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Article

E-Commerce Cross-Border and Domestic Dynamics: Decision Tree and Spatial Insights on Seller Origin Impact

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Abstract: Despite the cross-border availability of almost all goods and services online due to global Internet access, the domestic origin of sellers remains significant. This study examines the preferences for domestic versus cross-border goods and services in online purchases in the EU online market from 2020 to 2023. We use quantitative methods including ordinary least squares (OLS), decision trees, and spatial autocorrelation analysis. We find significant effects of currency, language(s), and Internet use on domestic online purchases, while cross-border online purchases are further influenced by prices and urbanization. Our analysis reveals patterns based on the origin of the seller: domestic, intra-EU, or non-EU seller. There is a strong preference for electronic goods and services, regardless of the seller's origin, while physical goods show a decreasing preference from domestic to intra-EU and non-EU sellers. Limited geographical effects and spatial patterns in online retailing were found, with a trend towards domestic localization. These differences in e-commerce by seller origin are primarily driven by country-specific characteristics (language(s), currencies) rather than geographic distance. The variation in the purchase of goods and services also depends on their physical and electronic form, that is, digital ordering and/or digital delivery. The expansion of e-commerce and the importance of country-specific characteristics require the development of standards to measure these influences.

Keywords: electronic commerce; online purchases; EU; OLS; feature importance selection; decision tree; spatial autocorrelation analysis

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1. Introduction

With online commerce transcending borders, the significance of a seller's origin persists both in cross-border and domestic online purchases. The evidence from OECD countries reveals a varied landscape, with approximately 40% of businesses engaging in cross-border e-commerce sales on average in 2020, a figure ranging from 18% in Norway to approximately 62% in Luxembourg [1]. Similarly, within the EU, the average share of online purchases conducted domestically stood at 81% in 2022, showcasing considerable variability across member states, from 33% in Luxembourg to 95% in the Netherlands [2]. Furthermore, while intra-EU online purchases accounted for an average of 31% of total transactions, with figures ranging from 13% in Poland to 78% in Cyprus, transactions from non-EU countries constituted an average of 19%, with figures ranging from 6% to 60% for these countries, respectively [2]. Despite the availability of cross-border online retailing, the domestic e-commerce model continues to dominate.

The prevalence of cross-country or domestic biases in online purchasing is evident within the EU Member States, which have harmonized e-commerce regulation. E-commerce regulations in the EU were introduced almost a quarter of a century ago, requiring service providers to provide details of e-services, their websites, online advertising, and sellers' contact information [3]. The subsequent Digital Single Market Strategy aimed to enhance online accessibility for consumers and businesses across Europe, encompassing digital content, high-quality cross-border parcel delivery, and measures to eliminate geo-blocking while prioritizing the use of trusted networks and services the protection of privacy and

personal data [4]. The recent Digital Services Act and Digital Markets Act strengthen the regulatory framework governing online services through rules for transparent online information that protect consumer privacy and establish rules for online platforms to ensure fair competition and prohibit unfair practices [5,6]. The evidence of EU Member States in online purchases presents a valuable opportunity to compare cross-border, internal, and domestic transactions based on the seller's origin of online goods and services.

Research on the disparities in online purchases across countries, particularly concerning the origin of the seller in both cross-border and domestic contexts, has received limited attention compared to the well-explored characteristics influencing individual online decisions. Several studies have delved into the determinants of online purchases cross-border or domestically by examining country characteristics [7–10]. The studies show that geographic, cultural, and other distances continue to be important in e-commerce, and there are also significant country-specific effects and domestic biases. However, a noticeable gap remains in understanding the influence of seller origin on cross-border vs. domestic online purchasing.

Furthermore, there is a significant gap in the literature regarding the factors influencing online purchases that are directly related to the origin of the seller and vary between cross-border and domestic e-commerce. We assume that the key online purchase indicators, such as the quality and price of online goods [11–13], delivery time and cost [9,14,15], cultural and language aspects [10,16], payment methods and currency [17,18], and available ICT infrastructure and literacy [19–21], may elucidate countries' differences in online purchases. Moreover, cross-border vs. domestic changes in online purchasing may be present due to the physical or electronic forms of goods and services [10]. In addition, the spatial distribution of online purchases, examined by the origin of the seller, remains relatively underexplored in e-commerce studies [22].

Despite the extensive literature on qualitative and quantitative factors influencing online shopping behavior, surprisingly, there is fragmented literature on the role of the origin of sellers in online retailing. While research has primarily focused on the influence of individual characteristics and attitudes towards e-purchases, we aim to investigate the relationship between country characteristics and cross-border and domestic online purchases through the origin of sellers. Country-specific components, along with consumers' personal characteristics, can have a significant impact on cross-border purchases [7].

Addressing these gaps in the literature will contribute to a more comprehensive understanding of the complex dynamics driving online purchasing behaviors, considering cross-border and domestic country contexts. Our objective is to bridge this literature gap and develop an understanding of the intricate relationship between online purchases and seller origins within European countries from 2020 to 2023.

Assuming a country-specific framework for this study with key indicators of online purchases, their potential associations with seller origin and dependence on electronic or physical types of goods, and also possible spatial dependence between country-specific e-commerce, this study aims to address the following research questions:

RQ1. Do and to what extent countries' characteristics matter for cross-border, intra-Union, and domestic online purchasing?

RQ2. Which key indicators of online purchases are more related to the seller's country for cross-border, intra-EU, and domestic purchases?

RQ3. How does the seller's origin relate to online purchases and their electronic or physical format?

RQ4: Does geographical dependence influence online purchasing behavior, considering the origin of the seller?

This article is organized as follows: we review the literature on online purchases and associated origins of sellers, describe the method and data used to conduct the analysis, present the results, discuss the findings, and address the conclusions and limitations.

2. Literature Review

2.1. Country's Evaluation of E-Commerce

E-commerce studies that focus on country differences tend to center on cultural aspects when the country of origin is considered [23–28]. While these differences have mostly been examined among individuals and firms, in this study we delve deeper into country characteristics. With an empirical aim, our study relies primarily on a literature review.

Despite the acknowledged importance of national and domestic attributes in online shopping, only a few studies have quantitatively assessed country differences between domestic and cross-border online purchases. Sleuwaegen and Smith's [7] findings reveal significant variations among EU countries according to the percentage of consumers engaging in cross-border transactions. Their study underscores the pivotal role of country-level determinants in influencing non-domestic purchasing decisions, including domestic market size, economic development, and ethnic diversity [7]. The determinants of overseas direct purchases—connectivity leaning toward air transport, customs efficiency, regulation quality, and globalization—were investigated across 61 countries spanning Asia, North/South America, Europe, Africa, Australia, and New Zealand from 2012 to 2014. Cho and Lee [8] found the first and last determinants to be statistically significant.

In another study, distance effects in e-commerce and express deliveries were examined using the gravity model across four dimensions: geographical distance, delivery time, delivery cost, and trade barriers. This research, conducted by a Dutch consumer manufacturer in Italy, Germany, the UK, Spain, and Sweden from 2013 to 2015, revealed that distance remains a crucial factor in e-commerce, with e-demand decreasing as the distance between supplier and e-customer increases [9]. Geographical distance was found to negatively impact e-commerce demand even after accounting for delivery time, delivery cost, and country-specific barriers. Moreover, substantial country-specific e-commerce demand persisted even after correction for differences in income, distance, delivery charges, and delivery times.

Applying the gravity model to evaluate bilateral online and offline purchases in the EU, the authors of the study investigated whether distance still plays a significant role in the online trade of physical goods, particularly within the linguistically fragmented EU market. The analysis revealed a significant reduction in distance-related trade costs to offline trade, although language-related trade costs increased. Furthermore, online trade introduced new sources of trade costs, such as parcel delivery and online payment systems. Overall, there were no indications that online trade favored home market products less than offline trade. The authors also explored potential strategies available to policymakers to enhance cross-border e-commerce in the EU Digital Single Market [10].

Based on these studies of countries' characteristics in e-commerce, our study contributes to the literature by understanding the influence of seller origin on cross-border, sub-country, and domestic online purchases using recent data from EU Member States (Table 1).

Table 1. Summary of prior studies on country characteristics in cross-border and domestic e-commerce.

Author(s)	Objectives of the Study	Country/Data	Cross-Border/Domestic Online Purchases
Sleuwaegen and Smith, 2022 [7]	To investigate how personal and country-specific environmental conditions affect the decision of individuals to make cross-border online purchases	30 EEA countries (28 EU Member States plus Norway and Iceland) for 2006, 2008, 2010, 2011, 2012, and 2014	Cross-border e-commerce
Cho and Lee, 2017 [8]	To identify logistics, regulatory, and globalization determinants of overseas direct purchases	61 countries, 2012–2014	Overseas direct purchases

Table 1. Cont.

Author(s)	Objectives of the Study	Country/Data	Cross-Border/Domestic Online Purchases
Kim et al., 2017 [9]	To provide an empirical analysis of express delivery services in cross-border e-commerce	the Netherlands consumer electronics manufacturer services to 721 regions in Germany, Italy, Spain, Sweden, and the UK, 2013–2015	Cross-border e-commerce
Gomez-Herrera et al., 2014 [10]	To investigate whether distance still matters for online trade in physical goods in a linguistically fragmented EU market	27 EU Member States, 2011	Online and offline purchases in bilateral trade
Present study	To assess the impact of country-of-seller on cross-border and domestic online purchases	28 EU Member States and Norway, 2020–2023	Cross-border, intra-EU, and domestic online purchases

2.2. Key Factors Influencing Online Retailing

Assessing online retailing necessitates considering key factors pivotal to e-commerce. Foremost among these are the quality and pricing of online goods and services. Mirroring traditional markets, competition on electronic platforms is primarily between sellers of different qualities and prices [11,13]. Additionally, platform service quality, like quality in offline sales, emerges as a critical determinant influencing cross-border online shopping, followed by considerations such as country of origin [12]. Cultural aspects also intersect with product quality, perceived value in e-commerce adoption, and cross-border e-commerce dynamics [27,29]. Studies affirm that pricing positively impacts customer purchase intentions [30]. Furthermore, a relationship between online and offline prices has been observed, with a decrease in online prices compared to offline prices represented by the consumer price index and indicating the presence of the Amazon effect [31]. Product pricing and promotion, as well as product location, are influenced by retail strategies to combat rising inflation [32]. In addition, the pricing strategy of cross-border e-commerce platforms significantly influences consumers' cross-border consumption frequency [33].

Another key aspect of online retailing relates to the delivery, shipping costs and time. The availability, timing, and associated costs of delivery can either encourage or deter consumers from online purchasing, whether from domestic or international sellers. E-commerce dynamics are inherently distance-dependent, as the demand for cross-border B2C e-commerce hinges on factors such as delivery costs and time [9]. However, another study notes that physical distance alone does not necessarily imply barriers to cross-border transactions [33]. In addition, studies underscore the significance of reducing distances for electronic goods delivery services to attract online customers across borders. Express delivery networks are concentrated in urban areas with suitable cargo volumes and low transportation costs due to high competition between transport companies, which highlights the centrality of urbanization in e-commerce [9]. Urbanization's impact on e-commerce is closely linked to the ability to receive online goods in the last mile, even if they undergo initial transportation via various modes such as air or sea [14].

Consumers from different countries have their own cultural and language preferences, often leaning towards particular sellers. Country-level variables and national culture should receive the same consideration as individual characteristics and formal institutions when implementing e-commerce [34]. Culture typically serves as a moderating force in shaping online consumer behavior [16]. Moreover, the language factor significantly influences online trading dynamics, with English-speaking exporting nations having a comparative advantage [10].

The convenience in payment options, including currency and payment methods can impact both domestic and cross-border online purchases. Sellers from the same region as buyers can offer currencies and payment modes that are more familiar, thereby streamlining transactions for buyers. Mobile payments and online banking play an important role in facilitating online transactions, as most online consumers use them for online shopping [17]. Research indicates that even a marginal 1% increase in the use of efficient and flexible cross-border payment systems can increase cross-border e-commerce growth by up to 7% [10]. However, cross-country dispersion in the use of payment instruments in Europe has gradually decreased in recent decades, with the introduction of the single currency accelerating the pace of convergence [18].

The linkage between online purchases and Internet access, Internet use, and digital literacy is based on their inherent digital nature intertwined with information and communication technologies (ICT). The probability of engaging in online purchases rises with increased Internet accessibility, the ability to find logistics and financial services, and sufficient digital skills [20,21]. Factors conducive to cross-border e-commerce of goods and services encompass computer literacy and usage [35]. This is consistent with research affirming that prior online experience significantly enhances consumers' intentions to shop online [36], heightened Internet users' self-efficacy correlates with increased e-commerce participation [37], and underscores the interplay among Internet security, trust, and product price [38]. Crucially, aspects appropriate to e-purchases extend to cross-border transactions, seller provenance, and participation in collaborative or sharing economies, all of which are influenced by Internet usage, among other factors [7].

Hence, when consumers navigate online purchases, considerations encompassing quality, price, delivery of goods, cultural preferences, language nuances, and Internet utilization converge to shape their choices between domestic and cross-border transactions. Given similar offerings across domestic and cross-border e-commerce platforms, consumers show a bias towards domestic e-commerce service providers over their foreign counterparts in retail [39].

2.3. Physical and Electronic Goods and Services in Online Purchases

Online purchases allow us to buy goods in both physical and electronic form, impacting both cross-border and domestic transactions. Research suggests that consumer behavior in online purchases is influenced by product characteristics [38]. Despite this, there remains a gap in understanding the relationship between cross-border and domestic e-commerce, particularly concerning physical and electronic goods, physical trade costs, and information costs [10]. Cultural disparities can further complicate matters, creating a perceived distance between consumers and sellers, even in transactions involving electronic goods [40]. Additionally, online purchases of electronic goods are subject to linguistic, cultural, and institutional variations [10]. Although distance continues to play a role in online trade, its impact is diminished compared to offline transactions [41]. Consequently, cross-border online purchases may favor electronic goods over physical ones.

2.4. Spatial Dependence in Online Purchases in Relation to Seller Origin

Geographical factors and spatial dependence play a crucial role in online purchases, particularly concerning the origin of the seller. This phenomenon is especially pronounced in transactions involving high-quality or lower-priced online products, with potential complications arising during cross-border deliveries. Distance in online shopping is intricately linked to delivery times and associated costs, as well as the possible products' returns. Moreover, the distance factor influences trading costs, especially for physical goods traded online [10]. Research examining e-commerce adoption in the context of Internet use finds significant spatial variations driven by differences in household income and the concentration of e-commerce hubs [42]. The study's results, considering the characteristics and spatiotemporal dynamics of the European digital divide, prove different types of e-

commerce in relation to European capitals [22]. Notably, while a North-South polarization pattern is evident in Europe, exceptions exist, particularly in the North-East [22].

2.5. Contributions of the Study

This article introduces several supplementary aspects to the literature on e-commerce. Firstly, we incorporate country-specific characteristics to elucidate differences across cross-border, intra-Union, and domestic online purchases. While prior studies have primarily focused on individual decision-making in cross-border and domestic shopping, our study uses recent 2020–2023 data from EU countries to analyze the factors influencing these transactions. Secondly, we aim to delineate the relationship between key indicators of online purchases and seller origin, specifically contrasting cross-border transactions with domestic ones. Furthermore, we distinguish between the physical and electronic formats of goods and services in online retailing within our study context. Thirdly, we conduct a spatial exploratory analysis of online purchasing patterns based on seller origin, a dimension that has been underexplored in e-commerce research until now, thereby bridging a gap in the literature. Additionally, our multi-approach methodology allows us to obtain a more diversified view of the evolution of e-commerce. It is worth emphasizing that, in the absence of relevant studies, our research questions are formulated to guide this exploratory study rather than hypotheses. Taken together, these contributions enhance our understanding of the catalysts shaping the European Digital Single Market and e-commerce landscape.

2.6. Model of the Study

The model of the study reflecting the indicators, research questions, and objects of the study is presented below (Figure 1).

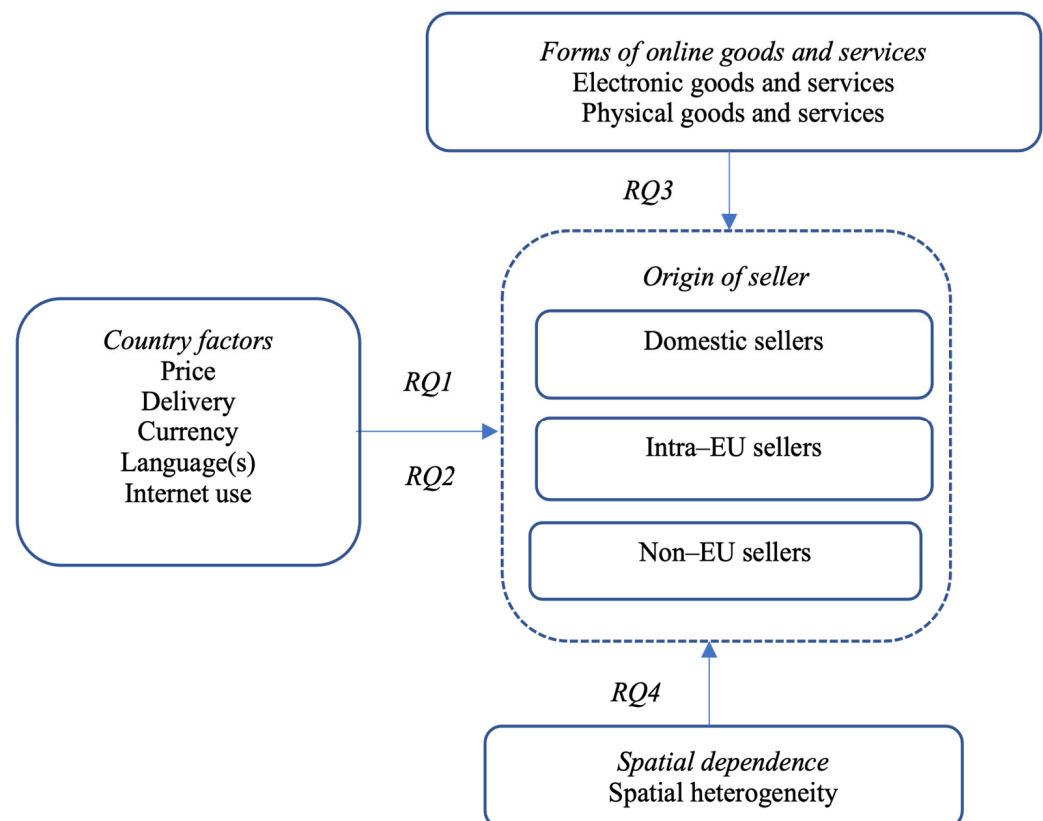


Figure 1. Model of the study.

3. Materials

The data is from Eurostat for the period 2020–2023 [43]. The assessment includes 28 European countries: Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, and Norway. The number of observations for each year and country is 112, and the sample size includes 3136 observations. The outcome variables are three variables based on the origin of the seller: domestic, EU, and non-EU. Country factors as exploratory variables were selected based on a literature review and reflect online price as an index of prices, delivery time as degree of urbanization, currency as national currency, language(s) as official language(s), and Internet use as its accessibility and digital literacy. The indicators of types of online goods and purchases are based on grouping according to the Eurostat methodology. The dataset is balanced panel, cross-sectional, and time series data. The descriptive statistics of the research variables are presented in Appendix A, Table A1.

The description of online purchases using the example of 2023 in the EU demonstrates diverse dynamics (Appendix A, Figure A1). The chart shows the large differences across countries in the share of online purchases within the country, within the EU, and abroad. The Netherlands, despite ranking highly overall in online shopping, is moderately represented in cross-border online purchases. While Luxembourg ranks first both for intra-EU and cross-border online shopping. This differentiation highlights the interest in exploring the factors influencing the prevalence of domestic and cross-border online purchases. To further evaluate these differences, we examine regressions and the spatial distribution of the online purchasing dynamic.

4. Methods

4.1. Regression Analysis of Country Differences in Online Purchases

The regression analysis is widely used for e-commerce research. Ayob (2021) uses OLS to estimate individual and county-level variables in e-commerce in ASEAN member countries [34]. Bartol et al. (2023) apply the mean- and variance-adjusted weighted least squares to examine e-commerce participation [37]. Cho and Lee (2017) used OLS to identify the determinants influencing overseas direct purchases [8]. Wang and Huang (2023) construct a benchmark regression model OLS to study the impact of digital finance on consumer online purchases [17]. Rosillo-Díaz et al. (2019) use multiple regression analysis to assess product quality, desires, and purchase intentions on e-commerce platforms [27].

We employ OLS regression to assess whether and to what extent there is a relationship between online purchases by origin of seller as the response, dependent variable, and country online indicators as the predictors, the independent variables for 2020–2023 in the EU countries. The OLS equation is:

$$f(y_{it}) = \alpha_i + \beta_1 x_{it} + \beta_2 d_i + \beta_3 d_t + \varepsilon_{it}, \quad (1)$$

where:

- y_{it} —the dependent variable, ‘online purchases’ with evaluation by origin of seller,
- x_{it} —the independent variable, ‘country online purchases indicators’,
- α_i —the intercept,
- β_1 —the slope coefficient for the independent variable,
- β_2 —the slope coefficient for the independent variable with d_i ,
- d_i —the dummy variable, equal to 1 if the i^{th} country is $country = i$ and equal to 0 otherwise,
- β_3 —the slope coefficient for the independent variable with d_t ,
- d_t —the dummy variable, equal to 1 if the t^{th} year is $year = t$ and equal to 0 otherwise,
- ε_{it} —the error / disturbance term,
- i —the country, and t —the year.

We include a series of dummy variables on the right-hand side of our regression equation to control for unobserved heterogeneity due to country and year effects. With the assumptions of the linear regression model: linearity in parameters, random sampling of observations, conditional mean equal to zero, absence of multicollinearity, and homoscedasticity of errors, the OLS estimators α and β are considered the best linear unbiased estimators of the actual values of α and β according to the Gauss-Markov Theorem. We apply robustness analysis using two-stage least squares regression (2SLS) with instrumental variables and Durbin-Wu-Hausmann and Wooldridge tests to check the serial correlation of the panel data, fixed-effects OLS model, endogeneity, and baseline regression results.

4.2. Feature Importance for Selection of Goods and Services in Online Purchases and Regression Analysis on Their Electronic and Physical Forms

Various methods have been used to select reliable exploratory variables in e-commerce studies. Ni et al. (2020) use exploratory factor analysis [12], Bartol et al. (2022) apply path analysis [37], and Rosillo-Díaz et al. (2019) employ confirmatory factor analysis [27].

We use the feature importance for the selection of most associated goods and services in their electronic or physical forms in online purchases with the seller's origin. Since the set of goods and services that influence online purchases by the origin of seller is not well studied in research, we consider a set of indicators in aggregated domains of electronic or physical goods and services (Table 1). We include 10 indicators in each domain, which are selected based on the Eurostat typology and their availability as data. To select key indicators from the data set that are important for our outcome variable, online purchases by seller origin, we use feature importance selection. Feature importance is part of tree-based decision making, and the random decision methods allow us to reduce the dimensionality of the data set and select the variables that are most closely related to online retail. We use feature importance selection with Gini impurity, which refers to the probability to which observations of predictors as features form the decision tree for 'online purchases' by splitting root nodes, nodes, and, further, leaves. The decision tree visualizes the Gini impurity principle (Figure 2).

Our dataset D contains samples from *two classes* of online purchases as the outcome variable: (1) greater than and equal to the median or (2) less than the median. This divide relates to the term of this method to use string variable format. This first level of the decision tree represents the outcome variable as the root node for domestic, EU, and non-EU sellers. Our dataset D also has 2 attributes (A, B) with 10 features (variables) in each. We need to choose which feature v_1, v_2, \dots, v_{10} best matches the outcome variable by splitting the data on nodes and leaves. The Gini impurity is equal to:

$$Gini(D) = 1 - \sum_{i=1}^j p_i^2. \quad (2)$$

In Equation (2):

p_i is the probability that the samples of time series (year) and cross-section (country) i belong to Classes (1) and (2) of online purchases at the node.

j represents the number of classes in the outcome variable, in the case of $D - 2$.

The Gini impurity ranges from 0 to 0.5, with a minimum (highest level of purity) of 0.

The decision tree is further constructed by binary splitting the feature space and defines the second level of the decision tree as node(s). Data set D is further split by attribute A (physical or electronic goods and services) into two subsets D_1 and D_2 with sizes n_1 (leaf on the left) and n_2 (leaf on the right), respectively. The Gini impurity by attribute can be defined as:

$$Gini(D_1, D_2) = 1 - (p_1)^2 - (p_2)^2 = 1 - \left(\frac{n_1}{n}\right)^2 - \left(\frac{n_2}{n}\right)^2. \quad (3)$$

This is the third level of the decision tree with the calculation of the Gini impurity of the left and right leaves.

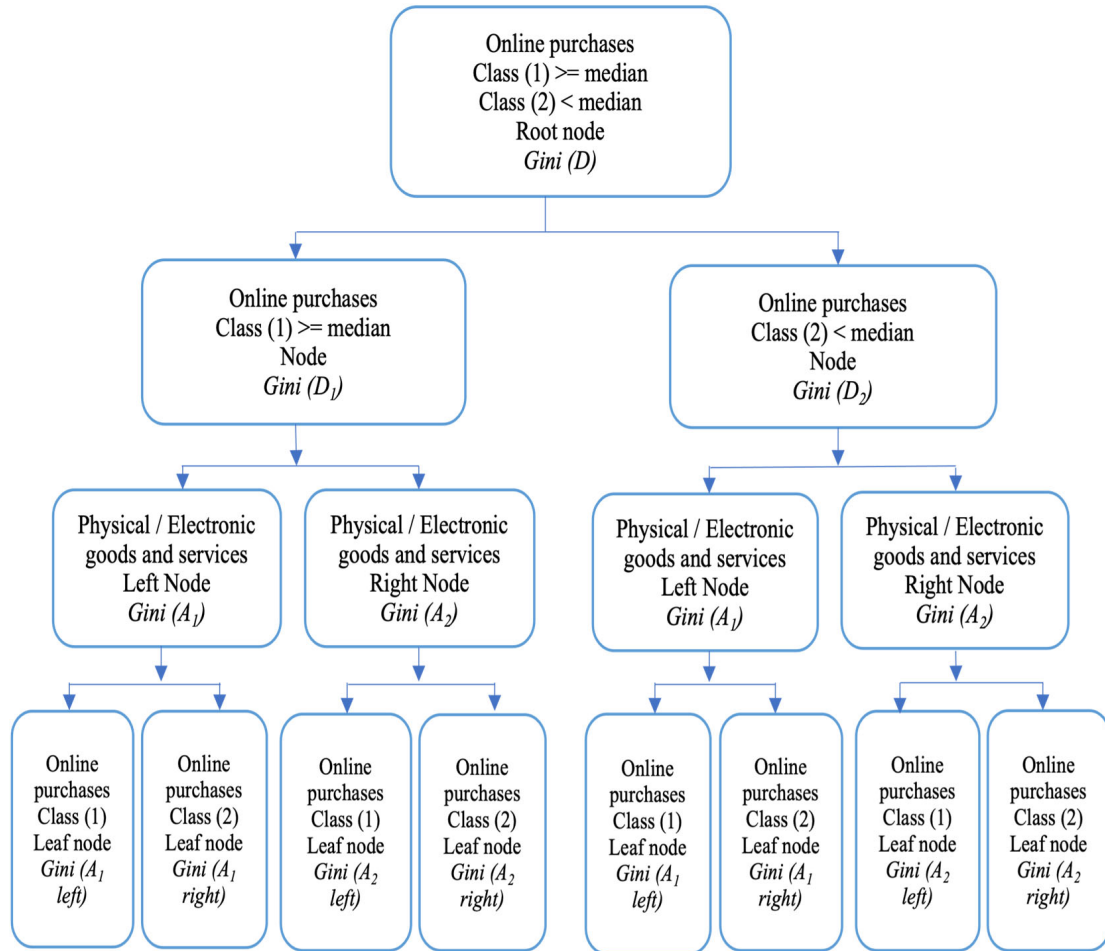


Figure 2. Diagram on the decision tree of Gini impurity as a feature importance.

The attribute with the lowest Gini impurity is selected to split the node. The decision tree algorithm selects the next feature to split, thus achieving the maximum reduction of impurities. The minimum impurity is obtained when all samples belong to the same class. Gini impurity states how likely an observation or sample is to be misclassified. The lower the Gini index, the lower the probability of misclassification.

To obtain a feature’s value from the attribute A , the weighted impurities of the branches are subtracted from the original impurities. The probability of reaching a node is calculated as the number of samples reaching the node divided by the total number of samples. The features are normalized by the sum of all feature values present in a branch, and after dividing it by the total number of branches in the tree, the overall importance of the feature is determined. The equation gives us the importance of one feature node with two leaves in a three-branched system:

$$Gini_A(D) = \frac{n_1}{n}Gini(D_1) + \frac{n_2}{n}Gini(D_2). \tag{4}$$

To calculate the Gini Gain as a feature importance, the weighted impurities of the branches are subtracted from the original impurities. The best feature is chosen by maximizing the Gini Gain (or by minimizing the Gini impurity). The higher the value of the Gini Gain, the greater is the importance of the variable [44].

$$\Delta Gini = Gini(D) - Gini_A(D). \tag{5}$$

Features are sorted in ascending order based on their scores, which indicate their relative importance for predicting the outcome variable (Appendix A, Figure A2). Further, we apply OLS regression according to Equation (1) to estimate the relationships between online purchases by seller origin and the electronic or physical forms of goods and services in online retail. We also use the same dependent variables and use the selected online goods and services as independent, exploratory variables.

4.3. Spatial Autocorrelation Analysis of Online Purchases by Seller Origin

Spatial autocorrelation analysis has been used relatively recently in e-commerce research. Sadowski et al. (2021) use local and global spatial analyses to assess e-commerce diversity in Europe [42]. Lutz (2019) applies exploratory spatial data analysis to a sample of 209 European regions to find local indicators of the European Digital Single Market [22].

We apply global spatial autocorrelation analysis with Moran's I index to measure the degree of spatial clustering of online purchases by seller origin in the EU countries [45]. This approach quantifies the relationship between how clustered countries' values are geometrically or topologically and how far they lag in space. This method also allows us to measure spatial autocorrelation by simultaneously using feature locations and their values. The equation for global autocorrelation with Moran's I index is:

$$I_g = \frac{n}{W} = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij}(x_i - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2} \quad (6)$$

In Equation (6), n is the number of spatial objects (countries) on the map indexed by i and j ,

W is the sum of all w_{ij} , $W = \sum_{i=1}^n \sum_{j=1}^n w_{ij}$,

x_i and x are the i -th and j -th spatial attributes, which are the values of online purchases by seller origin for the compared objects,

\bar{x} is the mean value of online purchases for all objects,

w_{ij} is the matrix of spatial weights.

The spatial weight matrix is constructed using the spatial contiguity weight matrix:

$$\begin{cases} 1, & \text{when region } i \text{ and } j \text{ have a common border} \\ 0, & \text{when region } i \text{ and } j \text{ have no common border} \end{cases} \quad (7)$$

In Equation (7), i, j are the spatial region's block numbers, and $i, j \in [1, n]$, where n is the number of this spatial region.

Through the global Moran's I index, the clustering situation of the data in the region can be assessed with a value $\in [-1, 1]$. Positive spatial autocorrelation will show that the data are clustered; negative autocorrelation is dispersed; and randomness is close to zero. For the results of the global Moran's I index, a statistical test for p-significance was performed with a 5% confidence level.

A second measure for the assessment of spatial autocorrelation is the Local Indicators of Spatial Association (LISA) assessment, which allows us to locate the Moran's I index results of the autocorrelated patterns or clusters of the data [46]. The LISA approach allows us to take statistics for each location with a significance score and establishes a proportional relationship between the sum of the local statistics and the corresponding global statistic. The local form of Moran's I coefficient for the i observation is defined with the formula:

$$I_l = \frac{(x_i - \bar{x}) \sum_{j=1}^n w_{ij}(x_j - \bar{x})}{\sigma^2}, \quad (8)$$

In Equations (8) and (9), n is the number of spatial objects (countries),

x_i, x_j are the values of the variable for the compared objects,

\bar{x} is the mean value of the variable for all objects,

w_{ij} is the matrix of spatial weights,

$$\sigma^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1} \quad (9)$$

The interpretation of the local Moran's index is similar to its global counterpart with statistical significance: high index values indicate the emergence of clusters with similar values, low values indicate the emergence of hot spots, and values near the expected value $E(I_i)$ indicates a random distribution of the variable in space:

$$E(I_i) = \frac{-\sum_{j=1}^n w_{ij}}{n - 1}. \quad (10)$$

5. Results

5.1. Regression Analysis of Countries' Differences in Online Purchases by Seller Origin

We test the linearity of parameters and random sampling of observations for linear regression with these assumptions for the dependent and independent variables. Scatter plots of the dataset show a good and varying level of linear association and a normal distribution between the assessed variables (Appendix A, Figure A3). Since the use of the OLS method requires the elimination of dependence in independent variables, multicollinearity is diagnosed using the variance inflation factor (VIF). The VIF values between our variables range from 1.0474 to 1.1954, which is less than 5 and allows us to use regression analysis. We address the heteroscedasticity and avoid country- and year-specific effects by applying OLS with dummy variables. To avoid autocorrelation of error terms, we apply White's heteroskedasticity estimator for robust standard errors. Thus, the linear regression assumptions are tested and allow the use of the OLS regression analysis.

We see that currency, language(s), and Internet use have the most significant influence on domestic online purchases (Table 2).

Table 2. Regression analysis results for country differences in online purchases.

Variables	Domestic Seller	Intra-EU Seller	Non-EU Seller
Price (v1)	−0.0159 (0.050)	0.0560 (0.036)	−0.1006 (0.026) ***
Urbanization (v2)	−0.0252 (0.107)	−0.0510 (0.076) *	−0.2178 (0.055) ***
Currency (v3)	−8.01053 (1.369) ***	11.8806 (0.972) ***	4.1367 (0.699) ***
Language(s) (v4)	−13.7694 (2.828) ***	2.7507 (2.007)	3.5379 (1.444) **
Internet use (v5)	1.2199 (0.276) ***	0.5950 (0.196) ***	0.4961 (0.141) ***
Number of observations	112	112	112
Fixed effects country	Yes		
Fixed effects year	Yes		

Notes: robust standard errors are in the parentheses under the estimated coefficients. ***, **, and * represent significance at 0.1%, 1%, and 5% levels, respectively.

For non-EU online purchases, all independent variables are significant. However, the positive or negative direction and strength of the effects of exploratory variables vary significantly between domestic and cross-border online retail. On average, an additional price increase leads to a 0.10% reduction in online purchases from non-EU sellers, ceteris paribus. Delivery times are more significant for non-EU sellers than intra-EU sellers; each additional percentage point in urbanization results in a 0.20% and 0.05% reduction in online purchases, respectively. Only Internet use has a positive relationship with online purchases, regardless of the seller's origin; however, its value decreases when moving from domestic to cross-border purchasing. An additional percentage increase in Internet usage results in

a 1.2% increase in domestic and a 0.5% increase in cross-border online purchases. Since the currency and language(s) are binary variables, their results show that the probability of domestic online retailing decreases on average by 8% when the currency changes from the national currency to the euro, *ceteris paribus*. In contrast, the expected probability of intra-EU and cross-border online purchases increases by about 12% and 4%, respectively, when the currency changes from domestic to euro. The expected probability of domestic online purchases corresponding to multiple official languages in a County leads to an average decrease of 13% when changing from one language to multiple languages, *ceteris paribus*. Conversely, the expected probability of cross-border online purchases equal to multiple official languages in a country result in an average increase of about 4% when changing from one language to multiple languages. It is worth noting that our estimates are based on independent variables separately for comparison, and we do not use regression as a model.

We can suggest that there are potential causal and reciprocal effects from two predictor variables: degree of urbanization and Internet use. We conduct robustness analysis to validate our regression results and to avoid potential endogeneity in regression, although we do not run the model. We estimate 2SLS using an instrumental variable as a nominal labor productivity per person indicator from the Eurostat database for 2020–2023. We suggest that this variable meets the conditions for a direct influence on the independent variables: degree of urbanization and Internet use, and no significant influence on the dependent variable. The estimates of 2SLS and two robustness tests show the potential causal effects for domestic online purchases, while for intra-EU and cross-domestic purchases, our fixed-effects OLS estimations are valid in the absence of exogeneity and autocorrelation in the data; they are homoscedastic and unbiased (Table 3).

Table 3. 2SLS and test results.

Variables/Test	Domestic Seller	Intra-EU Seller	Non-EU Seller
Degree of urbanization	0.3290	−0.0811	0.1986
(endogeneity) or Internet use (exogeneity)	(0.4404)/ 1.6539 (0.2072) ***	(0.0881)/ 2.0908 (0.2783) ***	(0.0561) ***/ 1.1468 (0.1774) ***
<i>p</i> -value Wu–Hausman test	0.6418	0.000	0.000
<i>p</i> -value Wooldridge test	0.6409	0.000	0.000

Notes: robust standard errors are in parentheses underestimated coefficients. ***, represent significance at the 0.1% level.

5.2. Feature Importance Selection and Regression Analysis for Electronic and Physical Online Goods and Services

We classified sellers' origin scores into two parts based on the median: low and high. For domestic online purchases, the median is 45.69%, for intra-Union it is 22.26%, and for cross-border it is 12.05%. The construction of the results of feature importance on a histogram based on the scores of indicators in the domains is presented in Appendix A (Appendix A, Figure A2). We selected the three most significant goods (services) by seller origin for online purchases, depending on their electronic or physical form (Table 4).

Different types of online products and services are associated with different origins of sellers. The most expanded physical goods and services are printed books, magazines, or newspapers, which are mainly associated with all online purchases: domestic, intra-EU, and abroad. Online electronic goods and services include e-books, online magazines or online-newspapers, and computer or other downloadable software. The most significant relationship between physical goods and services is observed for domestic online purchases and the weakest for cross-border purchases. The same trend exists for online electronic goods and services, however, with a stronger dependence on all sellers. Since our approach does not involve a model but a comparative method, we do not apply further endogeneity validity analysis. Moreover, since our sample of physical and electronic goods and services was randomly selected, the sample is unbiased.

Table 4. Regression analysis of online purchases by origin of seller and electronic of physical forms of online goods and services.

Origin of Seller/Type of Goods and Services in Online Retailing	Domestic Seller	Intra-EU Seller	Non-EU Seller
Physical online goods and services	<i>p</i> 4 Clothes, shoes, or accessories <i>p</i> 3 Children toys <i>p</i> 2 Printed books, magazines, or newspapers	<i>p</i> 2 Printed books, magazines, or newspapers <i>p</i> 10 Sports goods <i>p</i> 5 Computers, mobile phones, or accessories	<i>p</i> 2 Printed books, magazines, or newspapers <i>p</i> 5 Computers, mobile phones, or accessories <i>p</i> 8 Furniture, home accessories, or gardening products
Coefficient (Standard. error)	14.6926 *** (2.512)	5.3205 * (2.717)	−1.0179 (1.959)
Electronic online goods and services	<i>e</i> 8 E-books, online-magazines, or online-newspapers <i>e</i> 4 Computer or other software as downloads <i>e</i> 9 Music as a streaming service or downloads	<i>e</i> 2 Other apps (e.g., related to learning languages, travelling, weather) <i>e</i> 8 E-books, online-magazines, or online-newspapers <i>e</i> 9 Music as a streaming service or downloads	<i>e</i> 4 Computer or other software as downloads <i>e</i> 5 Games online or as downloads <i>e</i> 1 other apps (e.g., related to learning languages, travelling, weather)
Coefficient (Standard. error)	43.9261 *** (2.495)	16.9816 *** (1.429)	4.1057 *** (1.222)
Number of observations	112	112	112
Fixed effects country	Yes		
Fixed effects year	Yes		

Notes: Robust standard errors are in the parentheses under the estimated coefficients. *** and * represent significance at 0.1% and 5% levels, respectively.

5.3. Spatial Analysis of Local and Global Autocorrelation of Online Purchases

We analyze global autocorrelation, which measures a country's similarity to its neighbors, and examine the statistical significance of this relationship. The Moran's I index describes the similarity of objects in the neighborhood; its value for analyzed countries shows moderate spatial dependence and heterogeneity (Table 5). We see a low correlation between the analyzed countries on online purchases by seller origin, on average 0.3. Spatial correlation shows a negative trend in online purchasing localization from 2020 to 2023.

Table 5. Moran's I Index.

Origin of Seller/Year	2020	2021	2022	2023
Domestic seller	0.4781 (0.002)	0.2849 (0.044)	0.2530 (0.053)	0.2915 (0.034)
Intra-EU seller	0.3400 (0.021)	0.2483 (0.052)	0.2060 (0.078)	0.2385 (0.094)
Non-EU seller	0.3544 (0.017)	0.2359 (0.058)	0.2125 (0.069)	0.2138 (0.074)

Notes: The *p*-value with 5% significance is in parenthesis.

Based on the statistical significance of Moran's I index, we measure LISA relative to the spatial regimes in the map: high-high, where countries with high values of online purchases by seller origin are surrounded by countries with high corresponding values, low-low, where countries with low values are surrounded by countries with low values, high-low, where countries with high values are surrounded by countries with low values, and low-high, where countries with low values are surrounded by countries with high values. The visual presentation of hotspot maps of online purchases by origin of sellers

is presented in Appendix A (Appendix A, Figure A4a,b). We see that there is little spatial homogeneity through high-high and low-low localization. This also confirms the strong domestic localization of online retailing in the EU. Geographical distribution of online purchases by seller origin from 2020 to 2023 is presented in Appendix A (Appendix A, Figure A5a,b).

6. Discussion

Given the heightened focus on online purchasing catalyzed by the COVID-19 pandemic and the advancing capabilities of modern ICTs, the role of the origin of sellers in domestic and cross-border transactions remains under-researched, particularly with recent data. In this study, we evaluate the relationship between seller origin and online purchases of various goods and services in EU countries from 2020 to 2023. By addressing research questions, we aim to empirically elucidate the countries' differences in online purchasing and its domestic or cross-border prevalence.

First, our findings underscore the substantial influence of countries' characteristics on the prevalence of cross-border, intra-country, and domestic online purchases [7,9,10]. While certain nations, such as the Netherlands and Sweden, demonstrate a predominant share of domestic online purchases, others, such as Luxembourg, have EU sellers predominating in the purchases, or, in the cases of Slovenia and Portugal, a large proportion of foreign sellers. Hence, while individual consumer behaviors primarily elucidate e-commerce dynamics, our study emphasizes the pivotal role of countries' characteristics, including seller origin, in delineating disparities in online purchasing. This study aims to bridge existing gaps in e-commerce literature and contribute new insights into the dynamics of domestic and cross-border online transactions.

Further, by emphasizing key online purchasing indicators, we explain countries' differences in domestic, intra-Union, and cross-border transactions. Currency, language(s), and Internet usage emerge as primary influencers on domestic online purchases. Only currency and Internet use gave statistical significance in intra-EU online transactions, while all exploratory indicators, including price and urbanization, were significant in cross-border purchases. Internet usage demonstrates a positive relationship with online purchases, irrespective of the seller's origin. Each additional percentage increase in Internet usage yields a 1.2% surge in domestic and a 0.5% increase in cross-border online purchases. However, the impact of Internet use diminishes as consumers transition from domestic to international shopping. Our findings are consistent with previous studies. They are in line with Bartol et al.'s (2023) findings that Internet use is a strong predictor of e-commerce participation [37]. This is also consistent with the findings of Mahmood et al. (2022) and Ariansyah et al. (2021) on the importance of digital information literacy and digital skills for e-commerce [20,21].

In addition, we find interesting results on the significance of currency and country language(s) in shaping online purchasing behaviors. When currency shifts from domestic to euro, the probability of domestic online purchases diminishes by 8%, while online shopping within the EU and abroad increases by approximately 12% and 4%, respectively. This suggests that utilizing a national currency other than the euro tends to expand domestic online retailing instead of cross-border ones, and vice versa.

Similarly, language emerges as a critical factor influencing purchasing dynamics. Countries with a singular national language display a tendency towards domestic online purchases, whereas multilingual countries have an advantage towards purchases within the EU and abroad. The probability of domestic online purchases decreases by an average of 13% when transitioning from one language to multiple languages, while the probability of cross-border online purchases increases by about 4% under similar circumstances, *ceteris paribus*. These findings align with previous research, further highlighting the essential roles of currency and language in online purchasing dynamics [10]. The significant increase in trade costs associated with language boundaries, or "distances", found

by Gomez-Herrera et al. (2014) is supported by our findings of a strong, positive, and significant relationship between multilingual presence and e-purchasing [10].

The price indicator shows a significant impact only for cross-border online purchases. On average, additional price increases lead to a 0.10% downturn in online transactions from non-EU sellers. This confirms Azami's (2019) finding that product price does not have a significant relationship with customer purchases from online stores in the analyzed country [38]. This outcome is also consistent with Yim's et al.'s (2022) study, which found Amazon's effect between online and offline prices and a downward trend in the former, as well as the impact of competitive prices on e-commerce in general, as indicated by Immanuel et al. (2021) [30,31].

Although rising prices are expected to reduce cross-border online purchasing, the degree of urbanization shows a contradictory trend. Anticipating a surge in online purchases driven by high urbanization, along with reduced delivery time and costs, we surprisingly observe a negative relationship. Urbanization is more consequential for online purchasing outside the EU than within it, with each additional percent of urbanization correlating to a 0.20% and 0.05% decline in online transactions, respectively. This finding is partially consistent with and complements previous studies. Our results are not consistent with those of Malalgoda and Lim (2023), which show that public transport use is positively associated with mall visits and increased offline purchases [14]. However, we are coherent with Kim et al. (2017), who argue that distance in e-commerce is preserved, and it is express delivery that reduces the distance for cross-border demand [9].

It is noteworthy that the directional influence of most analyzed factors shifts from negative to positive when transitioning from domestic to cross-border online purchases, underscoring the dynamics within e-commerce. Considering the validity test of the regression outcomes as a model, we can infer the presence of omitted variables impacting domestic online purchasing, thereby necessitating intensified research attention to identify the determinants driving domestic transactions at the country level. Consequently, in response to our research questions RQ1 and RQ2, we underscore that countries' characteristics hold significance in shaping cross-border, intra-country, and domestic online purchases.

Second, we find the most associated goods and services in both electronic and physical forms in online purchasing, contingent upon seller origin. Books, magazines, and newspapers, whether in electronic or physical format, emerge as the most associated online purchases, irrespective of the seller's origin. Additionally, computer software, including downloadable applications, is the second-most associated electronic good. However, the most significant relationship between both physical and electronic goods and services is observed for domestic online purchases and the weakest for cross-border purchases, with electronic forms showing a stronger relationship. This underscores the prevalence of domestic online purchases despite the global accessibility of downloading software, games, and music [10]. The results of the study by Gomez-Herrera et al. (2014) confirm that the costs of distance selling are significantly reduced compared to offline trading of the same goods [10]. Our findings affirm that seller origin has a positive and linear influence on online purchases, contingent upon the electronic or physical form, thereby addressing our RQ3. Moreover, according to UNCTAD e-commerce statistics, they refer to digitally ordered or digitally delivered goods and services [47].

Third, our findings include the results from global and local spatial autocorrelation analyses. We find a low spatial correlation between the countries surveyed for online purchases based on seller origin, averaging 0.3. Furthermore, the spatial dependence concerning online shopping determines a declining trend from 2020 to 2023, indicating its domestic localization. While we identify unstable spatial patterns in the clustering of countries in the High-High and Low-Low categories, significant heterogeneity in online purchasing by seller origin remains indefinable as a response to our RQ4. This finding partially diverges from previous studies emphasizing the role of distance in e-commerce and the emergence of localized European hubs. We agree with Cho and Lee (2017), who found no global impact on foreign direct purchases [22]. We also support Gomez-Herrera et al. (2014), who

concluded that distance is associated with language and country barriers [10]. We partially support Kim et al. (2017), who argued that distance is still important in e-commerce even after correcting for delivery time, delivery cost, and country-specific barriers [9]. Although our findings are not consistent with Sawoski et al.'s (2021) results on distance reduction, we assume that this is due to the various factors analyzed [42]. In this regard, the question arises of identifying statistical indicators of e-commerce at the country level and on a global scale to assess its dynamics and comparability. Thus, the distance still remains more country-specific and less geographical.

7. Policy and Marketing Suggestions

The objective of this study was to examine how online purchases vary compared to domestic and cross-border sellers in the EU from 2020 to 2023. Our findings underscore the significance of countries' disparities and their profound impact on online retailing by seller origin. Drawing from our results and conclusions, we make several suggestions for policy and marketing strategies. While studies predominantly focus on individual decision-making processes in e-commerce, the influence of countries' characteristics on online purchasing remains relatively understudied. Our study reaffirms the role of country-specific characteristics in shaping online purchases and underscores the imperative for further exploration, particularly in relation to seller origin. Understanding the information barriers to online purchasing is crucial to each country in the digital economy. Moreover, the set of key factors of online purchases used in our study showed their more complex modification, primarily for domestic online purchases. Expanding research into country-specific characteristics of both domestic and cross-border online purchasing will enable the development models that accurately capture these dynamics.

Our analysis of global spatial autocorrelation reveals significant spatial localization of online purchasing within countries with limited connectivity to neighboring nations. Despite little spatial homogeneity, the detected spatial patterns are localized in the high-high and low-low environments, which suggests a potential trajectory toward further e-commerce polarization. Furthermore, the observed trend of increasing domestic localization of online shopping within the EU from 2020 to 2023 raises concerns, particularly in light of the EU's adoption of new e-commerce convergence measures.

Addressing the challenges of harmonizing digital development and market regulation within the EU necessitates additional measures to overcome borders in e-commerce, encompassing taxation, customs, delivery, and potential returns. Such measures should account for the nuances of currencies, languages, and cultural characteristics of countries to foster a more cohesive e-commerce ecosystem within the EU.

Given the consistently positive and sustainable impact of Internet use on online purchasing across all merchant's categories—domestic, Union, and international—prioritizing ICT development emerges as imperative. Heightened efforts aimed at infrastructure, promoting ICT adoption, enhancing digital literacy, and fostering relevant skills represent a compelling proposition for promoting online purchases.

Our marketing suggestions include increased emphasis on the origin of the seller, particularly in domestic or international online retailing, as this is critical for online purchases of goods and services in both physical and electronic form. Additionally, it is essential to recognize that predictors of online purchasing may have varying effects—both positive and negative—depending on whether transactions are domestic or cross-border. This requires marketing approaches tailored to these distinctions. Moreover, it is crucial to acknowledge the potential overlap and complementarity between products and services offered in electronic and physical forms. This interplay between different forms of goods and services should be factored into marketing strategies, enabling a more holistic approach to address consumer preferences and behaviors.

8. Conclusions

E-commerce is an integral business model for global and national trade. In this article, the country-specific characteristics of e-commerce were identified. We conclude that differences in e-commerce by seller origin are driven primarily by country-specific characteristics (language(s), currencies) and, to a lesser extent, geographic distance. It is important to note that the difference in purchasing goods and services online depends significantly on their physical and electronic form, that is, digital ordering and/or digital delivery. The expansion of e-commerce and the importance of country-specific characteristics require standards to measure them.

Our study represents one of the starting points for further analysis of countries' characteristics in e-commerce. We consider continued search and analysis of country-specific determinants in e-commerce, based on other countries, and additional key e-commerce indicators to be an important extension of this research. Studying the degree of disclosure of the country of origin in online and traditional stores, that is, the level of transparency of this information, will allow us to determine the availability of information in e-commerce by country and the impact on consumer choice of goods. Several studies examining the provision of information on labels, packaging, including seller origin, and other information that is usually present on physical goods for consumers show its importance for e-commerce [48,49]. The question of the most important country characteristics of goods and services for customers in the field of e-commerce—the country of origin and the origin of the seller—is also on the research agenda and will allow us to deepen the conclusions of this work.

9. Limitations

This study has several limitations. One of them is the use of certain key e-commerce indicators due to the availability of data. Another limitation is that the product categories analyzed may not cover all possible cross-border e-commerce transactions.

Since the data are from EU Member States with a generally harmonized approach to e-commerce regulation, our findings can be generalized with a certain level of probability to other regions and unions such as ASEAN, BRICS, and others.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author in connection with public availability of data and no new data generated.

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Conflicts of Interest: The author declare no conflict of interest.

Abbreviations

OSL—ordinary least squares,
OECD—the Organization for Economic Co-operation and Development,
EEA—European Economic Area,
Moran's I index—a measure of global spatial autocorrelation introduced by Patrick Alfred Pierce Moran,
LISA—Local Indicators of Spatial Association,
HH—High-High spatial rule, where countries with high values of online purchases by seller origin are surrounded by countries with high corresponding values,
LL—Low-Low spatial rule, where countries with low values are surrounded by countries with low values,
HL—High-Low spatial rule, where countries with high values are surrounded by countries with low values,

LH—Low-High spatial rule, where countries with low values are surrounded by countries with high values.

Appendix A

Table A1. Descriptive statistics of data and indicators.

Group/Indicator, Measure	Symbol	Mean	Std. Dev.	Min.	Max.
1 Origin of sellers, % of individuals					
Domestic seller	s1	46.39	14.60	14.04	79.57
EU seller	s2	23.32	11.60	2.30	53.09
Non-EU seller	s3	13.12	6.83	0.81	34.80
2 country online purchase indicators					
Harmonized indices of consumer price, %	v1	116.83	12.26	99.67	160.59
Distribution of population by degree of urbanization (cities), %	v2	38.03	11.18	18.70	88.80
Sole/multi official language(s), binary	v3	–	–	–	–
Currency national/Euro, binary	v4	–	–	–	–
Internet use, % of individuals	v5	91.02	5.59	74.27	99.81
3 Online purchases (3 months)—Physical goods and services, % of individuals					
Bicycles, mopeds, cars, or other vehicles or their spare parts	p1	5.52	3.14	0.53	12.86
Printed books, magazines, or newspapers	p2	12.85	6.85	1.36	29.23
Children toys or childcare items	p3	10.10	4.44	1.57	23.74
Clothes (including sport clothing), shoes, or accessories	p4	36.88	11.44	11.75	64.68
Computers, tablets, mobile phones, or accessories	p5	12.99	5.10	2.35	26.78
Cosmetics, beauty, or wellness products	p6	15.83	6.45	3.24	32.17
Consumer electronics or household appliances	p7	11.38	5.42	1.39	25.34
Furniture, home accessories, or gardening products	p8	14.72	7.57	1.46	35.98
Medicine or dietary supplements such as vitamins (online renewal of prescriptions is not included)	p9	12.08	7.21	1.68	38.96
Sports goods (excluding sport clothing)	p10	13.13	6.05	3.07	31.06
4 Online purchases (3 months)—Electronic goods and services, % of individuals					
Other apps (e.g., related to learning languages, traveling, weather) (excluding free apps)	e1	4.21	3.24	0.05	14.15
Films or series as a streaming service or downloads	e2	19.95	14.45	1.14	58.35
Tickets to cultural or other events	e3	14.78	11.12	0.26	46.78
Computer or other software as downloads including upgrades	e4	8.83	5.87	0.70	21.77
Games online or as downloads for smartphones, tablets, computers, or consoles	e5	9.41	6.11	0.78	26.17
Apps related to health or fitness (excluding free apps)	e6	4.15	3.28	0.08	13.53
Tickets to sport events	e7	4.19	3.29	0.20	16.29
E-books, online magazines, or online newspapers	e8	8.55	7.45	0.62	34.33
Music as a streaming service or downloads	e9	20.05	14.57	1.14	58.35
Subscriptions to the internet or mobile phone connections	e10	11.38	8.96	1.36	48.78

Source: own grouping, Eurostat data, 2024 [43]. Note: The goods and services listed are considered consumer goods purchased for personal use.

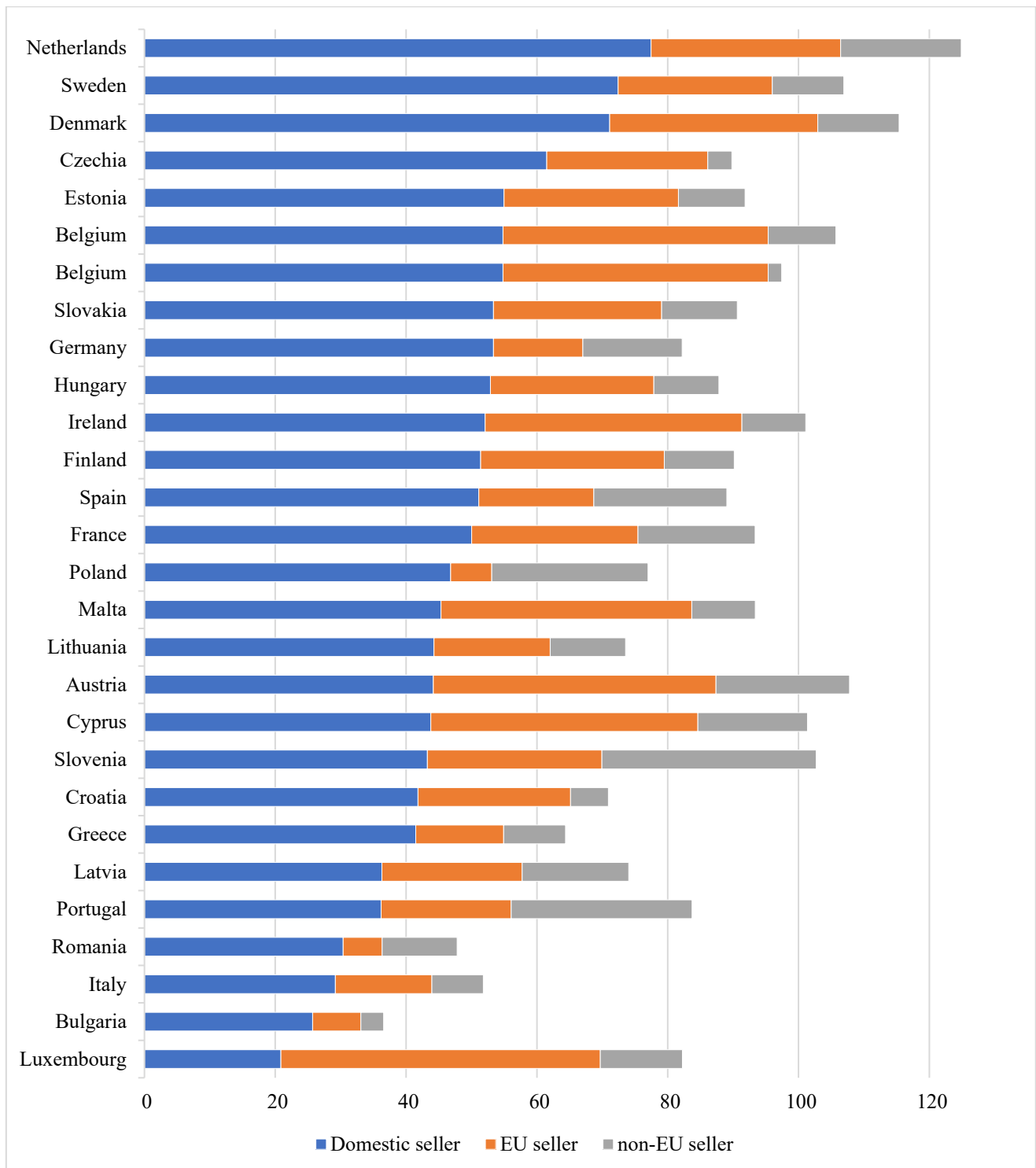
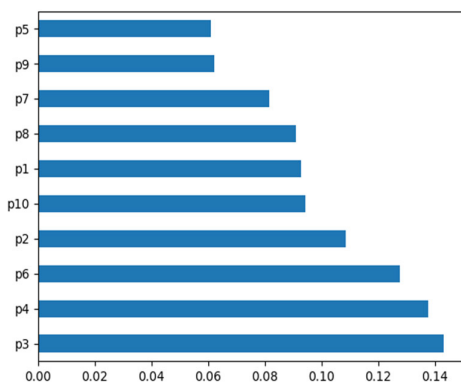
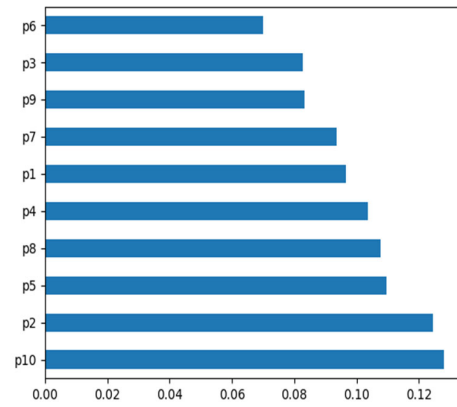


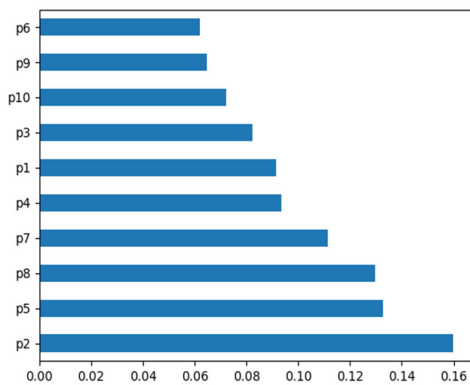
Figure A1. The share of domestic, intra-EU, and cross-border online purchases in EU countries in 2023 Source: Eurostat, 2024.



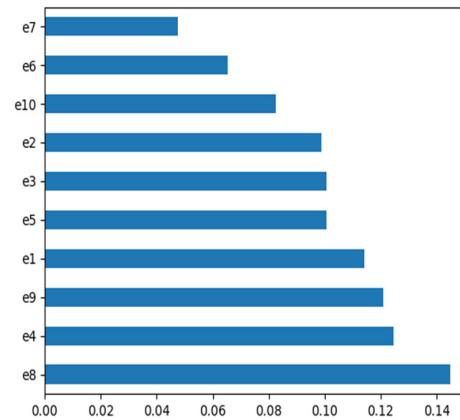
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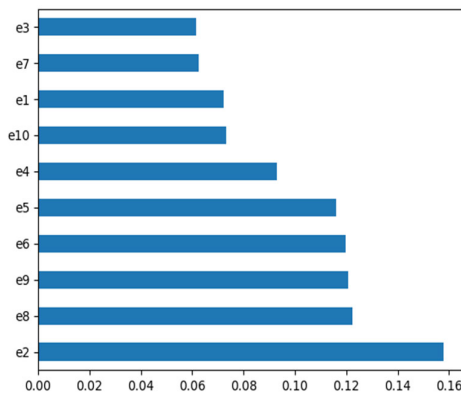
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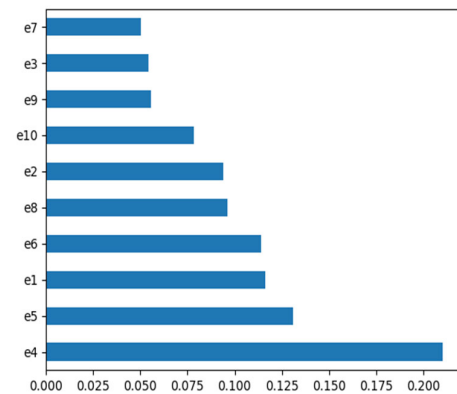
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(d)



(e)



(f)

Figure A2. Feature importance selection results on online purchases by seller origin and physical and electronic goods and services. (a) Domestic sellers and online purchases of physical goods and services. (b) Intra-EU sellers and online purchases of physical goods and services. (c) Non-EU sellers and online purchases of physical goods and services. (d) Domestic sellers and online purchases of electronic goods and services. (e) Intra-EU sellers and online purchases of electronic goods and services. (f) Non-EU sellers and online purchases of electronic goods and services.

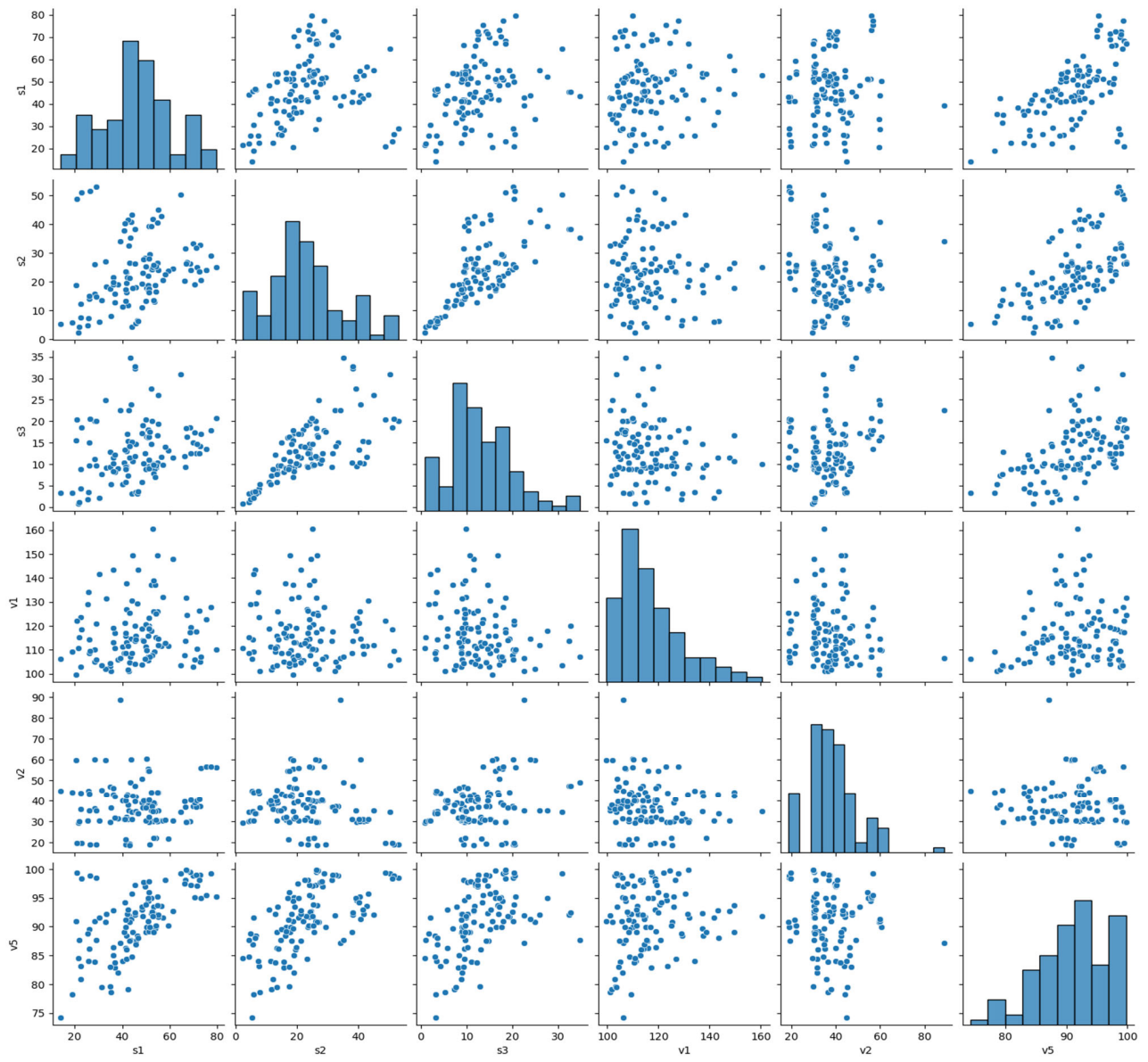


Figure A3. Linearity for research indicators.

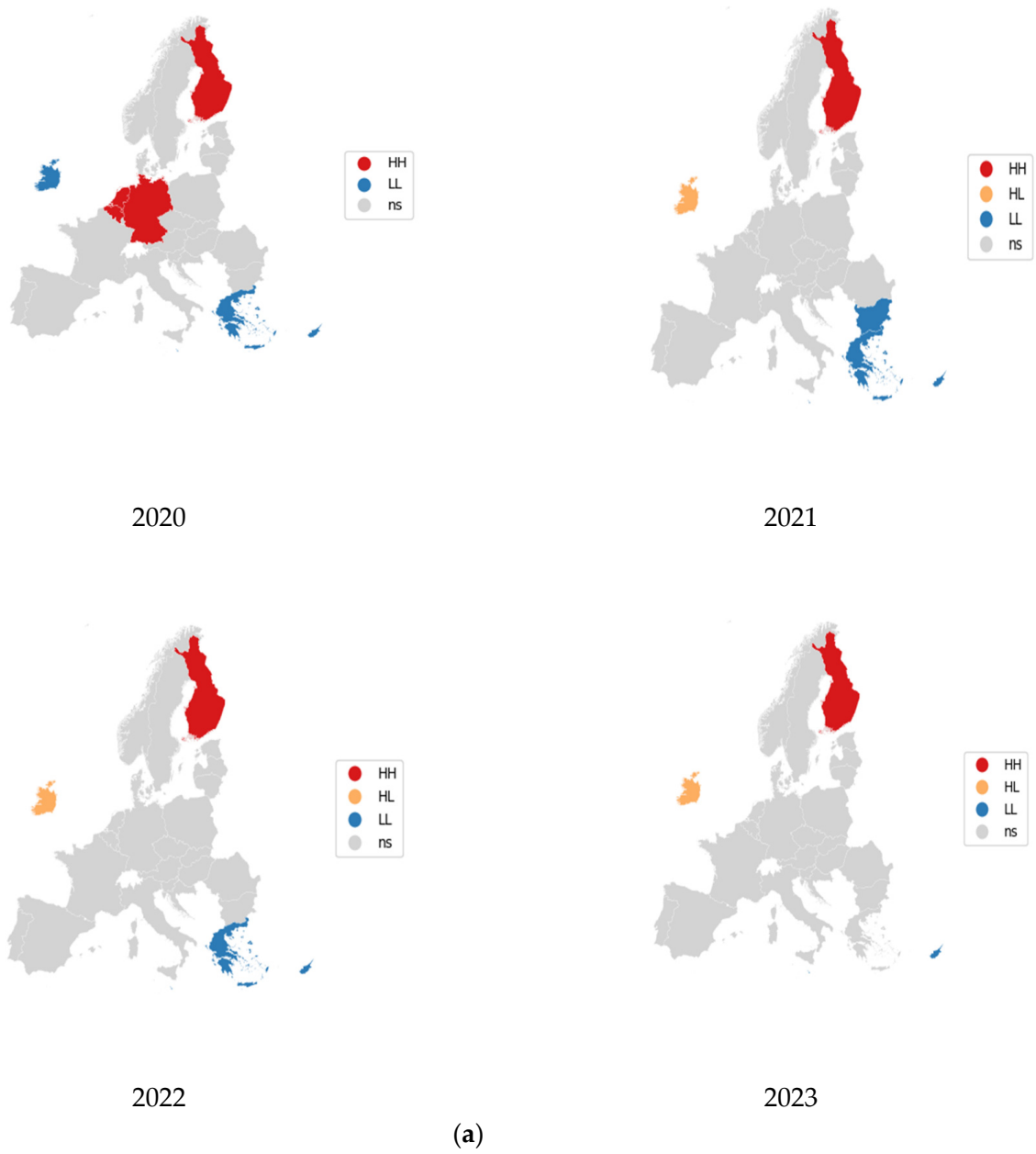
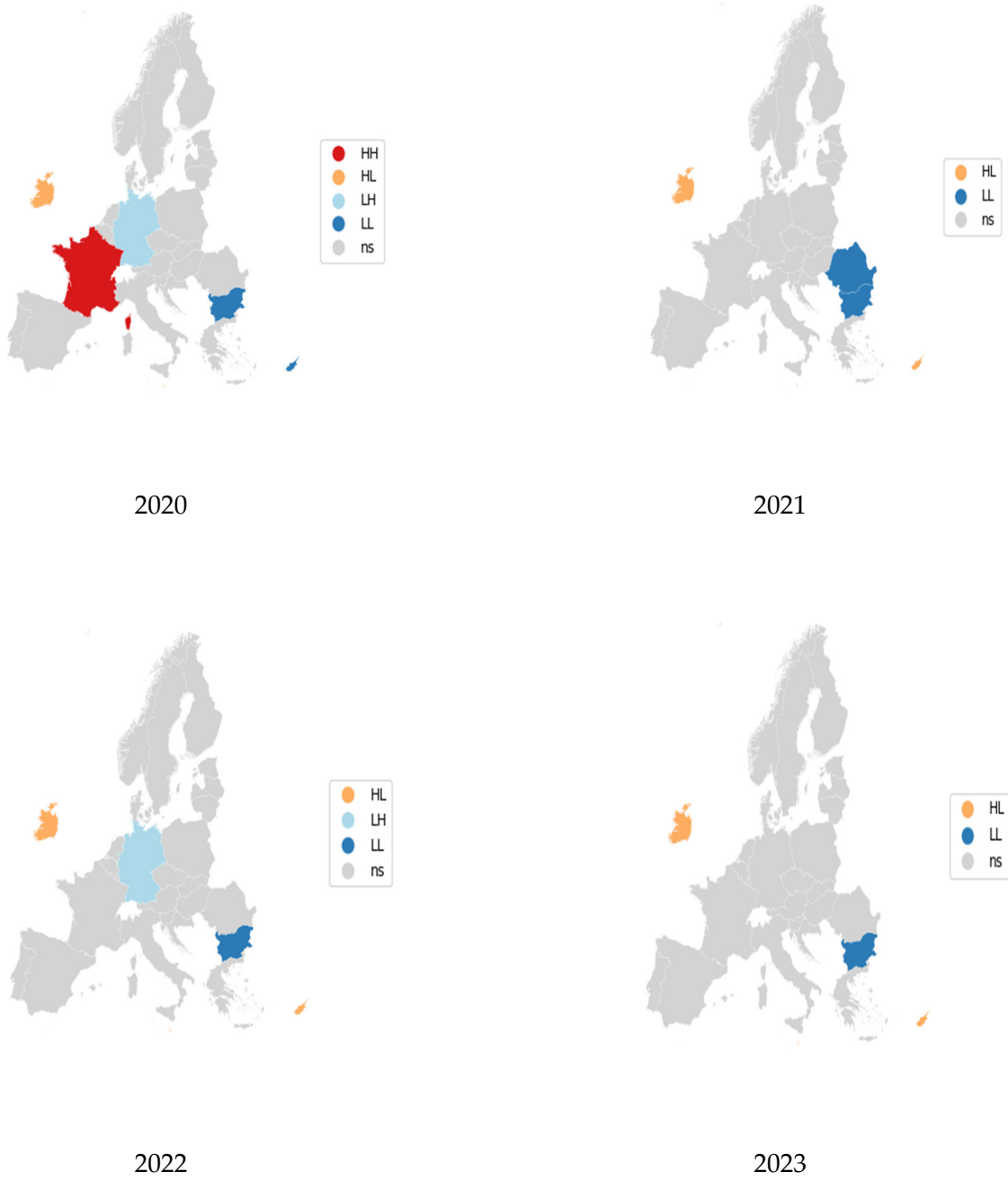


Figure A4. Cont.



(b)

Figure A4. Cont.

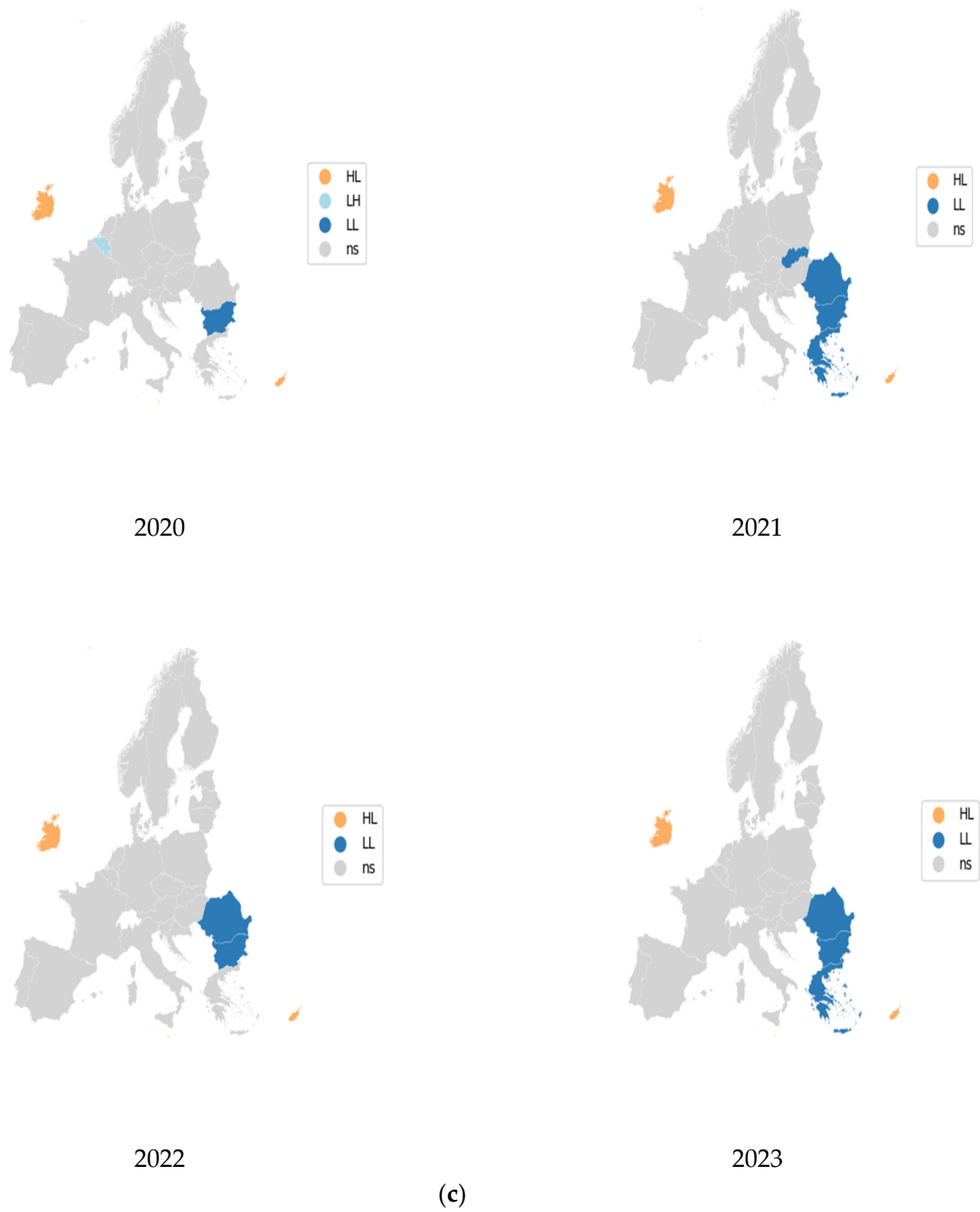


Figure A4. (a) LISA of online purchases by domestic sellers, 2020–2023. (b) LISA of online purchases by intra-EU sellers, 2020–2023. (c) LISA of online purchases by non-EU sellers, 2020–2023.

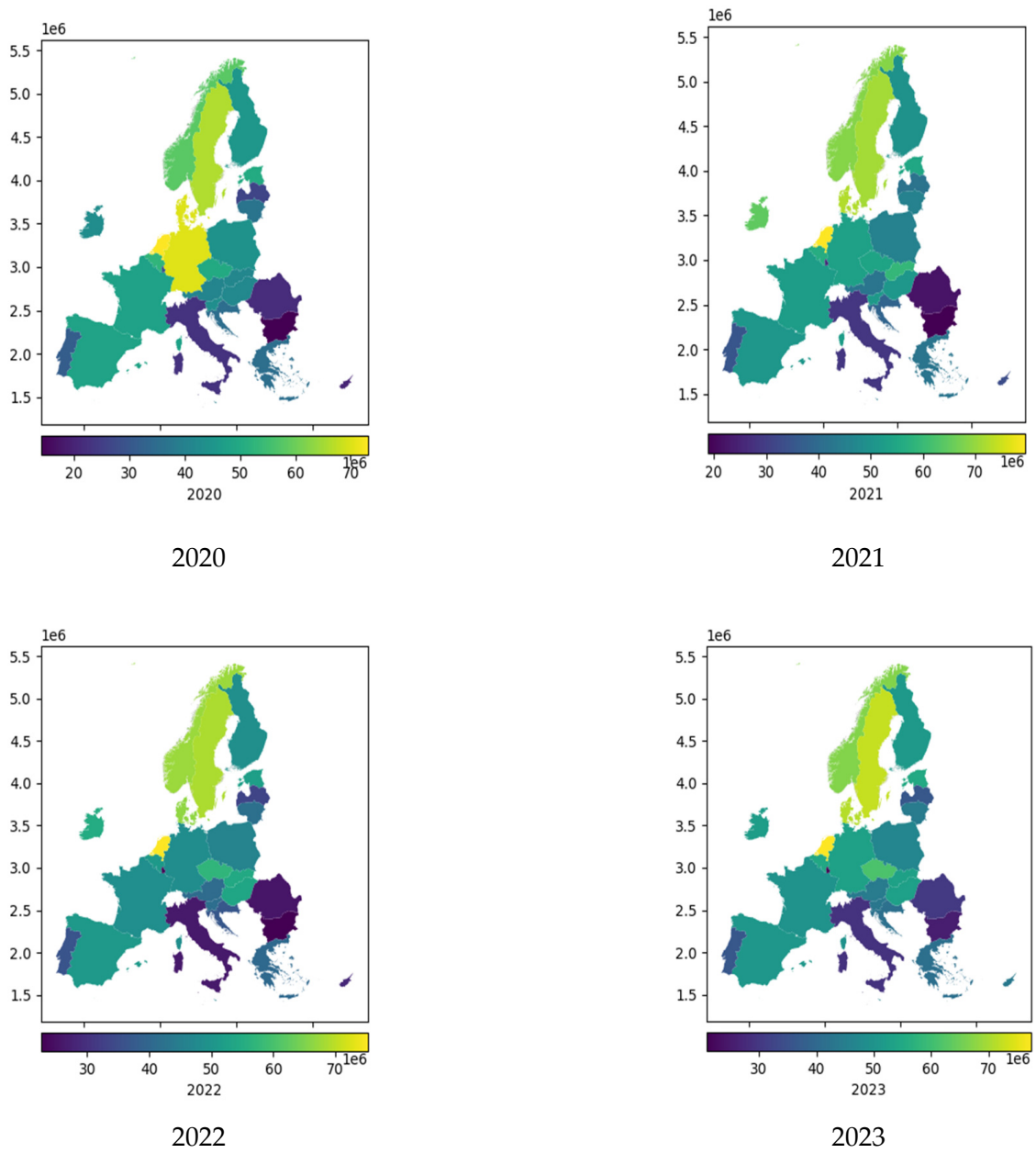
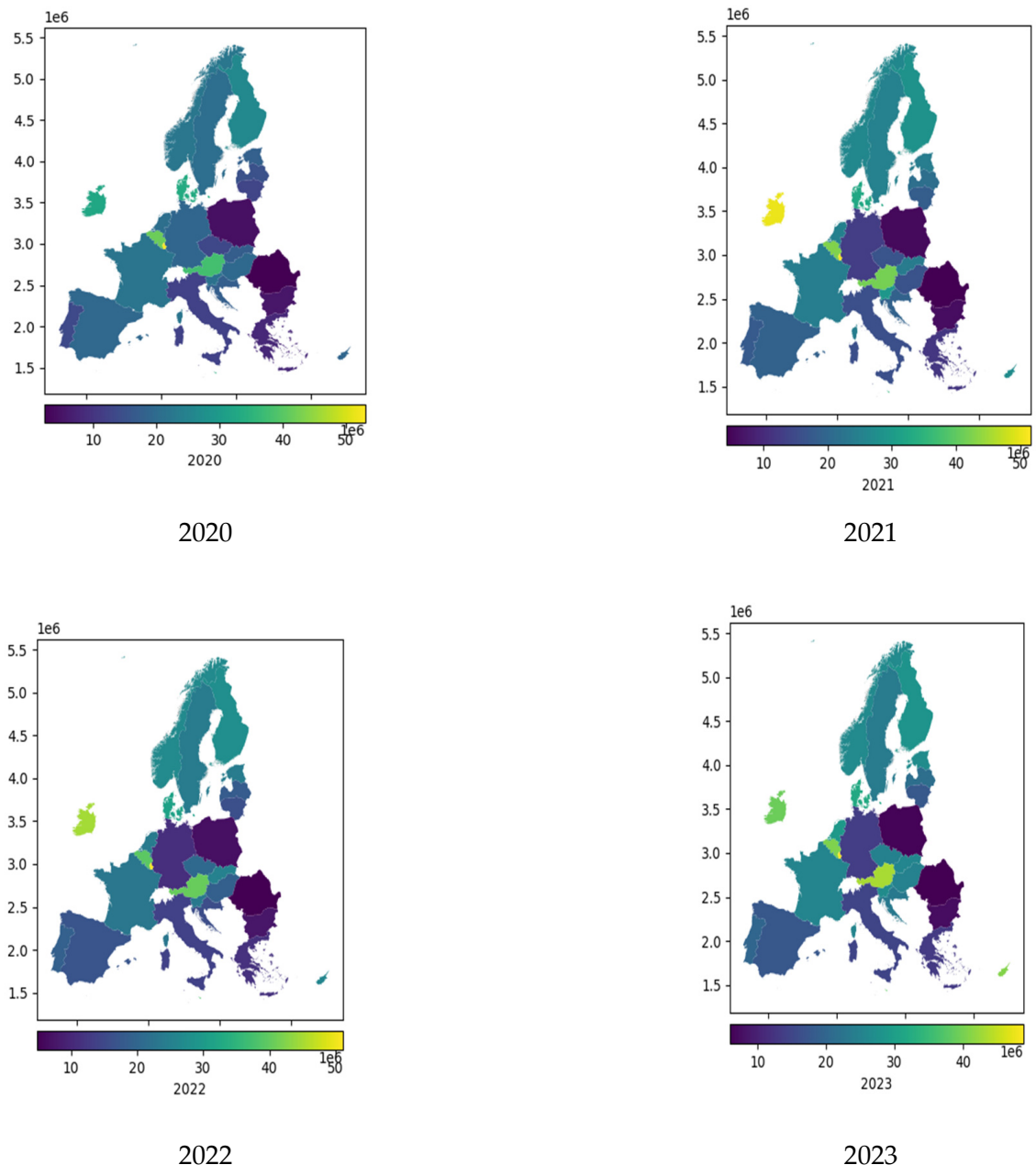


Figure A5. Cont.



(b)

Figure A5. Cont.

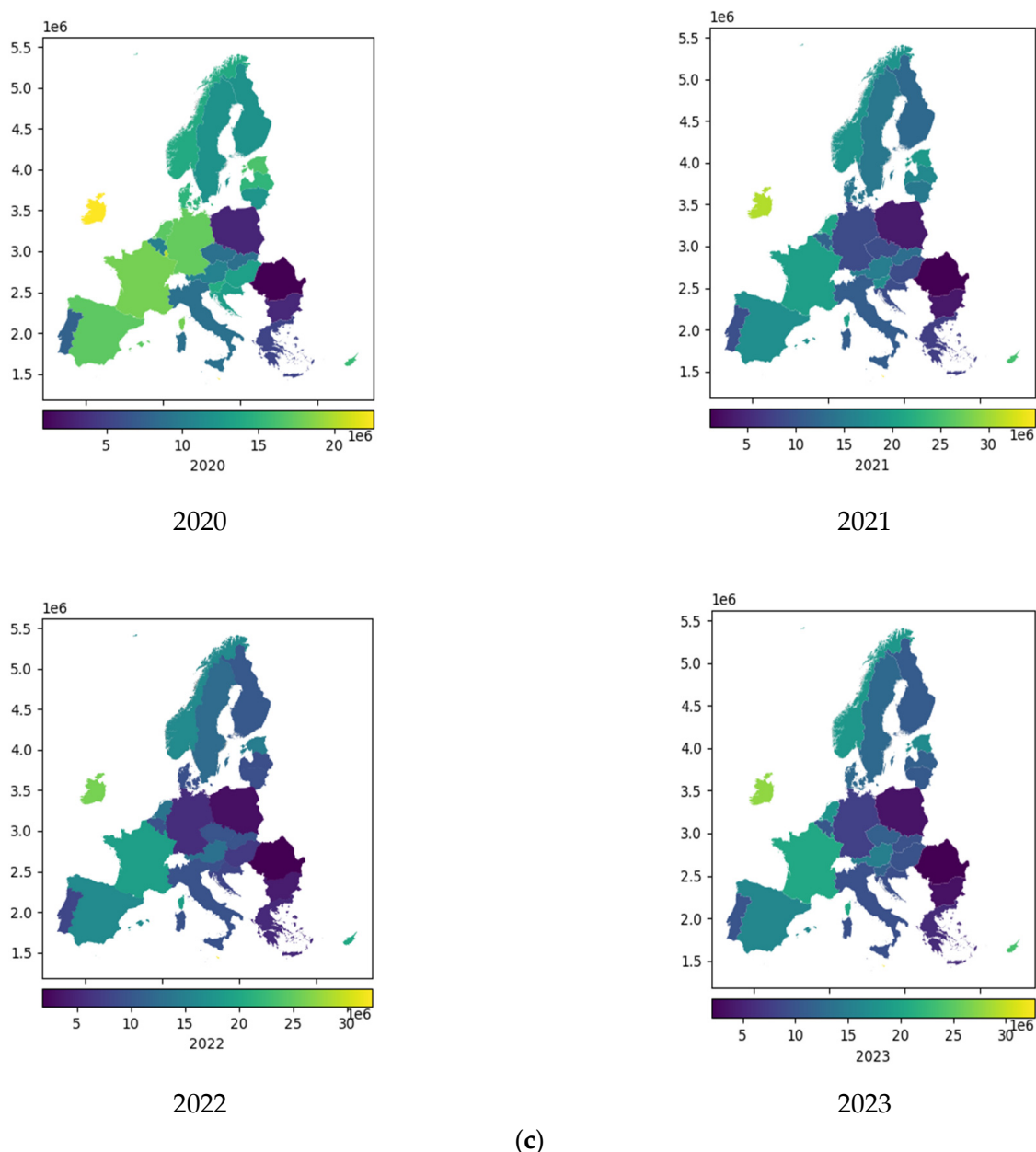


Figure A5. (a) Spatial distributions of online purchases by domestic sellers, 2020–2023. (b) Spatial distributions of online purchases by intra-EU sellers, 2020–2023. (c) Spatial distributions of online purchases by non-EU sellers, 2020–2023.

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