result of digitalization.

Csonto, Huang and Tovar (2019) examined a sample of 36 developed and developing countries to see the impact of digitalization on inflation. They found that digitalization has a negative impact on inflation, particularly through mark-up channel driven by higher productivity and online market competition. However, the effect of digitalization on inflation is relatively small where a 1% increase in the digitalization index implies a decrease in inflation of around 0.006%. In addition, digitalization does not significantly affect inflation through the price expectation channel. Nonetheless, digitalization has reduced the response of inflation to unemployment over time, causing the slope of the Phillips curve to become more tapered.

A study conducted by Coban (2022) examines the impact of internet access on inflation in ASEAN-5 countries. Employing the Pooled OLS method, they found that an increase in internet significantly drives down inflation in ASEAN-5 countries. This decline in inflation is due to the existence of the internet which facilitates access to information transfer in a rapid and easy way. The rapid flow of information allows consumers to easily find the desired product at the best price, reducing cost of information. In the case of producers, the unlimited information plays a part in transforming the market structure into a more competitive one and increasing productivity, resulting in lower price levels.

Djuranovik, Puspitasari and Kuntoaji (2021) examined digitalization in influencing inflation dynamics in Indonesia. they found that digitalization is statistically significant through the output gap, marginal cost and future inflation expectations in reducing inflation. Furthermore, the spatial analysis shows that digitalization through the marginal cost channel has a significant negative impact on inflation, while the output gap channel has no significant impact on inflation. For both national and spatial analysis, the control variables have a similar effect, the output gap are positive on inflation, while real effective exchange rate has a negative correlation with inflation.

Then, research conducted by Djuranovik, Puspitasari and Kuntoaji (2021) also found that there were various results in identifying the effect of digitalization on core inflation components in Indonesia such as traded food, traded nonfood, nontraded food and nontraded nonfood). Component fluctuations are influenced by whether products are traded externally or only traded domestically (nontraded), as well as the type of food or nonfood component. Digitalization does not significantly affect core traded food inflation as it is more influenced by food commodity price volatility and the import process. Meanwhile, digitalization only significantly affects core non-traded food inflation through the expectations channel.

2.4 A Potential Bias in Inflation Measurement

The current development of e-commerce changes shopping behavior from offline to online, which in turn contributes to outlet bias in inflation calculation. The shift in consumer shopping preferences from offline to online stores will change the cost of living and may not be captured in the calculation of inflation rates by statistical bureau (Charbonneau et al., 2017). In most cases, the expansion of digitalization will result in lower price levels in online sales compared to offline (Friberg et al. 2000; Yim et al., 2022). This is because online markets are characterized by efficient costs and more widespread market coverage (Charbonneau et al., 2017). This phenomenon has implications for the diversity of products available and saves consumers' energy and time in searching for products. From a producer's perspective, online marketplaces cut some costs such as store rental fees, allowing producers to set lower prices.

In some cases, online purchases do not always have cheaper prices than offline because it depends on the number of products purchased (Friberg et al. 2000). Online purchases in large quantities will receive lower prices. Meanwhile, purchasing only one unit will be lower in price if buying offline. This is due to the fact that online prices include fixed costs for packaging and shipping regardless of the number of items purchased, so one may expect lower price per unit in online stores if buying in large number of quantities.

2.5 The Presence of Flawless Payment System in E-Commerce

Empirical model studies in several countries show that the price level of goods in e-commerce is lower than in offline markets (Freiberg et al., 2001; ECB, 2015;

Cavallo, 2018). In the US, online product prices are on average 5 - 10% lower than prices in offline markets (Cavallo, 2018). A De Nederlandsche Bank (2017) survey found that two-thirds of online transactions save up to 6.5% compared to offline transactions. E-commerce reduces prices through several cost reduction channels, namely transaction costs (Williamson, 1985, 1986; Bakos, 2001; Stockdale and Standing, 2004), search costs (Brynjolfsson et al., 2003, Lendle et al, 2012), menu costs (Smith et al., 2000) and information costs (Brynjolfsson et al., 2003).

The price behavior of goods in e-commerce is different from offline markets. Price variation in e-commerce is higher than in offline markets (Jolivet, 2014; Cardona, M et.al 2015). Prices in e-commerce tend to have greater exchange rate pass-through than prices in offline stores (Gorodnichenko et. al, 2018). In addition, prices in e-commerce are also more volatile because each e-commerce platform applies different pricing strategies (Nygaard and Ragnhild, 2015). This increases the frequency of price changes and the level of price uniformity in e-commerce (Gorodnichenko et. al, 2016; Cavallo, 2018).



Figure 2.1 The impact of e-commerce on the price of goods

Source: Sveriges Riksbank (2015)

The lower prices of goods in e-commerce have the potential to have a disinflationary effect through fiercer competition (ECB, 2015; Riksbank, 2015). E-commerce makes it easier for consumers to compare prices and product quality. Increased consumer awareness of price and quality factors and more varied options reduce sellers' power to increase prices. Sellers will focus on increasing productivity to maintain or increase profit margins so that they can maintain or increase their market share.

The ease of adopting digital payment systems is a crucial factor in determining how easy it is for consumers and sellers to enter the e-commerce. Digital payment systems have become an integral part of the e-commerce ecosystem as they play a vital role in facilitating efficient, secure and convenient online transactions. The presence of digital payment instruments such as electronic money, credit cards, and electronic bank transfers provides wider access for consumers and sellers to make payment in e-commerce.

We take core inflation data as the dependent variable. For the independent variable, we consider the digitalization variable proxied by the e-commerce nominal transaction data. In this case, e-commerce transactions refer to transactions that occur on the Tokopedia, Shopee, Lazada, and etc. The e-commerce transaction variable is an endogenous variable. Therefore, determinants are needed to ensure that the e-commerce transaction variable is a valid proxy for digitalization. The frequency of data used in looking at the determinants of digitalization is annual, covering the years 2018 - 2022. This is due to the availability of data on determinants of digitalization that are generally annual in nature such as electricity supply, digital skills and income levels of people in a region. Thus, the first research objective is answered using monthly data frequency, while annual data to answer the second research objective.

3. Data and Methods

3.1 Data

We employed primary and secondary data. Primary data is in the form of qualitative data obtained through Focus Group Discussions (FGDs) and interviews. We are using monthly frequency data with a time period of 2018-2023 because e-commerce transactions as the main explanatory variable are high-frequency data. In addition, province-level data is more representative in showing inflation dynamics in the New Keynesian Phillips Curve framework, given that province-level data can capture heterogeneity in inflation-output dynamics across Indonesia (Aginta, 2021).

Then, we utilize several other variables as control variables such as the output gap taken from the residuals of the GDRP estimation results, the exchange rate represented by the real effective exchange rate which shows the strength of the rupiah exchange rate against a group of foreign currencies. Furthermore, various variables that are determinants of digitalization are also needed, namely electricity, digital skills and income levels. The various variables that have been described are summarized in appendix (1).

3.2 Empirical Models

We modify the model in equation (4) developed by Csonto, Huang and Tovar (2019) in the previous section to obtain the following model:

$$\pi_{xt} = \alpha + \beta_1 \pi_{x,t-1} + \beta_2 \pi_{x,t+1} + \beta_3 \delta_{xt} + \beta_4 \gamma_{xt} + \beta_5 X_{xt} + \varepsilon_{xt}$$
(5)

inflation rate, π_{xt} , as the dependent variable, δ_{xt} as the digitization factor variable proxied through e-commerce transaction data, and γ_{xt} as the output-gap. Other control variables that considered in the research model as indicated by X_{xt} which is the exchange rate. Meanwhile, ε_{xt} is an error term assumed to follow white noise properties so that $E[\varepsilon_t] = 0$. Equation (5) will also be used in analyzing the effect of e-commerce on inflation at the regional level. Variations in the level of e-commerce adoption and the level of availability on infrastructure supporting e-commerce transactions in each province in Indonesia make the regional level analysis is worth to be explored.

Furthermore, we develop equation (5) to analyze the impact of digitalization through e-commerce on inflation rate disaggregated or divided by product category. Thus, this study can obtain an analysis of the impact of e-commerce on inflation specifically by product category. In this analysis, disaggregated data of national level core inflation will be used due to data limitations. We will divide equation (5) into three equations based on food category using e-commerce transaction variable for food category (Dm_t) , fashion using e-commerce transaction variable for clothing category (Dp_t) , and electronics using e-commerce transaction variable for electronic products category (De_t) . The three empirical models can be written as follows:

$$\pi m_{i,t} = \beta_0 + \beta_1 ln Dm_t + \beta_n X_t + \varepsilon_t \tag{6}$$

$$\pi p_{i,t} = \beta_0 + \beta_1 ln D p_t + \beta_n X_t + \varepsilon_t \tag{7}$$

$$\pi e_{i,t} = \beta_0 + \beta_1 ln D e_t + \beta_n X_t + \varepsilon_t \tag{8}$$

In addition, to answer the second research question regarding strategies in optimizing the digitalization process, especially e-commerce, it is important to look at the factors that determine the development of digitalization. Referring to the study by Guha and Mukerji (2021), technology adoption or digitalization is determined by the market model which is the interaction of demand and supply. Specific to e-

commerce, we refer to the study of Waseem et al. (2019) which also considers the demand and supply side. The supply of electricity (*electricity*_{*i*,*t*}) and digital skills (*Digitalskill*_{*i*,*t*}) represent the digitalization framework, while the income of people in a region proxied by the wage rate (*inc*_{*i*,*t*}) represents the demand for digital adoption. The formulation of equation (9) is built to describe the empirical model of the determinants of digitalization as follows:

$$lnD_{it} = b_0 + b_1 lnelectricity_{i,t} + b_2 Digitalskill_{i,t} + b_3 lninc_{i,t} + \epsilon_{i,t}$$
(9)

Furthermore, to analyze the impact of payment systems on e-commerce, we will be looking at the indirect effect of digital payment systems on the price of goods in e-commerce. The indirect effect will be estimated using the Fixed Effect method as follows:

$$Online_{Seller_{it}} = \alpha Akun_{UE_{it}} + A_{it} + B_t + \beta X_{it} + \mu_{it}$$
(10)

where $Online_{Seller_{it}}$ is the number of sellers in e-commerce, $Akun_{UE_{it}}$ is the number of server-based electronic money accounts in province-i in year-t, A_{it} is the fixed-effect of province, B_t is the time-fixed effect, X_{it} is a set of control variables consisting of population, GRDP and number of Base-Transceiver Service (BTS) landings and μ_{it} is the unobserved component.

This study will also estimate the bias that occurs in inflation calculation due to the development of e-commerce. E-commerce causes consumers' shopping behavior to shift to online markets, which in turn affects outlet bias as one type of bias in inflation measurement (Goolsbee and Klenow 2018; Anugrah, Irmasari and Iskandar, 2019). The calculation of outlet bias in this study focuses on updating the calculation of outlet bias in Indonesia for the period of 2023. The estimation uses secondary data in the form of Consumption Value (NK) in the base year 2018 and online transactions for a number of CPI basket commodities in 2023. Outlet bias is estimated by comparing online commodity prices in e-commerce with offline commodity prices in the CPI basket by stages:

- 1. Online commodities are grouped according to the SBH 2018 grouping (11 groups). Subsequently, the share of transaction value of each group to the total e-commerce transactions was calculated.
- 2. We obtained the price difference between online and offline outlets from the difference in price growth in the online commodity group (%yoy) and inflation in the current year CPI commodity group (%yoy).
- 3. Outlet bias is measured by multiplying the Laspeyres index to the online share and the price difference between online and offline goods.

The Laspeyres Index is computed as follows:

$$I_n = \frac{\sum_{n=1}^{k} \frac{P_{ni}}{P_{(n-1)i}} (P_{(n-1)i} \cdot Q_{0i})}{\sum_{i=1}^{k} P_{0i} \cdot Q_{0i}} x \ 100$$
(11)

 I_n : N_{th} month index

 P_{ni} : Price of commodity type i in month n

 $P_{(n-1)i}$: Price of commodity type i in month n-1

 $P_{(n-1)i}.Q_{(0i)}$: Consumption of commodity type i in month n-1

 P_{oi} . Q_{0i} : Consumption value of commodity type i in the base year

3.3 Methods

We use a panel data structure as in equation (5). Referring to Csonto Huang and Tovar (2019), the e-commerce variable is endogenous which causes bias in the estimation. The issue of endogeneity in e-commerce variables is addressed by estimation using the Difference GMM method introduced by (Hansen, 1982; Arellano-Bond, 1991). GMM is designed to overcome endogeneity by using relevant instruments to estimate model parameters consistently. The J-Hansen statistic that is also generated in the GMM analysis helps to establish the validity of the instrumental variables. When we fail to reject the null hypothesis means that the instrumental variables, we use Two Stage Least Squares (2SLS) to overcome the endogeneity issue.

Specifically for the disaggregated model by product categories (equations 6, 7, and 8), we use time series data at the national level with the Two Stage Least Squares method used to analyze the linear relationship between the dependent variable and one or more independent variables at a given time.

We also use a simple quantitative method in estimating the outlet bias that arises in the calculation of inflation as an implication of the development of digitalization through e-commerce. Crawford (1993) method can be the basis in calculating outlet bias. This method compares the inflation rate of a particular retail outlet (in this case an online store or e-commerce) with the CPI inflation rate released by the statistical agency. This method measures the comparison of the inflation rate of the two outlets through the average price of the products sold in each outlet and also considers the weight of the product according to the weight in the price index basket released by the statistical bureau.

Qualitative methods were then used in this research in the form of Focus Group Discussions (FGDs) and interviews (field surveys). FGDs and field surveys were conducted to provide a comprehensive analysis, especially at the regional level, in analyzing two topics that became the research questions. First, to identify the impact of digitalization through e-commerce on inflation reduction. Second, to explore strategies in optimizing the role of digitalization through e-commerce to encourage price stability with the scope according to the region where the activity is carried out. The structure of the field survey questions can be seen in Appendix 2.

4. Results

4.1 Descriptives

Table 4.1 shows the results of descriptive statistics of the various variables used in the model. Variables such as inflation, nominal e-commerce transactions (trxecom), outputgap, and exchange rate (reer) consisting of 2,448 observations derived from data of 34 provinces in Indonesia with monthly frequency in the time period 2018 to 2023. This observation period is based on the availability of e-commerce data owned by Bank Indonesia.

Furthermore, model 2 analyzes product disaggregation inflation against ecommerce transactions based on product categories with the three highest nominal transactions. The variables used are disaggregated inflation (food, clothing, and electronics), e-commerce transactions (food, clothing, and electronics), exchange rate (reer), unemployment rate (unemp), and other control variables such as pandemic period dummy (covid) and Pertalite fuel price (fuel). The data used in this model is monthly national data with a time period of 2019-2023. Model 3 analyzes the determinants of digitalization in an effort to optimize the potential of digitalization through e-commerce. The model uses nominal e-commerce transaction variables (trxecom), digital skills (digiskill), the availability of electricity in an area (electricity) and the level of community income proxied by the level of wages (wages). The variables used in model 2 have a total of 204 observations in the form of data for 34 provinces in Indonesia with an annual frequency from 2018 to 2023.

VARIABLES	Obs	mean	s.d.	Min.	Maks.	Q1	Q2	Q3
inflasi (%)	2448	2,40	0,90	0,25	5,66	1,73	2,34	3,01
trxecom	2448	709,5	1.543,5	3,76	11801	44,60	142,98	484,78
(miliar)					.75			
output gap (%)	2448	-1,59	1,52	-2,44	3,39	-0,87	-0,15	0,96
Nilai tukar	2448	100,15	2,61	93,86	105,7	98,10	99,83	102,31
(REER)					1			
listrik (GWh)	2040	7.247,83	12.174,	183,32	54.48	1.058,13	2.595,05	5.252,6
			05		0,28			9
digiskill (%)	2040	62,84	15,22	24,23	93,98	52,07	64,23	74,73
Rata-rata upah	2040	2,87	0,66	2,01	5,53	2,37	2,66	3,19
(Rp juta)								
Unemp (%)	60	3,69	0,37	2,96	4,31	3,35	3,62	3,99

Table 4.1 Descriptive Statistics

The various research variables in table 4.1 show both national and regional information. Throughout the study period, the average inflation in Indonesia was 2.40%. Spatially, the highest inflation rate was in North Sulawesi Province in November 2019 at 5.66%, while the lowest inflation was in Bali Province in June 2021 and East Kalimantan in July 2021 at 0.25%. The *e-commerce* variable is proxied through nominal transactions in Rupiah. At the national level, the nominal value of *e-commerce* transactions has an average of IDR 709.50 billion. DKI Jakarta has the highest *e-commerce* transaction value reaching Rp 11.8 trillion in November 2022. In contrast, the lowest transaction value occurred in West Papua Province in June 2018 with a value of around Rp 3.76 billion. This is in line with the higher distribution of *e-commerce merchants* in Sumatra and Java-Bali regions relative to Eastern Indonesia (Central Bureau of Statistics, 2023).



Figure 4.1 Inflation Rate (yoy) and E-Commerce Growth in Indonesia

Source: Bank Indonesia, Author's calculation

Figure 4.1 illustrates the movement of inflation rate and total *e-commerce* transactions in Indonesia from February 2018 to December 2023. The growth of *e-commerce* in this graph is represented by the nominal value of transactions in the

four largest e-commerce in Indonesia. In general, e-commerce transactions in Indonesia show an increasing trend. This upward trend is accompanied by fluctuating inflation movements. The inflation rate experienced a downward trend from February 2018 to 2020, but afterward the inflation rate tended to increase. This inflation movement is also similar to the inflation movement at the regional level (See Appendix 3). This change in the pattern of inflation movement is allegedly influenced by the disruption caused by the Covid-19 Pandemic. The pandemic phenomenon causes a shock to the economy on both the supply and demand sides. Social restrictions that occurred in the early period of the pandemic limited economic activity and increased layoffs which contributed to a decrease in people's purchasing power, resulting in a decrease in inflation even to the regional level (Yuniarti et al., 2020; Nugraha et al., 2022). Indonesia's e-commerce growth also slowed down in the early period of the pandemic due to this decline in purchasing power (Ridhwan et al., 2023). Afterward, various efforts were made to boost the economy that could regain people's purchasing power and eventually increase inflation, but still at a manageable level (Coordinating Ministry for Economic Affairs, 2022). However, it should be noted that CPI inflation consists of core inflation, volatile food and administered prices. Therefore, in addition to the effects of the pandemic, the movement of CPI inflation is also driven by fluctuating external factors stemming from weather influences and geopolitical influences (volatile food inflation) as the invasion of Ukraine by Russia in February 2022 is in line with the inflation rate which tends to rise a month later. In addition, government policies (administered prices inflation) such as raising subsidized fuel prices in September 2022 also showed an increase in inflation after the implementation of the policy. Thus, CPI inflation cannot be used as an appropriate proxy to analyze the impact of *e-commerce*.

Core inflation is best used in looking at the disinflationary impact of *e*commerce. Core inflation excludes the prices of highly fluctuating goods and services such as food and energy. Meanwhile, *e-commerce* usually focuses on consumer goods that are more stable in price. Hence, the impact of *e-commerce* on these prices is more relevant to measure through core inflation. In addition, core inflation is also influenced by supply-demand interactions where this market equilibrium is affected by digitalization (Djuranovik et al., 2021). Figure 4.2 shows the movement of core inflation and *e-commerce* growth in Indonesia from 2018 to 2023. The growth of *ecommerce* is accompanied by a declining trend of core inflation. This shows that the efficiency and price formation resulting from digitalization through *e-commerce* can reduce the core inflation rate.



Figure 4.2 Core Inflation Rate (%) and *E-Commerce* Transactions in Indonesia Source: Bank Indonesia, Author's Calculation

4.2 Estimation Results

4.2.1 Digitalization on Core Inflation

In response to the first research objective, which is to examine the effect of digitalization through *e-commerce* on reducing the inflation rate in Indonesia, we utilized data on inflation rates and *e-commerce* transactions in various provinces in Indonesia. The dependent variable used in this study is core inflation for which data is available at the provincial level.

Table 4.2 Estima	ation Results	s of the	Effect of	E-Commerce	Transactions	on	Core
		Inflatio	on in Ind	onesia			

VARIABLES	Inflation
Lntrxecom	-0,055***
	(0,019)
f.inflation	0,789***
	(0,018)
Outputgap	0,338*
	(0,204)
lnreer	-0,289***
	(0,042)
Observations	2414
R-squared	0,656
Number of Provinces	34

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Calculation

Table 4.2 above confirms the negative effect of *e-commerce* transactions on Indonesia's core inflation. A 1% increase in *e-commerce* transactions is associated with a 0.055% decrease in core inflation. These regression results confirm previous studies that found the effect of digitalization, including *e-commerce*, on reducing inflation (Calson-Ohman, 2018; Csonto et al., 2019; Kulakov and Vinogradov, 2020, Djuranovik et al., 2021).

Previous studies explain the negative relationship between digitalization and inflation through three transmissions. First, the inflation expectation channel where the development of digitalization increases transparency and information disclosure in the market, thus keeping prices at a low level. Second, digitalization reduces the price response to output-gap due to cost reduction resulting in increased efficiency in production and high flexibility in the market, hence reducing the steepness of the slope of The New Keynesian Phillips Curve. Assuming that the initial capital is fixed, the costs that can be cut from the production process such as shop rent, electricity and others lead to an increase in production capacity. In aggregate, the increased production capacity also increases the level of potential output. However, demand fluctuations will be offset by a faster increase in supply and in turn, prices will tend to be more stable. Third, through lower production costs. Technology adoption increases producer productivity and leads to more efficient production costs. The changes in costs due to digitalization also affect the price formation behavior of producers. Fiskara et al. (2023) found that online markets in Indonesia have highly competitive market characteristics and price changes occur periodically because they

are responsive to market shocks. With efficient production costs and competitive online market characteristics, the prices formed in the market are competitive.

The control variables also significantly affect the movement of core inflation, including forward-looking inflation expectations, output gap, and exchange rate. Forward-looking inflation expectation has a significant effect of 0.789 on core inflation. This result shows that core inflation is influenced by forward-looking inflation expectations. This finding is consistent with the findings of Puspitasari et al. (2019) on the characteristics of inflation in Indonesia, which shows that future inflation expectations have a greater influence on the inflation rate than past inflation expectations.

4.2.2 Digitalization on Disaggregated Inflation

A further specific analysis was conducted to examine the effect of digitalization on the three largest contributing components of e-commerce transactions in Indonesia, namely: (1) food products; (2) clothing products; and (3) electronic products. The estimation results of the effect of digitalization on product disaggregated inflation can be seen in appendix 4, 5, and 6.

The coefficient of e-commerce transactions consistently has significant effect on reducing food inflation. In model (1), a 1 percentage point increase in e-commerce transactions in the food product category significantly reduces inflation by -0.738%. Then, the unemployment variable does not significantly affect food inflation. This can happen because food inflation in Indonesia is generally influenced by supply-side factors (Ismaya and Anugrah, 2018). In model (2), a 1-point increase in the percentage of e-commerce transactions in the food category significantly reduces inflation by -0.700%. Real exchange rate appreciation also significantly affects food inflation by -0.085%.

The coefficient of e-commerce transactions is also consistently significant in reducing clothing inflation. In model (1), a 1 percentage point increase in e-commerce transactions in the clothing product category significantly affects clothing inflation by -1.022%. Then, the unemployment variable significantly affects the decline in clothing inflation by -0.678%. In model (2), the effect of the e-commerce transaction variable becomes small when the unemployment variable is not considered in the model. A 1 percentage point increase in e-commerce transactions in the clothing product category significantly affects clothing inflation by -0.234%. Real exchange rate appreciation also significantly affects clothing inflation by -0.035%.

Moreover, the coefficient of e-commerce transactions is also consistently significant in reducing electronics inflation. The largest effect of *e-commerce* transactions on reducing electronic inflation is achieved in Model (1) when the real exchange rate control variable is not considered in the model at -0.208. In Model (2), the effect of *e-commerce* transactions in the electronic product category on electronic inflation becomes small when the *unemployment* variable is not considered in the model at -0.077.

4.2.3 Digitalization on Inflation: Regional Analysis

Referring to Mehrota (2007), exploring inflation dynamics at the regional level is very relevant for countries with large geographical conditions to accommodate cross-regional differences in the form of institutions, economic and market structures as well as economic and trade relations between regions. In addition, incorporating regional variation into regional analysis can improve the precision in estimating inflation dynamics within the framework of the New Keynesian Phillips Curve (NKPC) theory. Thus, exploring the effect of e-commerce transactions on inflation at the regional level is relevant given that the western part of Indonesia (17 provinces in the Sumatra and Java-Bali regions) accounts for more than 80% and 82% of the country's population and Gross Domestic Product (GDP), respectively. In contrast, the eastern region only accounts for about 20% of the country's population and GDP.

	JAWABALI (1)	SUMATERA (2)	KTI (3)		
VARIABLES	Inflation	Inflation	Inflation		
Intrxecom	-0.151***	-0.085***	-0.083***		
F.inflation	(0.048) 0.783***	(0.031) 0.805***	(0.028) 0.796***		
Outgap	(0.049) 0.153**	(0.030) 0.130**	(0.024) 0.146*		
Reer	(0,067) -0.388***	(0,062) -0.222***	(0,087) -0.303***		
	(0.109)	(0.064)	(0.062)		
Hansen J	0.025	0.170	0.120		
Endog	0.082	0.010	0.301		
Observations	497	710	1207		
R-squared	0,645	0,677	0,651		
Num. of Provinces	7	10	17		

Table 4.3 Digitalization on Regional Inflation: Estimation Results

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Calculation

Table 4.4 above shows that the negative effect of *e-commerce* transactions on inflation is also found in all regions, with the largest to smallest coefficient found in Java-Bali region of -0.151, Sumatera of -0.085, and Eastern Indonesia Region (KTI) of -0.083, respectively. The consistency of the negative effect of *e-commerce* on inflation in all Indonesian regions is also confirmed by Djuranovik et al. (2021) who found that the inflation-decreasing effect of digitization in Indonesia also occurs at the regional level.



Source: DIDD BI, Author's Calculation

Figure 4.3 Share of E-Commerce Transactions based on Region in Indonesia

According to the DIDD data in Figure 4.3, the proportion of the nominal amount of *e-commerce* transactions in the Java-Bali region is 79% of the total *e-commerce* transactions in the span of 2018 to 2023. Meanwhile, Sumatra only contributes 12% of the total *e-commerce* transactions and followed by the KTI region at 9% of the total *e-commerce* transactions.

4.3 In-Depth Analysis of *E-Commerce* Environments: Regional Analysis Approach

We seek out an in-depth analysis to further explore the behaviors of consumers and producers in e-commerce that represent Indonesia in general. We explored e-commerce developments in three regions of Indonesia (East Java, North Sumatra, and South Sulawesi), including e-commerce transaction trends, the challenges they face, and their impact on regional economies, particularly on regional inflation. First, Java Island, Indonesia's growth centers, which dominate economic activity and support Indonesia's GDP more than any other province.

The growth of e-commerce in East Java has shown a significant increase in recent years. The nominal transaction in 2023 reached Rp59.75 trillion, an increase of 108.7% compared to 2020. Surabaya is the main center with a contribution of 28.58% of total transactions, followed by Sidoarjo and Malang. The main constraint to evenly distributed growth is unequal internet access, with 33.69% of entrepreneurs choosing not to use e-commerce due to low digital literacy. Local governments and the private sector are working to improve this condition through digital training for MSMEs and the development of infrastructure on internet access. The fashion category dominates e-commerce sales in East Java with a share of 21.76%, followed by personal care (14.01%). However, intense price competition leads to a decline in profit margins, especially as manufacturers sell directly on the platform. To overcome this, some entrepreneurs adopt a strategy of different pricing schemes between physical and online stores, adjusted to product margins. Fastmoving food products have a small contribution in e-commerce due to consumer preference for direct purchase in traditional markets (see Appendix 7).

Second, North Sumatera, the province where the major city of Medan is located. E-commerce in North Sumatra is driven by increased digital literacy and competitiveness. In terms of transaction volume, North Sumatra experienced a growth of 36.02% in 2024, although the nominal transaction fluctuated. Fashion and personal care categories remain favorites. Government programs such as "Fast Track Digitalization of 1000 MSMEs" have helped improve digital literacy and overcome key challenges such as limited human resources and access to technology. Digitalization allows MSMEs to expand their market, but there are still constraints on financing, human resources, and technology infrastructure. Pricing strategies such as discounts and promos are used to attract consumers in e-commerce. Therefore, the local government is seeking to strengthen inter-regional collaboration and business partnerships to support MSMEs. However, many small businesses still rely on offline sales due to high platform administration costs (see Appendix 8).

Third, In South Sulawesi, Makassar City dominates e-commerce transactions with a share of 58.2% of total transactions. Demand is dominated by fashion products (28.95%) and personal care (15.84%). However, challenges such as uneven internet infrastructure and low digital literacy hinder market expansion. The government has introduced regulations and initiatives to support MSMEs through mentoring and digitalization of business processes, including the launch of APPAKABAJI application to facilitate MSMEs. E-commerce has a significant impact on price competition, particularly for fashion products, with a more limited effect on food products. Consumers utilize price transparency to compare the best deals,

driving price efficiency. Also, E-commerce has shown a positive impact on local economic growth, especially through price transparency. However, its influence on the fast-moving goods category is still limited. Improving supply chains and strengthening infrastructure are important steps to increase e-commerce's contribution to price stability and economic growth. Logistics and distribution cost challenges remain a constraint. In the upcoming years ahead, optimizing e-commerce requires improvements in digital infrastructure, literacy training, and collaboration with platforms to reduce administrative costs for MSMEs. Government programs continue to focus on equalizing digital market access across regions (see Appendix 9).

4.4 Digitalization Determinants

Waseem et al. (2019) breaks down the determinants of the expansion of digital adoption through e-commerce into three main factors. First, technological factors relating to ICT infrastructure and digital devices as a framework for digitalization. Second, social factors, focusing on non-monetary factors that enable access to digitalization such as education level and digital literacy. Third, economic factors, emphasizing economic and business aspects in encouraging someone to use ecommerce.

Meanwhile, Guha and Mukerji (2021) look at digitalization penetration using a market framework. In general, digitalization makes the market more efficient through lower production costs and increased productivity. On the demand side, key determinants of digitalization penetration include social and economic household characteristics, such as age, education level and economic status. The supply side includes various factors that present the availability of digitization processes such as electricity availability and mobile network quality.

VARIABLES	Intrxecom
lnlistrik	0,867***
	(0,000)
digskill	0,041***
	(0,000)
lnupah	0,483**
	(0,004)
Constant	-6,485***
	(0,000)
Observasi	2040
R-squared	0,883
Number of provinsi	34

Table 4.4 The Digitalization Determinants

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 Source: Author's Calculation The availability of electricity in a region is a key factor in the level of ecommerce adoption in a region. The regression results show that the availability of electricity that supports the occurrence of transactions in e-commerce has the greatest influence with 0.867%. This is encouraged by the findings of Twi-Brempong et al. (2019) who found that electricity is a fundamental infrastructure in operating e-commerce. We emphasize that the availability of electricity supply is necessary in using digital devices which are then used for online shopping. In addition, access to electricity also allows producers to enter the online market more easily. Access to electricity complements the benefits of access to the internet and mobile networks to accelerate e-commerce adoption.

Another digital infrastructure can complement the role of electricity availability in e-commerce penetration in Indonesia. Starting with internet access, which reached 79.5% nationally in 2023 and has had a positive trend since the last five years (APJII, 2024). At the regional level, BPS data for 2022 shows that more than 80% of households in 28 out of 34 provinces in Indonesia have internet access. In addition, based on a survey conducted by Kominfo (2023), access to cellular phone signals has reached 94% of respondents in non-3T areas and 88% of respondents in 3T areas. These data indicate the good development of digital infrastructure in Indonesia. This development of digital infrastructure to the regional level will support the sustainability of the online market in Indonesia.

Then, household income level represents the individual economic aspect in looking at e-commerce penetration in Indonesia. An increase in income allows for greater e-commerce transactions. This is confirmed by the positive effect of income level on increasing e-commerce transactions by 0.48%. This is in line with the findings of Jati et al. (2023) that the amount of one's income increases the demand for purchasing goods online.

4.5 Bias Measurement on Inflation

Due to the dynamics of the economy, including the impact of digitalization on household consumption trends, this may affect the measurement of inflation in Indonesia. Laspeyres Index fails to capture changes in spending behavior as well as the cost of living due to digitalization. This phenomenon leads to a bias measurement on inflation. Furthermore, to explain the current inflation dynamics in the midst of the growing digital era and changes in consumption preferences, it is necessary to calculate bias as an indicator.

Studies related to the measurement of inflation bias have been conducted in various developed and developing countries. Sabourin (2012) stated that the bias in calculating inflation in Canada was 0.2% on average per year from 2005 to 2009. In addition, the study of Hausman and Leibtag (2009) found an upward bias in US inflation with an average of 0.32%-0.42% in the food group in the CPI for the period 1998-2001. On the other hand, a study by Filho and Chamin (2012) in the period 1987-2002 concluded that the calculation bias in Brazil's CPI figure was 4.5% per year, or 3.5% higher than the published inflation. Meanwhile, a study by Wuryandani et al. (2004) found a bias in Indonesia's CPI of 0.47-1.26% and an upward bias. Lubis et al. (2024) suggested that the total measurement bias in the Indonesian CPI is currently in the range of 0.42% to 0.81%, with a higher lower bound than previous studies, although the range of bias is smaller. These results are mainly driven by higher outlet bias in line with changes in people's consumption preferences for online shopping (e-commerce).

CPI	Values (%)
Avg. Inflation	2,610
Avg. Price Gap	0,757
Onlie Market Share	7,900
Outlet Bias	0,216
Previous Study result	0,370-0,810

Table 4.5 Bias Measurement Result

Source: Author's Calculation

The largest bias was observed in the transportation group and the lowest in the housing, water, electricity, gas and other fuels group. The largest bias is in the transportation group (appendix 10) which could be due to: i) competition between transportation service providers is intense in the digital market. This forces companies to provide more aggressive discounts or special offers to attract customers, which is not always reflected in the offline market. Meanwhile, offline markets may be more dominated by fares regulated by the government or transportation associations, making them more stable and less flexible in price changes, ii) digital transportation services often have lower operating costs as they do not require the operational costs of physical terminals or large distribution networks, iii) consumers in digital markets have easier access to compare prices and choose cheaper options, encouraging companies to offer more competitive prices. Meanwhile, the lowest bias occurs in the housing, water, electricity, gas and other fuels group. This is possible because: i) potential buyers can compare house prices across multiple platforms so that prices remain competitive in both offline and online markets; ii) both offline and digital home sellers often use property agents to sell their homes. Agent commission fees that tend to be the same affect the price similarity between the two markets; iii) house prices are more influenced by local factors such as location, economic conditions, and local market demand; iv) government regulations regarding property taxes, electricity tariff prices, water, gas and other fuels apply equally to both offline and online transactions, helping to maintain price similarity in both markets.

4.6 The Effects of Payment Systems on E-Commerce

Modernization of payment infrastructure has encouraged innovation in digital payment tools, such as electronic money, fast payment, and Quick Response code Indonesia Standard (QRIS). The adoption of digital payments by the public has also increased. electronic money has grown positively at a significant level since early 2021. Electronic money transaction volume grew 34.9% (yoy) in July 2024. The growth of server-based electronic money accounts moves in line with the development of transactions in e-commerce (Appendix 11).

Table in appendix 11 shows a share of payment methods used in e-commerce transactions were still dominated by Bank Transfers and Electronic Money. As can be seen from the growth per year, transactions through cash and "Buy Now Pay Later" experienced the highest growth. Meanwhile, bank transfer and electronic money methods tend to slow down. On the other hand, transactions through kiosks/minimarkets have decreased. This indicates an increasing trend of customers making transactions by utilizing digital payments (Appendix 11). In the spatial dimension, interconnections between provinces continue to increase, indicated by an increase in average degree. Average degree measures the average number of connections (degree) at each node in the network. In e-commerce, each connected

agent is considered a node, while transactions between agents are considered connections (Appendix 11).

Furthermore, table in appendix 11 explains that the number of *server-based* Electronic Money accounts is associated with the number of sellers or *merchants* on *e-commerce* platforms in all models used. To be more specific, some exception for model 4 which includes all control variables—was statitistically insignificant. As of today, the "unbankable" people face barriers to be participated in various economic activities due to not having a basic saving account, this also means they cannot make a transaction in e-commerce. The E-Money has opened the opportunity for "unbankable" people to have a basic saving account through the adoption of serverbased E-Money. Allowing them to participate in e-commerce, both as sellers and buyers. Therefore, E-Money is indicated as a digital transaction method in the community that is directly connected to financial inclusion and digital economy (online trading activities).

5. Implication / Policy Recommendation

- 1. The finding of a declining effect on inflation as an effect of increased transactions in *e-commerce* implies Bank Indonesia along with the Government needs to encourage the development of e-commerce. The government also needs to work on strengthening e-commerce in maintaining price stability by considering to provide price comparison features on e-commerce platforms to help consumers make better decisions and prevent price monopoly among producers, so that prices are better capped. Consumer and merchant education on price ethics and cooperation between various related parties can also contribute to a more stable and transparent e-commerce environment.
- 2. The finding of bias in inflation measurement implies the need to pay attention to traditional inflation measurement in reflecting the impact of e-commerce on prices. It is necessary to adjust the basket of commodities available at online prices with offline price commodities so that the deviation between online and offline prices is smaller. Therefore, BPS should consider measuring prices of goods in online markets, not only in offline markets, to obtain more accurate inflation figures.
- 3. The government also needs to strive for infrastructure equality in supporting the smooth implementation of e-commerce transactions. This can be done by ensuring the availability of evenly distributed electricity as a fundamental infrastructure for the implementation of e-commerce platforms, especially the availability of electricity outside Java Island to increase online transaction activities through e-commerce. Then, MSMEs as business actors in encouraging e-commerce transactions need to get end-to-end support and assistance to encourage the application of digitalization. Strategic and synergistic efforts are needed between the central and regional governments in encouraging the level of digital literacy of Indonesian consumers and producers.

6. Conclusion and Further Research

This study conducts an empirical review of the effect of digitalization through ecommerce on inflation in Indonesia using nominal e-commerce transaction data as a proxy for e-commerce and core inflation with national and regional data levels. Based on the results of this study, the following conclusions are drawn:

- 1. The growth of e-commerce transactions in Indonesia has a negative effect on reducing core inflation in Indonesia, both at the national and regional levels.
 - The effect of e-commerce transactions is consistently found to be significantly negative on product disaggregation inflation in the three dominant e-commerce product categories of food and beverages, clothing, and electronics with the highest degree of influence in the clothing category.
 - The effect of digitalization through e-commerce transactions on reducing inflation is found in three regions of Indonesia which includes Java-Bali, Sumatra, and KTI with a greater degree of effect in the west such as Java-Bali compared to the eastern region such as KTI.
- 2. This study also examines the possibility of bias in the calculation of inflation. Based on the basket, the largest bias is recorded in the transportation group while the lowest is in the housing, water, electricity, gas and other fuels group. The result of the bias calculation on inflation measurement is slightly lower, this study found a bias outlet of 0.216 compared to the previous bias calculation study. Taking into account the results of the measurement bias, an inflation target with a range of $\pm 1\%$ is still relevant to be applied in setting the national inflation target.
- 3. In the review of optimizing digitalization to drive the smooth implementation of Indonesia's digital economic activities, especially e-commerce, the following conclusions were obtained as follows:
 - Through analyzing the indirect effects of payment systems on inflation in Indonesia, this study finds that the number of Electronic Money accounts in Indonesia has a significant effect on the increase in the number of sellers on e-commerce platforms. The presence of digital payment instruments such as electronic money, credit cards, and electronic bank transfers provides wider access for consumers and sellers to conduct payment transactions in e-commerce.
 - Infrastructure adequacy is important in supporting the smooth implementation of e-commerce transactions. Through the analysis of the determinants of digitalization, it is found that electricity is the most fundamental infrastructure in the smooth implementation of e-commerce transactions. Another important infrastructure is the level of internet penetration. In addition to supply-side factors, demand-side factors also contribute to the smoothness of e-commerce transaction activities. This study found that the level of individual digital expertise contributes to the determinants of digitalization.

Other findings related to the consumer behavior survey on Indonesian ecommerce show that the reasons for using e-commerce are more efficient and cheaper. While the most popular product categories based on consumer surveys are clothing, care and beauty, and electronics.

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Appendix

No	Variables	Description	Scale	Hypotheses	Sources
1	Inflasi	Core Inflation	%		BPS
2	E-commerce	Nominal Transaction in e-commerce	Billion Rp	-	BI
3	Output gap	Residual of GDP Estimation	%	+	BPS
4	unemp	Unemployement Rate	%	-	WDI
5	Nilai tukar	Real Effective Exchange Rate	%	-	Bruegel
6	Covid	Dummy COVID-19 Period			
7	Fuel	Price of Pertalite	Rp ribu	+	BPS
8	uprod	Labor Forces	Jiwa	+	BPS
9	Listrik	Percentage of Households by Province and Source of Lighting from Electricity (Percent)	GWh	+	BPS
10	Keahlian Digital	Proportion of Adolescents and Adults 15-59 Years of Age with Information and Computer Technology (ICT) Skills by Province	%	+	BPS
11	Tingkat Upah	Average wage of workers by Province	Rp Juta	+	BPS

Appendix 1. List of Variables

Pelaku	Question Magnitude						
E-Commerce	Item Category						
representative	Buyer demographics						
	Payment method preferences of sellers and buyers						
	Pricing scheme						
	Number of merchants						
Entrepreneurs	Business profile						
	Pricing scheme						
	Registration & onboarding experience on e-commerce platforms						
	Account or e-money opening experience						
	Store preference (e-commerce or physical)						
	Challenge						
Government	Regulation of buying and selling on e-commerce platforms						
Representative	MSME sales program on e-commerce platforms						

Appendix 2. FGD and Survey Questions

Appendix 3. Inflation and E-Commerce



	(1)	(2)
VARIABLES	inffood	inffood
lntrxecom_food	-0,738**	-0,700**
	(0,358)	(0,312)
f.inffood	0,853***	0,778***
	(0,077)	(0,076)
unemp	-0,030	
	(0,376)	
reer		-0,085**
		(0,038)
covid	1,026**	1,014***
	(0,399)	(0,368)
Infuel	4,729***	5,730***
	(1,678)	(1,500)
Constant	-15,609**	-11,707**
	(6,982)	(5,223)
Observations	59	59
R-squared	0,780	0,788

Appendix 4. E-commerce Transactions on Food Inflation

Appendix 5. E-Commerce Transactions on Fashion Inflation

	(1)	(2)
VARIABLES	inffashion	inffashion
Intrxecom_fashion	-1,022**	-0,234**
	(0,496)	(0,105)
1.inffashion	0,622***	0,815***
	(0,152)	(0,048)
unemp	-0,678**	
	(0,306)	
reer		-0,037***
		(0,010)
Constant	11,907**	5,946***
	(5,602)	(1,637)
Observations	59	59
R-squared	0,888	0,928

	(1)	(2)
VARIABLES	inftech	inftech
lntrxecom_elektronik	-0,208***	-0,077**
	(0,071)	(0,037)
f.inftech	0,624***	0,882***
	(0,120)	(0,047)
unemp	-0,252***	
	(0,091)	
reer		-0,008*
		(0,004)
Constant	2,366***	1,345**
	(0,815)	(0,604)
Observations	59	59
R-squared	0,896	0,870

Appendix 6. E-Commerce Transactions on Electronics Inflation



Appendix 7. In-Depth Analysis: East Java Graphs

Growth in the Nominal and Volume of e-commerce Transactions



Growth in the number of merchants in East Java involved in e-commerce (Buyer Province)



Share of E-commerce Transactions by Regency/City in East Java (Buyer Province)



Share of E-commerce Transactions by Product Category (Buyer Province)



Appendix 8. In-Depth Analysis: North Sumatera





Development of the Number of Merchants in North Sumatra



				Input				Output			Penunja	ng
Tahun	Peringkat	Skor	Sumber Daya Manusia	Penggunaa TiK	an Pengeluaran untuk TIK		Perekonomia	n Kewirausahaan dan Produktivitas	Ketenaga- kerjaan	Infrastruktur	Keuangan	Regulasi dan Kapasitas Pernda
2024	•	46.0	49,9	58,8	40,1		29,5	35,9	40,3	67,2	45,9	67,4
2024	9	46,0	Perubahan	pilar y	ang signifik	a	n					
2023	10	43,4	Output	P	Kewirausahaan dan Produktivitas	9	,3 †	Pemprov mengg (KUMKM) melalu Bermartabat. Pela pelaku KUMKM se	elar pelatiha i program Fi tihan dilakuki ihagai <i>digitol</i> i	n untuk 1000 ast Track Dig an selama tiga	pelaku kop italisasi (FT bulan untuk handal	erasi dan UMKM D) 1000 KUMKM : menjadikan para
2022	13	38,2						perand reprinting of	ougu ugrur	narreter Julip	non loon.	
2021	13	34,2	Input	X	Sumber Daya Manusia	6	i,4 †	Pemprov dan mitr Smart Digital Lead untuk menghasilk	a dari Cambri er – Sumut Be an 30 pemim	dge University rmartabat set pin di Sumate	menyeleng agai bagian ra Utara.	jarakan pelatihan dari program DLA
2020	12	31,4	Penunjang		Regulasi dan Kapasitas Pemda	4	,3↓	Meskipun Angka H 2021 menjadi 69, rata nasional 71,9 memenuhi standa	larapan Hidu 6 tahun pada 1 tahun. Hal in 14 sarana pras	p mengalami k 2022, angka i i disebabkan i iarana baru m	enaikan dar ini masih jau oleh jumlah encapai 269	i 69,2 tahun pada Jh di bawah rata- rumah sakit yang 6. ³³

Fast-Track Digitalization Survey



Growth of E-commerce Transaction Value in 2021-2024 in North Sumatra





E-commerce Transaction Volume Growth Chart 2019-2024



E-commerce Payment Methods by Nominal Number of Transactions in TW II-24 in North Sumatra

Transaction Volume by Product Category in Q2 2024



Appendix 9. In-Depth Analysis: South Sulawesi

Comparison of Nominal Growth of Transactions to and from South Sulawesi



Comparison of Transaction Volume Growth to and from South Sulawesi



Comparison of Transaction Amounts and Buyer and Seller Regions







Comparison of Population and Share of E-commerce Users



Share Growth Based on Transaction Amount



Growth of Nominal Share of E-Commerce Transactions by Product Category



Growth of E-Commerce Transaction Share by Seller Location (District/City) 2018-



2023

E-Commerce Nominal Share Growth by Seller Location (Product Category) 2018-2023



Comparison of Transaction Amount Based on Buyer Location and Seller Location



E-commerce Payment Method Preferences



Correlation between GRDP Growth Rate and Nominal Growth Rate of E-commerce Transactions in South Sulawesi

Appendix 10. Measurement on Inflation Bias

KELOMDOK	2023			
KELOWIPOK	Inflasi Online	Inflasi SBH	Deviasi	
INFORMASI, KOMUNIKASI, DAN JASA KEUANGAN	-1,07	-0,12	0,95	
KESEHATAN	0,31	2,49	2,18	
MAKANAN, MINUMAN, DAN TEMBAKAU	4,48	4,89	0,41	
PAKAIAN DAN ALAS KAKI	-1,50	1,17	2,67	
PERAWATAN PRIBADI DAN JASA LAINNYA	0,62	4,36	3,75	
PERLENGKAPAN, PERALATAN, DAN PEMELIHARAAN RUTIN RT	2,21	2,71	0,51	
PERUMAHAN, AIR, LISTRIK, GAS DAN BAHAN BAKAR LAINNYA	2,18	2,06	-0,11	
REKREASI, OLAHRAGA, DAN BUDAYA	0,36	2,07	1,71	
TRANSPORTASI	13,41	8,16	-5,25	

Appendix 11. E-Commerce on Digital Payment Instruments



Jenis	Jenis Pembayaran						
Situs	Tunai	E-Money	Kartu Kredit	Mini-	BNPL	Lain-	Transfer
			/Debit Online	market		nya	Bank
Situs A	4,54%	31,61%	6,46%	2,49%	6,71%	0,02%	48,17%
Situs B	4,63%	26,07%	1,96%	7,45%	5,39%	0,00%	54,49%
Situs C	2,89%	24,36%	26,61%	0,75%	12,55%	1,42%	31,75%
Situs D	46,94%	23,92%	1,04%	0,27%	10,60%	5,83%	13,17%

E-Commerce and Electronic Money Transaction Volume







E-Commerce Transaction Volume by Product Category



Spatial Interconnection of Online Commerce in 2018



Spatial Interconnection of Online Commerce by 2023

Dependen	variabel:	log(jumlah	penjual	e-commerce)
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Variable	Model 1	Model 2	Model 3	Model 4
log(jumlah akun server-based)	0.129** (0.064)	0.115* (0.065)	0.109* (0.063)	0.259 (0.071)
Jumlah BTS		0.00004 (0.0000)	0.00004 (0.0000)	0.00000 (0.0000)
log(PDRB)			0.872* (0.449)	3.857** (1.669)
log(jumlah penduduk)				-0.012 (0.016)
Constant	9.835*** (0.993)	10.068*** (1.026)	-7.022 (8.771)	-64.144* (33.087)
Time fixed effect	Yes	Yes	Yes	Yes
Provinsi fixed effect	Yes	Yes	Yes	Yes
Jumlah observasi	660	165	165	116

*** 1%, ** 5%, *% 10%. Angka dalam kurung merupakan standard error

Analysis of the Effect of the Number of Server-based Accounts on the Number of Sellers in E-Commerce



Commodity Basket: Online Availability



Interconnections based on Product Categories