

## STUDY ON THE IMPACT OF E-COMMERCE DEVELOPMENT ON INFLATION IN THE EURO AREA

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This article explores the impact of e-commerce development on inflation in the euro area. Low inflation in the euro area has been a concern for policymakers since the global economic crisis. Economic growth and inflation have recovered in many countries, but in the euro area, growth has remained sluggish and inflation low. As a result, to reach its inflation target the European Central Bank cut its policy rate to zero and implemented several non-standard monetary measures. The possible cause of the disinflation could be digitalization and e-commerce development. With the development of digital technology and the internet, company competition may increase, and costs will decrease. The main hypothesis of the study is that the developing e-commerce sector may channel into lower consumer inflation. The e-commerce development was measured by two indicators, namely a share of online purchases by individuals and a share of purchases by enterprises via a computer network. To evaluate the impact of e-commerce, a panel database on 19 euro area countries was compiled. Initially, a cross country analysis shows no negative relationship between e-commerce development measures and inflation. However, a basic linear panel model with fixed effects and a panel vector autoregression showed negative impact of e-commerce development and digitalization on inflation. As a result of a panel analysis, the hypothesis of the disinflationary impact of e-commerce was generally confirmed. However, given a weak relationship between e-commerce development and inflation in a basic cross-country analysis, the negative relationship was likely attributable to the ongoing upward e-commerce development trend. The trend has a natural cap of 100%, meaning that this disinflationary factor will eventually fade away. For many countries, in 2019, the share of online purchases by the population was below 50%. Should the trend stop, inflation in the euro area may accelerate. Among other factors hindering the e-commerce development and digitalization are tighter information technology regulation and worsening international trade relations.

**Keywords:** e-commerce, digitalization, inflation, eurozone, panel linear model, PVAR, monetary policy

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## ИССЛЕДОВАНИЕ ВЛИЯНИЯ РАЗВИТИЯ ЭЛЕКТРОННОЙ ТОРГОВЛИ НА ИНФЛЯЦИЮ В ЗОНЕ ЕВРО

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В статье рассматривается влияние развития электронной коммерции на инфляцию в зоне евро. Низкая инфляция в зоне евро была проблемой для мировой экономики после глобального экономического кризиса. Экономический рост и инфляция восстанавливались во многих странах, но в зоне евро рост остался вялым, а инфляция низкой. В результате Европейский центральный банк для достижения целевого показателя по инфляции снизил ставку до нуля и принял ряд нестандартных мер денежно-кредитной политики. Возможной причиной дезинфляции может быть цифровизация и развитие интернет-торговли. С развитием цифровых технологий и интернета конкуренция компаний может повыситься, а издержки

снижаются. Основная гипотеза исследования заключается в том, что развивающийся сектор электронной коммерции может привести к снижению потребительской инфляции. Развитие электронной коммерции измерялось двумя показателями: долей покупок через интернет физическими лицами и долей покупок предприятий по сети. Для оценки влияния электронной торговли была собрана база данных по 19 странам еврозоны. Первоначально межстрановой анализ не выявил отрицательной связи между показателями развития интернет-торговли и инфляцией. Однако базовая линейная модель панельных данных с фиксированными эффектами и векторная авторегрессия показали негативное влияние развития электронной коммерции и цифровизации на инфляцию. В результате панельного анализа гипотеза о дезинфляционном влиянии электронной коммерции была в целом подтверждена. Однако, учитывая слабую взаимосвязь между развитием интернет-торговли и инфляцией в базовом межстрановом анализе, отрицательная связь, вероятно, была обусловлена продолжающимся трендом развития интернет-торговли. Тренд имеет естественный предел в 100%, т.е. этот дезинфляционный фактор со временем исчезнет. Пока еще у многих стран в 2019 году доля покупок населения в интернете была ниже 50%. В случае останова тренда инфляция в зоне евро может ускориться. Среди других факторов, сдерживающих развитие электронной коммерции и цифровизацию, могут быть более жесткое регулирование информационных технологий и ухудшение международных торговых отношений.

**Ключевые слова:** интернет-торговля, цифровизация, инфляция, зона евро, панельная регрессия, панельная векторная авторегрессия, ДКП

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## Introduction

Consumer inflation is becoming a more and more important indicator around the globe. Stable price growth may reduce uncertainty for economic agents and support general economic activity. The monetary policy in many countries now involves inflation targeting aimed at achieving a sustainable target level of inflation.

Despite loose monetary policy in the euro area, inflation remains low amid the expansion of e-commerce and digitalization. The mechanism behind the disinflation caused by digitalization and e-commerce expansion may lie in increasing competition and cost reduction. These channels were statistically confirmed in [1]. Internet access made it easy for consumers to find and purchase any goods or assets from a vast variety of suppliers. On the other hand, this availability could reduce the barriers for the suppliers and sellers, spreading information about the goods and distributors. This view was cited in [2]. Moreover, the internet allows substituting traditional distribution channels for enterprises reducing their costs. This aspect of digitalization and e-commerce impact on inflation was studied in [3]. The authors measured the impact of digitalization at about -0.04 to -0.13 percentage point on inflation from a 1% increase in the percentage of internet users to the total population.

Papers [2], [4], and [5] show the similarity between offline and online price dynamics. However, online prices change more frequently. These studies were conducted on the shopping platform database and a price-comparison website. This also means that price indices could reliably represent the actual price dynamics even if they were based on offline prices.

Digitalization may also lead to higher productivity. Papers [2, 6, 7] advocate that increased productivity arising from digitalization of various sectors may eventually lead to slower inflation. Firstly, increased productivity may result in lower costs. Secondly, automatization and new skill requirements for new technologies may result in job displacement. Therefore, labor income and aggregate demand would be suppressed. The related framework was described in [2] and [6]. In article [7] authors highlight the importance of large multinational corporations for lower inflation. New technologies and the development of e-commerce allow large technology companies to increase their market share. Higher market

concentration may lead to higher income inequality and lower demand. Paper [8] studied heterogeneity of companies due to technology diffusion. The authors revealed a productivity gap among companies and singled out a group of the most productive large multinational corporations.

The object of this study is inflation dynamics in the euro area.

The goal of this study is to estimate the impact of e-commerce development on inflation, given the country-specific parameters and the European Central Bank's monetary policy.

The objectives of this article are:

- 1) To reveal a statistical relationship between e-commerce development and inflation;
- 2) To estimate the impact of e-commerce development based on a panel model;
- 3) To estimate the impact of e-commerce development based on a PVAR model and compare it with the panel model estimate in 2);
- 4) To compare the impact of monetary policy with and without accounting for the e-commerce development.

The main hypothesis of this article is that the e-commerce development and digitalization may have a disinflationary impact. Since the low global inflation now mostly concerns developed economies, the study considered the euro area. Besides, the euro area is an interesting case due to an unconventional monetary policy conducted by the European Central Bank (ECB) and heterogeneity of the country-members.

The standard instruments of monetary policy of the ECB include short-term interest rates regulation via open market operations, required reserves rate, and standing facilities [9]. Apart from the standard measures, many central banks have implemented unconventional measures of monetary policy, which include negative interest, forward guidance, and asset purchases programs. The ECB also introduced these unconventional measures following the world economic crisis to improve its monetary policy efficiency. The ECB sets the level of short-term interest rates in the economy via standard policy measures, while the quantitative easing policy expands the ECB's balance sheet and allows to manage the long-term interest rates.

The specifics of the euro area are the heterogeneity of the economies reflected by the economic dynamics and the debt level across countries. The banking sector also plays an important role in the monetary policy transmission in the euro area. The ultra-low interest rate environment suppresses margins for the banking sector, though it could be offset by other sources of income.

### Research methodology

To test the impact of monetary policy on inflation, we can use statistical and econometric analysis. After a preliminary statistical analysis, two econometric models were estimated. The variable of interest in both models was consumer inflation measured by the harmonized index of consumer prices at the national level. This indicator was built on similar consumer baskets across countries. This makes it comparable in the cross-country analysis. We employed a linear panel model for inflation with fixed effects as a basic model. This model was estimated via the within estimator. For inference, the clustered standard errors were used. The basic model has the following specification:

$$y_{i,t} = \alpha + \beta X_t + \theta_i + \varepsilon_{i,t}, \quad (1)$$

where  $y_{i,t}$  is the HICP growth,  $\alpha$  is a constant,  $\beta$  is a coefficient vector,  $x_t$  is the matrix of explanatory variables,  $\theta_i$  is an individual effect,  $\varepsilon_{i,t}$  is a random error.

Several global and local (at the euro area and the country level, respectively) explanatory variables were used in the model. We collected annual data from several sources, namely the ECB's database, Eurostat, the World Bank database, and the Federal Reserve database. The unbalanced panel spanned from 2010 to 2018 and included all the euro area economies (19 countries).

Global variables in the model are:

• Short-term interest rates (lagged Euro Overnight Index Average rate, EONIA), which reflect standard monetary policy;

- The ECB balance sheet (assets, YoY), which reflects non-standard monetary policy;
- Nominal effective euro, YoY (lagged by two periods);
- Crude oil price (Brent, YoY);

Local variables are:

- Retail trade turnover (except motor vehicles and motorcycles, YoY);
- Unemployment rate;
- General government budget surplus/deficit (% of GDP);
- General government debt (% of GDP);
- Trade openness measured by the sum of exports and imports as a percentage of GDP;
- Enterprises purchasing via computer networks (% of all enterprises);
- Individuals' online purchases (at least one purchase over the last twelve months, % of all individuals).

The e-commerce indicators restricted the overall sample from 2010, while the other indicators were available from earlier years. The e-commerce indicators were treated as exogenous, given they associated with e-commerce penetration and consumer preferences.

One of the potentially endogenous variables in the baseline specification above is standard monetary policy instruments reflected by EONIA (the ECB reacts to the inflation dynamics, setting the level of short-term interest rates). EONIA directly depends on the monetary policy stance, more accurately reflecting the situation in the banking sector than the main refinancing operation rate. Another potentially endogenous indicator could be the ECB's assets, which reflect the non-standard monetary policy implemented by the ECB to improve the monetary policy transmission mechanism.

As an extension of the basic specification, a panel vector autoregression (PVAR) model was used, which was described in recent papers [10]. This model incorporates interaction among endogenous variables and may give an economic interpretation regarding efficiency of a monetary policy. However, the model requires more observations for the estimation and accurate inference.

The PVAR model in this paper has the following specification:

$$y_{i,t} = \alpha + \sum_{m=1}^k B_m y_{i,t-m} + CX_{i,t} + \delta_i + \varepsilon_{i,t}, \quad (2)$$

where  $y_{i,t}$  are local and global endogenous variables,  $x_{i,t}$  are exogeneous variables,  $\alpha$  is a global constant,  $\delta_i$  reflects fixed effects,  $B_m$  and  $C$  are coefficient matrices, while  $\varepsilon_{i,t}$  are random shocks.

We conducted the estimation via the generalized method of moments. Nominal effective exchange rate dynamics and population e-commerce indicators were treated as exogenous variables in the model, while the HICP growth and EONIA were set endogenous.

The response to monetary policy shocks is the point of interest, while the effect of e-commerce could be inferred from the coefficient estimates. The orthogonalized impulse responses were used to calculate the response from monetary shocks.

## Results

In contrast with our hypothesis, an initial cross-country analysis showed a weak positive relationship between e-commerce and inflation over the last five years (Fig. 1). This could be attributable to other country-specific factors, affecting inflation.

The largest share of online purchases among individuals was in the Netherlands, Luxemburg, and Germany. The share of online-buyers in the euro area was below 60% on average.

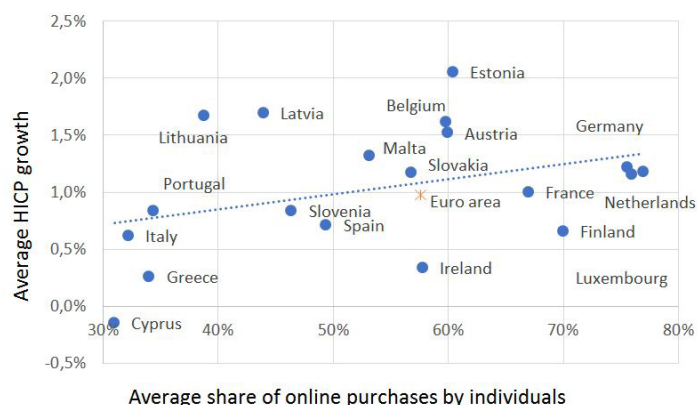


Figure 1. Inflation and online purchasing indicators as a percentage of all in the euro area (2015–2019)

Source: ECB, Eurostat, authors' estimates

However, the chart below (Fig. 2) illustrates a rather negative relationship between inflation and indicators of online purchases for individuals and enterprises over time. The inflation dynamics were sluggish in 2015–2019 (about 1% on average) amid an increasing percentage of online purchases. This may indicate that the upward trend of e-commerce development suppressed inflation dynamics.

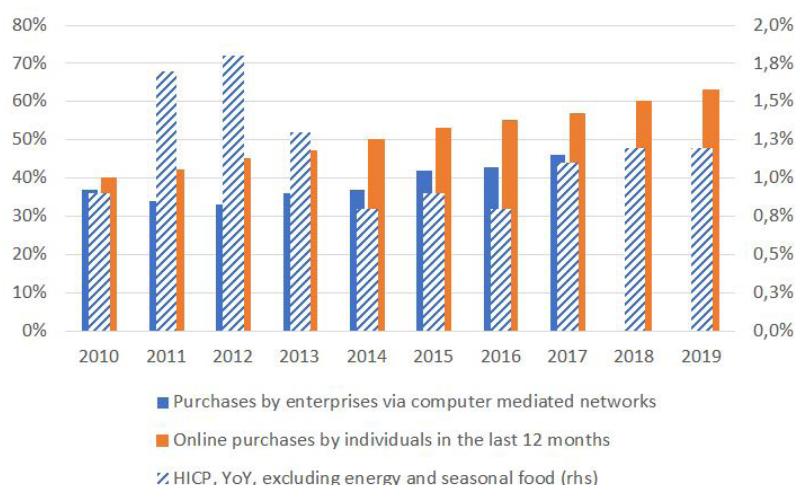


Figure 2. Inflation and online purchasing indicators as a percentage of all enterprises and individuals in the euro area

Note: the last available data on enterprises was for 2017.

Source: ECB, Eurostat

The panel model allows for exploring the cross-country impact of e-commerce in more detail. Table 1 illustrates the results of the baseline linear panel model estimation with fixed effects. Fixed effects were used based on the Hausman test results.

Several specifications were used to obtain robust estimates. In all the specifications EONIA, Brent, e-commerce for individuals, and the ECB assets (YoY) were significant. Given the three specifications, the coefficients are generally in line with economic intuition. Among inflationary factors are Brent price growth, the ECB's asset growth, and retail sales growth. Other factors showed a disinflationary effect. The EONIA rate demonstrated a disinflationary impact as a standard monetary policy instrument. Most importantly, both e-commerce variables showed a disinflationary effect, which was in line with the main hypothesis of this paper.

**Table 1. The estimation results of the baseline linear panel model  
(three specifications with different sets of variables)**

	(1)		(2)		(3)	
	HICP growth		HICP growth		HICP growth	
ECB assets, YoY	0.016	***	0.016	***	0.016	***
	(0.003)		(0.003)		(0.003)	
EONIA (lagged)	-1.760	**	-2.012	***	-2.047	***
	(0.759)		(0.759)		(0.759)	
Brent, YoY	0.029	***	0.029	***	0.029	***
	(0.003)		(0.003)		(0.003)	
E-commerce, individual	-0.123	***	-0.125	***	-0.125	***
	(0.030)		(0.030)		(0.030)	
NEER, YoY (lagged)	-0.027		-0.030		-0.031	
	(0.025)		(0.025)		(0.025)	
Retail sales, YoY	0.014		0.008		0.009	
	(0.025)		(0.025)		(0.025)	
E-commerce, companies	-0.019		-0.021	*	-0.021	*
	(0.013)		(0.013)		(0.013)	
Unemployment	-0.159	*	-0.152	*	-0.155	*
	(0.080)		(0.080)		(0.080)	
Openness			-0.011		-0.010	
			(0.016)		(0.016)	
Debt			-0.003		-0.003	
			(0.020)		(0.020)	
Surplus/deficit					-0.007	
					(0.184)	
R-Squared	0.653		0.658		0.658	
Observations	153		153		153	

Note: positive gauge of NEER reflects appreciation.

\* means 10% significance

\*\* means 5% significance

\*\*\* means 1% significance

Clustered standard errors are in the parentheses.

Source: authors' estimates

To extend the baseline model, the PVAR model was estimated (Table 2). Since the data were scarce, the model was restricted by only one lag and a smaller set of variables. The EONIA and HICP growth were set endogenous, while the ECB asset growth, the e-commerce indicator for individuals, and NEER were treated as exogenous. Before the PVAR estimation, the local variables were tested for the unit root, applying the test proposed in [11]. HICP growth was stationary, while the population e-commerce indicator was not. This could be attributable to the e-commerce development trend as more and more technological innovations are introduced over time. However, the e-commerce development trend may eventually plateau or even reverse, for example, due to tighter regulation. IT regulation in the world could potentially become tighter and detrimental to e-commerce. The regulation policy of the IT sector was discussed in [15].

Moreover, trade relations could worsen. For example, potential trade conflicts between large economies, such as the USA or China, may lead to commerce deteriorating. Such a threat became feasible in 2018–2019

when the US and China considered and imposed tariffs on trade flows between each other. Therefore, the nature of the e-commerce development trend is probably not truly time-dependent.

Finally, the e-commerce development trend has a natural cap of 100%. At the moment, several countries exhibited the share of online purchases below 50%. After reaching the levels closer to 100%, the potential for further e-commerce development will likely be exhausted. Therefore, disinflationary pressure from it can stop.

The impact of the e-commerce indicator on inflation was negative. This generally supports the main hypothesis of this paper.

**Table 2. PVAR estimation results**

	EONIA		HICP, YoY	
Lagged EONIA	0.547	*	-0.2458	
	(0.255)		(0.312)	
Lagged HICP, YoY	-0.099		0.3907	**
	(0.122)		(0.122)	
ECB assets, YoY	-0.0009		0.0337	***
	(0.007)		(0.010)	
E-commerce, individuals	-0.0441	*	-0.0492	
	(0.017)		(0.026)	
Lagged NEER, YoY	-0.0025		-0.091	**
	(0.084)		(0.035)	

Note: positive gauge of NEER reflects appreciation.

\* means 10% significance

\*\* means 5% significance

\*\*\* means 1% significance

Standard errors are in the parentheses.

Source: authors' estimates

The impulse response from the standard monetary shock (Fig. 3) was negative, in line with the economic sense. The model was compared with the same model without the e-commerce variable. Factoring the digitalization of commerce reduced the overall impact of unexpected monetary policy shock. Meanwhile, the shock itself was not significant.

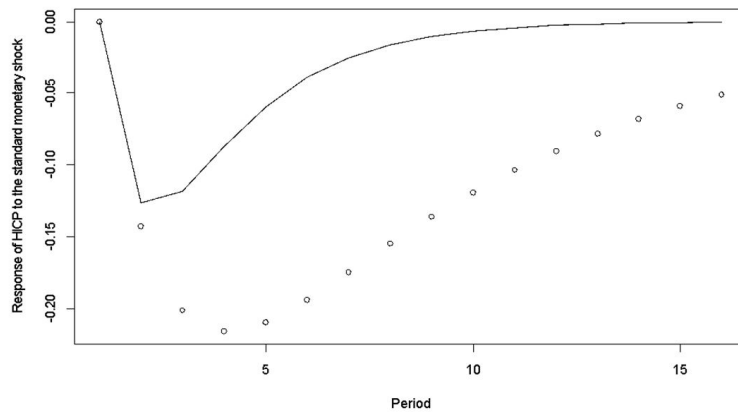


Figure 3. Orthogonalized impulse response from the standard monetary policy shock to HICP with the e-commerce variable (line) and without the e-commerce variable (dotted line)

Source: authors' estimates

Based on the PVAR model with endogenous ECB asset growth the shock of non-standard monetary policy was positive as expected. This means that non-standard measures boost inflation. However, similar to the standard policy, the shock was not significant.

To extend the analysis we can factor out the trend from the e-commerce indicator by taking the first difference of the respective indicator. This operation suppressed the significance of the coefficients in the baseline model.

In closing, there are several main results:

1) A preliminary statistical analysis showed an upward trend of e-commerce proxy (a share of online purchases among individuals and a share of purchases by enterprises via a computer network) in 2014–2018. This is a new result, revealing the current e-commerce development trend.

2) A panel analysis showed a statistically significant negative impact of a share of e-commerce on inflation (an increase of the share of online purchases by 1% leads to about -0.12% to -0.13% impact on inflation, while an increase of a share of purchases by enterprises via a computer network by 1% produced only -0.02% impact on inflation). This result confirms previous studies, such as [3], but also provides an important insight into the impact of e-commerce usage among companies. The latter was not extensively covered in related literature.

3) A PVAR model demonstrated insignificant results for an e-commerce development proxy;

4) An impulse response demonstrated a smaller magnitude of the standard monetary policy impact after considering an e-commerce variable. This implies a lower efficiency of monetary policy in the euro area. This issue is new and important and it reveals policy insight for decision-makers.

*Further studies* may relate to the underlying mechanism of disinflation. The analysis could be based on macro indicators, such as labor costs or unemployment, or on micro indicators of several particular companies.

The next step could be an analysis of spillovers from digitalization and e-commerce development, which may spread to other countries and regions. Considering the global value chain [16], the global disinflation trend may persist. The heterogeneity of the euro area can play an important role in its inflation dynamics, especially with regard to its unconventional monetary policy. The related issues were studied in [17–21]. Finally, the impact evaluation of IT regulation on digitalization will also extend this article.

## Conclusion

The impact of e-commerce on inflation estimated to be *generally disinflationary* based on a sample of the euro area countries in 2010–2018 for both individuals and companies. This is new and important results for economic policy. However, this was likely attributable to the positive trend of e-commerce development rather than purely cross-country e-commerce development characteristics. This trend may eventually plateau as a result of stricter regulation of the IT sector or external trade deterioration. Currently, many countries exhibited the development of e-commerce far below the potential 100%. However, should this cap be reached, the disinflationary pressure from the e-commerce development will fade. Should the e-commerce development trend stop, we would observe the possible acceleration of inflation in the euro area. On the other hand, e-commerce development in other countries may produce disinflationary spillovers, contributing to global disinflation. From the theoretical point of view, the panel analysis based on the linear model with fixed effects and panel VAR model supports the hypothesis of the disinflationary impact of e-commerce development. This result may be useful for decision-makers and economic policy evaluation.

The analysis of monetary shocks revealed the efficiency of the standard monetary policy instruments, factoring the e-commerce development effect. Meanwhile, the results for the non-standard monetary policy shocks were positive. However, the estimates were insignificant.



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