ASECU South-Eastern Europe Journal of Economics 2 (2024) 147-180 SEEJE

EMPIRICAL STUDY ON EURO CURRENCY CONFIDENCE UNDER GLOBAL CHALLENGES

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Abstract

The relationship between the euro and globalisation is an important component of economic integration; it has enabled smoother trade and investment among member states of the European Union since the currency was launched. This process has not only increased commerce inside Europe but has also had an influence on the global economy. The euro's impact reaches into global banking and trade, highlighting the interdependence of global economies and the significance of public perception in maintaining the stability of the euro. This paper uses data-mining methods, namely decision trees and neural networks, to examine the factors that influenced the perception of the euro among citizens of Eurozone member states in 2019 and 2022. The years were intentionally chosen to compare attitudes before the pandemic and the changes caused by the COVID-19 pandemic. In 2019, perceptions were observed in a stable economic and social context, whereas in 2022, the effects of the pandemic, such as economic shocks and recovery efforts, were analysed. This study is important for detecting changes in public opinion resulting from the pandemic, assisting policymakers and the European Central Bank in formulating ways to strengthen support for the euro. Gaining insight into these perspectives may result in developing more inclusive policymaking, thereby helping to resolve inequities among member states or demographic groups and guaranteeing the long-term stability of the currency.

Keywords: Euro, economic perceptions, CART algorithm, Neural networks, Eurobarometer, European Union

JEL Classification: D91. Role and Effects of Psychological, Emotional, Social, and Cognitive Factors on Decision Making

The paper was among the five nominated papers for the ***Tsekouras Prize for Young Economists***, awarded by the *Association of Economic Universities of South and Eastern Europe and the Black Sea Region (ASECU)* which will be announced at the ASECU International Conference, Montenegro, July 2025.

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1. Introduction

Public opinion about the euro extends beyond questions of monetary efficiency and includes everyday convenience, institutional trust, and identity. Supporters emphasise the euro's role in lowering transaction costs, enabling seamless travel and cross-border business, and anchoring macroeconomic credibility. Critics, however, point to perceived price increases associated with currency changes, concerns over the loss of national monetary autonomy, and symbolic attachment to legacy currencies. These divergent viewpoints, i.e., economic utility versus perceived costs, European integration versus national sovereignty, and European identity versus national symbolism, shaping opinions about the euro as a complex outcome across countries and demographic groups.

The COVID-19 shock offered a before-and-after perspective through which these viewpoints may have shifted. In 2019, Eurozone citizens reported their opinions in a relatively stable social and economic context. By 2022, households had experienced pandemic disruptions, uneven recoveries, and accelerated changes in payment habits. Despite the rich body of research analysing public support for the euro, existing studies rely on traditional regression-based frameworks and focus on long-term trends, structural determinants, or crisis-related shifts. Contributions such as those by Roth et al. (2015, 2019, 2022) or Banducci et al. (2003, 2009) analyse public confidence in the euro using macroeconomic indicators, institutional trust, or demographic gradients, but they do not provide a direct micro-level comparison of the determinants before and after the COVID-19 pandemic. Moreover, earlier papers typically evaluated predictors individually rather than assessing the relative importance of competing mechanisms, such as institutional performance, cross-border convenience, and payment habits, within a unified analytical framework. There is also limited use of interpretable machine-learning approaches that can both rank determinants and derive respondent profiles in a transparent way. This paper addresses such gaps by constructing three perceptual constructs (C1–C3), comparing their influence in 2019 and 2022, and applying CART and MLP models to identify shifts in the importance and the profiles most associated with negative views of the euro.

This paper aims to fill this gap by providing a structured comparative analysis of the determinants of euro confidence before and after the COVID-19 shock. First, we classify the relevant Flash Eurobarometer items into three conceptually coherent constructs and derive synthetic indicators for each of them: C1 - Institutional reforms (perceived performance and reforms in key policy domains); C2 – Travel and business facilitation (perceived convenience and cost reductions across borders); and C3 – Payment methods (cash versus electronic payments in daily life). These constructs are built as weighted aggregations of survey items, where weights reflect the relative importance of each item obtained from CART-based variable importance measures.

In this way, each respondent receives a score for C1–C3 that summarises their perception of reforms, cross-border benefits, and payment habits, respectively.

In this study, we use the term "trends" not to describe long-run time-series dynamics, but to capture changes between 2019 and 2022 in: (i) which construct most strongly influenced confidence in the euro; (ii) how strongly demographic factors were associated with euro confidence; and (iii) which profiles of respondents were most likely to hold negative views. This framing links the paper's aim to a clear and measurable contribution.

Methodologically, we combine Classification and Regression Trees (CART), which yield transparent variable-importance rankings and human-readable profiles, with Multilayer Perceptron (MLP) neural networks as an out-of-sample validation layer. Our research questions are:

Q1. Which of the constructs (C1–C3) had the strongest influence on confidence in the euro in 2019 and 2022, and how did their relative importance change?

Q2. Which demographic factors (country, education completion age, age, job) most differentiated perceptions, and did their effects intensify after COVID-19?

Q3. Which respondent profiles were most likely to hold negative views in each year?

The paper makes three contributions. First, it offers the Eurozone a pre- versus post-COVID micro-comparison that ranks the relative influence of institutional, convenience-related, and payment-habit constructs on confidence in the euro and indicates how these ranks shifted across the studied period. Second, it identifies actionable profiles of likely sceptics, as defined by specific combinations of country, education, and age, informing targeted communication and reform priorities. Third, it proposes a transparent construct-level mapping of survey items and interpretable machine-learning models (CART with MLP validation) that situates other attitudinal settings within which heterogeneous mechanisms compete.

We position our study within the literature on euro support and identity, clarify the construct mapping, and detail the CART–MLP framework and validation strategy. We then present results for 2019 and 2022, highlighting construct importance, demographic differentiation, and profiles of negative perceptions. We conclude with implications for policy design and communication, highlighting factors reinforcing cross-border convenience and addressing institutional concerns, which can increase public confidence in the euro.

The paper is structured as follows. Section 2 reviews the relevant literature on monetary perceptions and the determinants of support for the euro. Section 3 presents the data, the construction of the three perceptual constructs, and the methodological framework based on CART and MLP models. Section 4 reports the empirical results for 2019 and 2022, focusing on construct importance, demographic differentiation,

and respondents' profiles. Section 5 concludes by discussing the policy implications of the findings and outlining avenues for future research.

2. Literature Review

The social and cultural construction of money goes beyond its physical form as a facilitator for the exchange of goods and services. Adam Smith (1776) acknowledged this in his work titled *The Wealth of Nations*. In order to simplify and streamline transactions, money was created, and it carries a subjective value determined by human judgement. This allows for easier exchanges that do not require direct trade in goods and services. An additional point made by Wimmer (2018) is that a sense of loyalty and emotional connection to one's own nation can emerge in the image of money as a public good. The perception of money is influenced by cultural and social contexts, according to Simmel (2005). This is affected by various factors, including the stability of a nation's monetary system and citizens' trust in the government's financial management capacity. Therefore, the significance of money extends beyond its economic value, since it functions as a powerful cultural and social symbol (Holton and Turner, 2010). Money reflects the values of a society or nation, thus becoming a symbol (Genschel and Jachtenfuchs, 2017).

2.1. Money, Identity and Monetary Integration

The association between money and national identity stems from the cultural and social connotations attached to it as stated. A national currency acts as a powerful signifier of the value and financial power of a country or a community (Helleiner et al., 2003; Negri et al., 2020). In addition, it can serve as a means of expressing values and customs. Symbols, images, and inscriptions engraved on banknotes play a crucial role in shaping and enhancing national identity (Holton and Turner, 2010; Risse, 2003). The strength of a currency can signify the country stability and trust, serving as the basis for national identity (Leblond, 2003). The Swedish and Danish krone are an example of stable currencies, with a rich history of economic and political stability (Hobolt and Leblond, 2009). Another possible illustration is Germany's former currency, the Deutsche Mark, which was once renowned worldwide for its remarkable strength and consistent stability, this is seen in polls that have shown an overwhelming consensus against the adoption of the euro as the country's official currency, despite its introduction by the federal government in 1999 (Risse, 2003).

A monetary area represents a geographical space in which member states coordinate their monetary policies and use the same currency (Encinas-Ferrer, 2013). The currency area uses a common currency accepted by all member states, facilitating commercial transactions and reducing currency conversion costs. A common monetary policy also helps to maintain economic stability and prevent financial crises, since member countries share responsibility for coordinating monetary policy and

maintaining financial stability (Baldwin and Wyplosz, 2020). Established in the 3rd century BC, the monetary union of the Roman Empire introduced the denarius and provided a remarkable model for a centralised currency over vast territories (Boerner and Volckart, 2011). Although several efforts aimed to replicate this feat were made, both in the interwar period, such as the Scandinavian Monetary Union of the 1920s and 1930s, and later in the 1960s, for example through the African Monetary Union, political and economic problems repeatedly delayed such aspirations (Bergman, 1999).

There are currently 20 member states of the European Union that are Eurozone. Croatia is the most recent member state of the Eurozone, joining in 2023. The Maastricht Treaty of 1992 pioneered the creation of the Economic and Monetary Union, laying the foundations for its establishment (European Central Bank, 2023). Nations that met the benchmarks were welcomed into the Eurozone (European Central Bank, 2021). The launch of euro banknotes and coins in 2002 was a historic moment for the euro (European Central Bank, 2023). Its implementation facilitated the consolidation of the monetary union and aimed to eradicate currency fluctuations between member states, thus increasing trade. Before the adoption of the euro, trade transactions between member countries were hampered by the use of individual national currencies. The introduction of the euro allowed for seamless travel and trade throughout the Eurozone (European Union, 2022a). Currently, the euro can be considered one of the most important pillars of the European Union and a stable, reliable and globally recognised currency.

The key element of the European Monetary Area is defined by the single currency, the euro, which aims to increase the level of the European integration process that began in 1990 (Genschel and Jachtenfuchs, 2017). As argued in the first paragraph of the paper, any currency can be viewed as a social construct, so it is of interest to analyse the perception EU citizens regarding the euro. Further studies will be presented to understand the impact that citizens' perception has on a currency and why it is important for the Eurozone.

2.2. The importance of euro perception

Relevant literature states that assessing how citizens perceive the euro is important for various reasons, as described in this section.

First, economic issues may have a different impact on individuals, depending on their age, occupation, and socio-economic status. Analysing citizens' perceptions provides insight into the different impacts of economic issues and allows for a deeper understanding of the situation. For example, inflation peaks can affect people differently, depending on their income and spending habits (Witt, 2016). Studying citizens' perceptions can help to recognise distinct classes of citizens and to create appropriate policies to address economic issues.

Second, in order to improve communication with citizens, it is essential to understand their perceptions of the euro. This understanding allows government officials and central bankers to communicate more effectively with the public (Banducci et al., 2003). In cases of misconceptions about the functioning of the euro, responsible institutions can provide clearer information to help EU citizens understand the monetary system (Roth and Jonung, 2022). By analysing citizens' perceptions, officials can identify gaps in their communication strategy and take corrective measures to ensure effective dissemination of information.

Additionally, understanding how citizens perceive monetary policy is crucial for improving its effectiveness (Marcussen and Zølner, 2003). According to Verdun (2019), this type of analysis can provide valuable information on how monetary policies affect citizens. Officials can consider unfavourable perceptions, as well as their causes, to protect people and improve economic performance (Derose et al., 2007). By better understanding citizens' perceptions, institutions that aim to design and implement monetary policy at the EU level can make sounder and better-informed decisions.

Finally, the sustainability of a currency depends largely on the trust it inspires. Stronger trust in the euro can not only boost financial growth but also attract investment and ensure greater stability. In order to assess the factors shaping such trust, it is essential to assess citizens' opinions (Roth and Jonung, 2022). This type of analysis can reveal ways to strengthen trust in the euro, including more effective communication with the public and adopting appropriate monetary strategies.

Trust in a currency is essential for its functioning and survival over time. People use the currency to buy goods and services, as well as savings. When trust in a currency is lost, it becomes worthless and cannot fulfil its role as a means of trade or a store of value (Skaggs, 1998). Trust in the euro is fundamentally necessary for the longevity of the Eurozone, which consists of 20 European Union member states that share the euro as a common medium of exchange. If individuals trust a currency, they will willingly incorporate it into their transactions. If trust in a currency declines, people will rush to get rid of it, inevitably causing a decline of its value (Bordo et al., 2013). Finally, if a currency is scarcely accepted or used by people, it may well become worthless. Residents of a Eurozone member country may decide to exchange their savings into alternative currencies if they have a negative outlook on the euro; this act alone could cause the euro to depreciate. Accordingly, a reduction in the real value of the euro can propel rising inflation and economic instability throughout the Eurozone. This link has been well-established in several reports (Banducci et al., 2003; Hobolt and Leblond, 2014; Roth et al., 2015; Roth et al., 2019).

2.3. Determinants of public opinion towards the euro

The perception of a currency can be seen in three primary dimensions. The cognitive dimension refers to an individual's awareness and understanding of the value, design and security features of a currency. Factors such as education, experience and exposure to different currencies may influence this dimension. People who travel frequently are likely to have more in-depth knowledge of currencies compared to those who do not travel. The emotional connections that citizens have with their currency should also be taken into account when examining the currency of a country or community (Tyszka and Przybyszewski, 2006). The affective dimension of currency involves people's emotional connections and feelings towards it, influenced by the culture, history and identity of the nation. For example, an individual may feel a sense of loyalty and pride for their currency due to its historical significance and shared cultural values, as also supported by Engelberg and Sjöberg (2006). Finally, when evaluating a country's currency, the assessment of its quality is of paramount importance. The valuation of a country's currency is impacted by its economic performance and government policies. The evaluative dimension is strongly influenced by these two factors. A country with a strong economy and competent management of its finances is likely to have a positive public opinion of its currency.

The three dimensions of perception, emotion, and evaluation are interconnected. People's cognitive information about a currency can affect their emotions and evaluations, while their emotions and evaluations can shape their understanding of the currency. Thus, a comprehensive approach that considers all three dimensions is necessary for understanding how individuals perceive a national currency.

The significance of the euro extends beyond it being a mere currency; it embodies national sovereignty and independence, as discussed earlier. However, the transition to the use of the euro may be perceived by some people as a loss of national identity. Hobolt and Leblond's (2009) study of the Swedish and Danish referendums provides further evidence confirming this phenomenon. Research by Kaltenthaler and Anderson (2001), Marcussen and Zølner (2003), and Jubille and Leblang (2007) further supports this claim. For those with a strong sense of national identity, the use of the euro may be seen as a threat to their cultural values and traditions. Such notions are reinforced by fears of losing control over monetary and fiscal policies, as well as by the negative economic effects of European integration, such as job losses and rising prices. Isengard and Schneider's (2006) study of German citizens' scepticism illustrates this argument. On the other hand, people who identify more with European values and have a positive attitude towards European integration perceive the euro as an opportunity to strengthen European solidarity and enjoy the economic benefits of a unified market. In their paper, Negri et al. (2020) argue that a sense of national and European identity can coexist. This implies that views of the euro can also be affected by factors such as attitudes towards European integration and national identity.

The level of trust in one's own government can have a significant impact on perceptions of the euro, but the degree of influence varies depending on the circumstances of each country. Countries with strong governments and successful economic management may generate more trust in their own government. While decreasing trust in European institutions can leads them to a doubtful or negative view of the euro. Gabel's (1999) survey of European public opinion on the benefits and disadvantages of EMU, together with trust in European institutions, was analysed using statistical methods such as factor analysis and regressions. Qualitative interviews with European citizens were also conducted to gain a deeper understanding of their motivations and perceptions of EMU. Using these mixed methods, Gabel uncovered a comprehensive view of public perceptions and the factors shaping them, confirming the role of trust in one's own government and economic performance in shaping perceptions of the euro. The perception of the euro is shaped by various factors, including the strength of a country's economy and government. In Germany, for example, where the economy and government are robust, there is a perception that the European Central Bank is not doing enough to protect Germany's interests, which can lead Germany people to a negative perception of the euro (Isengard and Schneider, 2006). Conversely, countries with weak economies and unstable governments may have less trust in their own government and more trust in European institutions, such as the European Central Bank. This can lead people to have a more positive outlook on the euro and increased demand for euro membership (Hobolt and Leblond, 2009). In Bulgaria, for example, people believe that joining the euro could provide economic and financial benefits (Roth and Jonung, 2022). Therefore, the perception of the euro is influenced by the level of trust citizens have in their own governments, and varies from country to country.

A favourable perception of the euro can be undermined by inflation, which erodes trust in the currency and the institutions responsible for management. Studies by Banducci et al. (2003) and Roth et al. (2019) have validated this claim, establishing a significant negative relationship between inflation rates and public perception of the euro. Consequently, theoretically, high inflation rates lead to price increases while eroding the purchasing power of the currency, which can lead to a loss of trust in the euro and the ability of European monetary institutions to maintain fiscal stability.

Citizens' satisfaction with their financial situation could have a significant impact on the phenomenon examined in this paper. Research by Bergbauer et al. (2020) shows that those who are satisfied with their financial well-being are more likely to support the euro and the ECB. The authors found that EMU supporters were the largest group of respondents who rated their household financial situation as good or very good. In contrast, respondents who expressed significant dissatisfaction with their financial situation had a different perspective. EMU supporters accounted for

only 10% of respondents in this group at the end of 2019, indicating a further decline from pre-crisis levels.

Demographic factors

Gender may affect perceptions of the euro, but there are no studies that clearly state or refute this. Findings by Bergbauer et al. (2020) indicate that, while men and women share similar attitudes towards the euro, fewer women identify as supporters of EMU. The author states that in Eurobarometer surveys, women answered "don't know" more often than men, by a difference of around 5%. This paper will further explore whether gender, as a demographic factor, has any significant impact on perceptions of the euro.

People's perceptions of the euro can be influenced by their age and experiences. Growing up in a world where the single currency is a reality, young people are more likely to have a favourable view of the euro (European Union, 2022b). In contrast, older people, who may retain a nostalgic attachment to their former national currency, may be more sceptical. Their previous experiences with economic turmoil, such as currency devaluation and inflation, may lead them to view the concept of a common currency with more suspicion (Tyszka and Przybyszewski, 2006). The fact that older people's opinion is rather against the euro is also supported, studied and confirmed by Banducci et al. (2009) in their paper *Economic interests and public support for the euro*. This paper analysed the effect of demographic variables on public support for the euro.

Education can significantly influence the way the euro is perceived, especially among Eurozone member countries. In countries that have not yet adopted the single currency are less affected by education as a factor, according to Banducci et al. (2009). Fernández and Eigmüller's (2018) article *Social Education and the Educational Divide in European Identity, 1992–2015* explores this topic in more depth. Using various statistical models, including linear regression and mixed-effects analysis models, the authors were able to explore the correlation between education and feelings of belonging to the EU. By controlling for variables such as age, gender, and socioeconomic status, the study revealed that education did indeed have a significant effect on the development of European identity. The study's findings were based on data from the Eurobarometer survey conducted between 1992 and 2015 and covered a range of age groups and countries. The authors concluded that people with higher education tend to associate themselves more with the EU and consider belonging to the EU as an integral part of their identity. In contrast, people with lower education are less likely to identify with the EU and do not consider belonging to it significant for their sense of self. Therefore, education also plays a crucial role in shaping opinions on the euro, as supported by the relevant literature (Isengard and Schneider, 2006).

The perception of the euro can be influenced by a person's occupation, albeit indirectly, as this is generated by the level of education that the person needed to obtain a particular job. Thus, educated professionals, such as those in finance, economics, or international trade, often have a more favourable view of the euro due to their knowledge of the economic benefits it offers. However, those with lower education working in low-wage fields, such as agriculture or domestic services, may be more sceptical of the euro, as they may not have access to information about its benefits and may be more susceptible to economic difficulties. Research by Bergbauer et al. (2020) confirms the above. The aforementioned study stated that managers, senior professionals, and the self-employed persons are more likely to support the euro, while manual workers, housewives, and the unemployed are sceptical about the euro.

Individuals involved in international business and, consequently, exposed to currency risk have a more advanced understanding of the euro and show a greater interest in foreign exchange market developments. Gabel and Hix's (2005) study found that, for several reasons, international business and trade may be factors that shape perceptions of the euro. The authors analysed data from the 2002 UK public opinion survey, which included questions about experience with and attitudes towards the euro. The researchers used regression analysis to assess the correlation between perceptions of the currency and experience with the euro, taking into account factors such as education, age, and income. The results of the study indicated that individuals who traded in the euro with other countries and who had more experience in handling the currency had a better perception of it. The authors attributed this relationship to the fact that such individuals are exposed to the benefits and disadvantages of using the euro as a trading currency. People with trading experience are likely to be more aware of the dangers associated with currency fluctuations and may be more inclined to protect themselves against such dangers by adopting a single currency to eliminate them. The authors' analysis shows that trading in the euro can shape people's perspective on the currency, which can significantly influence political choices regarding admission to the Eurozone.

2.4. Research hypothesis

This study aims to illustrate the impact of three distinct categories of variables—demographics, national governmental efficacy, and individuals' economic expectations—on perceptions of the euro held by residents of the Eurozone. The study puts forward three hypotheses, which will be validated or not using empirical investigation:

H1: Perceptions of Eurozone citizens regarding the euro are impacted by various demographic factors.

H2: The performance of national governments plays a significant role in shaping individuals' perceptions of the euro.

H3: The economic expectations of people are a key determinant in influencing how the euro is perceived.

In addition, the paper intends to identify the profiles of people who hold a negative opinion, in order to identify groups that should be given more attention regarding this issue.

3. Methodology

3.1. Data used

This paper uses data from the 2019 and 2022 Flash Eurobarometer surveys conducted in Eurozone countries. The Eurobarometer is a public opinion survey programme set up by the European Commission to monitor the attitudes of EU citizens towards economic, political, and social issues. The paper's main aim is to collect comparable information across Member States on how Europeans perceive the European Union, its institutions, and key policies, such as Economic and Monetary Union and the euro. Such survey data are regularly used by EU institutions to assess public trust, policy acceptance, and differences in attitudes between countries, making the Eurobarometer a reliable and widely recognised source for studying citizens' confidence in the euro. The Eurobarometer monitors public opinion in EU member states, targeting individuals aged 15 and above, using a typical sample size of 1,000 per country, with the exception of smaller nations, such as Luxembourg or Malta. Such surveys compare sample compositions to population demographics using post-stratification proportions (w1) to ensure accuracy. These proportions adjust the significance of each participant's data based on their country's population, age, gender, and profession, using data from National Research Institutes and Eurostat. This method enhances the precision and representativeness of the survey results.

The countries in the analysis are: Belgium (BE), Germany (DE), Greece (GR), Spain (ES), Finland (FI), France (FR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Austria (AT), Portugal (PT), Cyprus (CY), Estonia (EE), Latvia (LV), Malta (MT), Slovakia (SK), Slovenia (SI), and Lithuania (LT).

In previous Eurobarometer surveys, up to Eurobarometer 31A (June 1989), different sampling methods were used and varied from country to country. Sampling designs were either multi-stage national probability samples or stratified national quota samples. In each country, a random selection of sampling points was made in such a way that all types of areas (urban, rural, etc.) were represented in proportion to their population. Respondents were selected at a second stage. In Belgium (until Eurobarometer 23), Denmark, Luxembourg, and the Netherlands, a random selection from the population or appropriate electoral rolls (of persons or households) was used. In Belgium (since Eurobarometer 24), France, Italy, the United Kingdom, and Ireland, quota sampling by sex, age, and occupation based on census data was applied, while

in Greece, Spain, and Portugal, a random route procedure was used. Germany employed quota sampling by sex, age, and occupation based on census data until Eurobarometer 23 and a random route procedure since Eurobarometer 24 (October 1985).

In the Standard and Special Eurobarometer series, a comparison is made for each participating country between the composition of the sample and an appropriate description of the population regarding the socio-demographic criteria to be used in the calculation of post-stratification weights. National research institutions and Eurostat provide the descriptions of populations and apply a national weighting procedure, using marginal weighting and cross-sectional analysis.

Each sample instance is associated with a post-stratification weight, denoted w1, which is calculated according to the country's population and its socio-demographic structure. The most detailed level of geographical subdivision to which Eurobarometer data sets can be broken down usually corresponds to country-specific regional levels applied in the sampling procedure. These GEOGRAPHICAL UNITS are coded in the REGION variable (P7). For each country, the relationship with the official NUTS classification (Eurostat's Nomenclature of Territorial Units for Statistics) is documented in the variable description. This attempts to correct the importance of the information provided by an instance, taking into account the size of the population of the country from which it comes and the age group, sex, occupation, etc.

The use of these weights is important for obtaining more precise and representative results in the process of extrapolating findings. Given that samples are of the same size, with minor exceptions, but represent populations of different sizes, it is normal for an observation from a larger population to have a higher weight than an observation from a smaller population, since it is expected to represent more instances in the population of origin. The same can be said for population structure by sex, age, and other characteristics.

These weights are calculated using information on the composition of the target population provided by National Research Institutes and/or Eurostat. The use of these weights in the analysis of Eurobarometer data provides more precise and representative results regarding the target population.

3.2. Algorithm CART

CART stands for Classification and Regression Trees, initially introduced by Breiman in 1996, and operates by iteratively partitioning data into multiple subspaces to ensure that outcomes in each final subspace are as similar as possible. This technique is referred to as recursive partitioning (Berk, 2008).

The main characteristics of CART trees (Berk, 2008) include: the ability to handle extensive datasets; the ability to handle small implicit predictors, both numerical and categorical; the ability to easily disregard redundant variables; the ability to handle missing data through surrogate splits; the capacity to easily interpret small trees; and the difficulty in interpreting large trees.

Another point to note about this algorithm is that it also provides measures of variable importance. In a CART tree, the importance of a variable is measured by considering its contribution to the reduction in variation in child leaf nodes, relative to the variation specific to the parent node from which they originate. Specifically, variable importance is most often quantified using the cumulative Gini index at the tree level, depending on the relationship (Tahsildar, 2019).

$$(1) \qquad Gini = 1 - \sum_{i=1}^{n} p_i^2$$

Where p_i is the probability that an instance is classified in a certain category.

Gini Impurity, used for splitting nodes when the target variable is categorical, is calculated as 1 minus Gini (Sharma, 2020). A lower score indicates purer nodes. The more important a variable, the purer the resulting nodes, thus lowering Gini Impurity. Importance is determined by the factor's capacity to reduce diversity and create refined subcategories.

Balancing Methodology for CART algorithm

In order to ensure the most accurate analysis, "don't know" or "didn't answer" responses were removed from the target variable. Since the target variable, perception_n (questionnaire item q1_1), has the structure shown in Figure 1, the analyses were performed on several balanced samples. To obtain a validation dataset, a 30% sample was extracted from the original data, preserving the original structure of the target variable. The training set was split into three samples, keeping the minority category unchanged and randomly splitting the majority category into three samples. This resulted in a proportion of approximately 50% for the majority category and around 40% for the minority category. The weighting variable w1, described above, was also included in the trees produced. Trees were also generated based on the CART algorithm using all three aggregate samples simultaneously, with the minority category replicated three times.

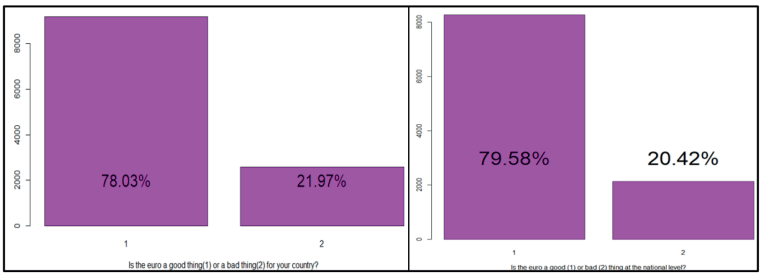

Figure 1. Distribution of target variables for 2019 and 2022

Source: personal processing in Rstudio

Survey responses on economic matters were transformed for clarity: negative views got negative values, neutral responses got 0, and positive views got positive values. Principal Component Analysis identified four economic frameworks. Decision trees were created to pinpoint key variables, validated using the Random Forest technique. Table 1 shows total and average variable significance across samples.

Using the average importance percentages, weights were created to achieve average scores for each construct at the level of each instance. These variables, called constructs (C), represent weighted aggregations of variables that can be seen in Table 1. This was done using the following formula:

$$(2) \quad c_{in} = \sum_{1}^{j} Q_{ji} * p_j$$

Where: i - is the instance number; n - is the component number; j - represents the question number (question code); Q_{ji} - represents the answer of instance "i" to the question; p_j - represents the weighting value obtained by hierarchically weighting the variables These variables are called constructs (C) and represent a weighted aggregation of variables as follows:

- C1, construct referring to reforms needed at the level of each country comprising questions: Q10 (with all derived questions) and Q9.1
- C2, construct referring to advantages brought by the euro: Q7 (with all derived questions)
- C3, construct referring to ease of handling euro coins and banknotes: Q3a1 and Q3a2
- C4, construct referring to euro coins: Q4 and Q5

Construct C4, has only one important variable (see Table 1), will be presented with its original name. No other transformations were applied to it.

Discretisation of variables was performed in R Studio using the discretise () function from the rules package - specifically the "cluster" method with the k-means algorithm - to create categories. This method ensures high homogeneity within intervals (Fonseca, 2019). Categorial variables are plotted in Figure 2.

The CART algorithm was used to train decision trees for each of the three samples. Table 2 presents explanatory variables' relative magnitudes and performance. Demographic variables were analysed separately using the same methodology, the results are presented in Table 3. Finally, trees combining all constructs and important demographic variables were created using the CART algorithm, relevant results are displayed in Table 4.

3.3. Neural networks

Neural networks are mathematical models inspired by the human brain. They are used in machine learning and AI, and they consist of artificial neurons connected by synaptic weights, organised into layers: an input layer, one or more hidden layers, and an output layer. Data flow through these layers, processed from input to output, producing the final result (Dongare et al., 2008).

This study implemented neural networks using the RSNNS package in R, a comprehensive library for building and training neural networks in R. The number and size of hidden layers depend on the problem's complexity and network architecture (Uzair and Jamil, 2020). A larger number of hidden layers can enhance learning and capture complex relationships, but they require more data, training time, and technical resources. By adjusting synaptic weights and learning from the training dataset, neural networks can recognise patterns, make predictions, and solve tasks in classification, regression, image recognition, natural language processing, and more (Schmidhuber, 2015). Multilayer Perceptron (MLP) neural networks, a type of feedforward neural network, consist of several hidden layers between the input and output layers (Zare et al., 2012). Each neuron in the hidden layer uses a nonlinear activation function to process inputs, introducing non-linearities that allow the MLP to model complex relationships.

Various activation functions were used, including Rprop (Resilient Backpropagation), Quickprop, SCG (Scaled Conjugate Gradient), Backprop Weight Decay, Backprop Momentum, Std_Backpropagation, and BackpropBatch, as described by Taud and Mas (2017) and Jurgen et al. (2014), to train and optimise neural networks.

The libraries used to implement neural networks in RStudio are RSNNS (used for artificial neural networks), caret (for evaluating and comparing machine learning models), NeuralNetTools (to visualise and analyse neural networks), and ggplot2 (for graphs). The categorical variable country was converted into binary dummy variables, representing each country as 1 or 0. Dataset normalisation was performed to ensure optimal neural network performance by reducing feature variation and preventing gradient-related issues. Various neural network structures were tested, and the best models are presented in Table 5. Automatic parameter optimisation was used to enhance model performance.

The Olden method, based on Garson's algorithm but improved, determines variable importance in neural networks (Garson, 1991). It calculates importance by summing the products of connections between input, hidden, and output layers, preserving both magnitude and sign. Unlike Garson's approach, the Olden method handles multiple hidden layers and avoids misleading absolute magnitudes, focusing instead on relative contributions and sign changes.

4. Results

4.1. CART results

Results by construct

Table 1 in the Annexes presents the cumulative and average importance of explanatory variables for each construct in 2019 and 2022, which were assessed via decision trees using the CART algorithm. In the Institutional Reforms framework, during the 2019–2022 period, there was an increased emphasis on education, the labour market, and major systemic reforms, while healthcare and retirement reforms declined in priority. For Travel and Business Facilitation, affordable travel remained important, while price comparison became less significant, with a growing focus on reducing fees and improving business processes. The growing importance of education and labour market reforms supports the argument of Bergbauer et al. (2020) and Roth and Jonung (2022) that confidence in the euro depends on effective domestic governance and visible progress in key institutional areas. At the same time, the continued relevance of travel affordability and reduced transaction fees aligns with Banducci, Karp, and Loedel (2003) and Baldwin and Wyplosz (2020), who highlight that tangible, everyday economic benefits remain central to sustaining public support for the common currency.

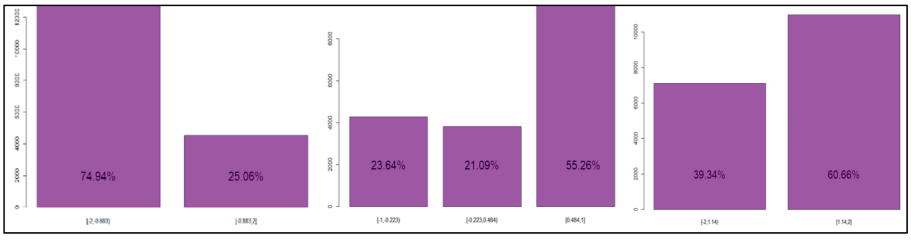

Figure 2. Distribution of the constructs for 2019

Source: personal processing in Rstudio

The Payment Methods framework showed a significant shift from currency and paper money transactions to electronic payment methods, reflecting changing consumer preferences and payment innovations. This result supports Tyszka and Przybyszewski (2006), who noted that the cognitive and evaluative dimensions of currency perception evolve with people's experience and habits. The shift toward electronic payments reflects changing behavioural patterns and aligns with Simmel (2005), who emphasised the social and cultural adaptation of money to modern forms of exchange. Average significance percentages were used to determine the combined importance of factors at the concept level, labelled C1, C2, and C3, and discretised accordingly. Figures 2 and 3 display the distributions of these concepts for 2019 and 2022.

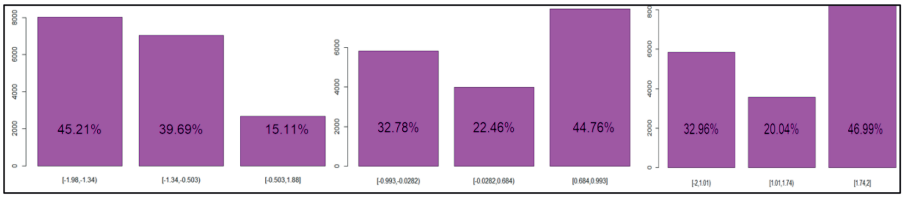

Figure 3. Distribution of the constructs for 2022
Source: personal processing in Rstudio

Table 2 in the Annexes highlights the significance of frameworks and efficacy measures using the CART technique on each sample. In the 2019 sample I, C2 was dominant having 97% importance, achieving 71.5% accuracy, 76.60% sensitivity, and 56.07% specificity. This outcome aligns with Banducci, Karp and Loedel (2003), who emphasised that citizens' support for the euro is largely driven by its economic utility and everyday advantages. The dominance of C2 (Travel and Business Facilitation) confirms that practical benefits, such as easier transactions and mobility, remain the main factors shaping positive perceptions of the euro. C3 had minimal impact at 3%. The limited impact of Construct III (Payment Methods) suggests that payment behaviour plays a smaller role in shaping perceptions of the euro compared to broader economic and institutional factors highlighted by Banducci et al. (2003) and Roth and Jonung (2022). By 2022, C2 was solely important at 100%, compared to 68.73% accuracy, 72.41% sensitivity, and 55.25% specificity, indicating a strong focus on travel and business facilitation in sample I.

In sample II (2019), C2 held 87% importance and 64.93% accuracy. C3 and C1 contributed 11% and 2%, respectively. By 2022, C2's importance rose to 97%, and C1 and C3 scored 2.5% and 0.5%. Accuracy improved to 67.55%, having 70.05% sensitivity and 58.42% specificity, showing a refined focus on travel and business in sample II.

In sample III (2019), C2 accounted for 87% of the importance, resulting in 64.93% accuracy. C3 and C1 contributed 11% and 2%, respectively. In 2022, C2's importance slightly decreased to 92%, while C3 and C1 increased to 4%. This led to 65.88% accuracy, 67.50% sensitivity, and 59.96% specificity, indicating a more balanced influence from all constructs in sample III. From 2019 to 2022, C2 consistently held the highest importance, underscoring its role in shaping perceptions about the euro. Performance metrics showed slight improvements, reflecting a refined understanding of public perceptions based on these constructs.

Demographic variables

As shown in Table 3 in the Annexes, in 2019, sample I identified country as the most important variable at 42%, followed by age at the end of studies at 36%. The model

showed moderate accuracy (62.99%) and balanced sensitivity (64.36%) and specificity (58.90%). These results are consistent with previous studies highlighting cross-country differences and the role of education in shaping euro perceptions. The strong impact of the country variable confirms the findings of Hobolt and Leblond (2009) and Gabel (1999), who showed that national context and trust in domestic institutions significantly affect attitudes towards the euro. Likewise, the importance of education aligns with Banducci et al. (2009) and Fernández and Eigmüller (2018), who demonstrated that higher educational attainment fosters a stronger European identity and greater support for the common currency.

Sample II highlighted 'age' at the end of studies' (46%) and 'country' (30%) as key factors, with an accuracy of 64.68% and higher sensitivity (67.71%) compared to specificity (55.55%). This finding reinforces arguments of Banducci et al. (2009) and Fernández and Eigmüller (2018), demonstrating that education remains a central determinant of euro support, as it strengthens understanding and identification with European integration. The continued relevance of the 'country' variable supports Hobolt and Leblond (2009) and Gabel (1999), who emphasised that national economic context and institutional trust shape cross-country variation in citizens' perceptions of the euro.

Sample III similarly emphasised 'country' (44%) and 'age at the end of studies' (42%), achieving 64.62% accuracy and 67.99% sensitivity, but lower specificity (54.49%). By 2022, the importance of 'country' increased in sample I to 68%, with 'age at the end of studies' at 30%. The model's accuracy dropped slightly to 59.69%, with improved specificity (62.86%) but lower sensitivity (58.80%). These results further confirm the persistence of national and educational impact on euro perceptions. The strong and growing importance of the 'country' variable aligns with Hobolt and Leblond (2009) and Roth and Jonung (2022), who showed that citizens' confidence in the euro varies across national contexts depending on economic conditions and trust in governance. The continued relevance of education supports Banducci et al. (2009) and Fernández and Eigmüller (2018), indicating that higher educational attainment consistently fosters more favourable attitudes toward the euro and European integration.

In sample II, age at the end of studies remained important at 56%, with country at 37%, maintaining similar performance metrics, with accuracy of 64.11% and sensitivity of 67.39%. Sample III identified age at the end of studies (48%) and country (41%) as dominant factors and showed improved accuracy (67.56%) and sensitivity (74.17%), but reduced specificity (43.89%). Overall, from 2019 to 2022, country and educational attainment gained importance in influencing euro perceptions. While accuracy and sensitivity generally improved, specificity varied, reflecting changes in the model's ability to identify negative perceptions.

Final analysis with CART algorithm

Table 4 in the Annexes presents the results of applying the CART algorithm to each of the three samples using the previously selected demographic constructs and variables. The table shows the importance of variables and performance indicators obtained for each sample. In addition, an average value is provided for each of the important variables and performance indicators.

For 2019, sample I showed that Construct II (C2: Travel and Business Facilitation) was the most important at 62%, followed by country at 23%. The model reported an accuracy of 71.7%, sensitivity of 76.51%, and specificity of 57.25%. Sample II also identified C2 as dominant at 70%, with age at the end of studies at 18% and country at 12%, achieving 67.78% accuracy. In sample III, C2 remained essential at 59%, with country at 29%, resulting in 70.08% accuracy. Across all samples, C2 was the dominant factor in predicting euro perceptions.

These findings are in line with Banducci, Karp, and Loedel (2003) and Baldwin and Wyplosz (2020), who emphasised that citizens' support for the euro is primarily driven by its economic advantages and cross-border convenience. The consistent dominance of Construct II (Travel and Business Facilitation) underlines the importance of tangible economic benefits, such as easier travel and business transactions, in sustaining positive attitudes towards the euro. The additional impact of education and country context supports Fernández and Eigmüller (2018) and Hobolt and Leblond (2009), confirming that both knowledge about the EU and national circumstances continue to shape public perceptions of the common currency.

4.2. Neural network results

For 2019, Network 13 using BackpropBatch achieved the best performance, with an F1 score of 0.8612, accuracy of 75.99%, sensitivity of 76.29%, and specificity of 63.39%. For 2022, the same Network 13 maintained superior performance, with an F1 score of 0.8507, accuracy of 78.7%, and sensitivity of 78.76%, but with reduced specificity at 44.44%. Overall, BackpropBatch remained the most effective learning method for Network 13, although its specificity decreased in 2022, indicating an increase in false positive identifications. Results and variable-importance values associated with each independent variable from Network 13 are presented in Figure 4.

In the 2019 graph (left side of Figure 4), C2 is the most important variable positively impacting perceptions of the euro. Following C2, Ireland (IE), Luxembourg (LU), Finland (FI), and age at the end of studies also show significant positive importance. Construct III (C3: Payment Methods) and several other countries, such as Austria (AT), Estonia (EE), Germany (DE), and Portugal (PT), also contribute positively, but to a lesser extent. Variables such as age, France (FR), Italy (IT), Cyprus (CY), and Belgium (BE) have minimal to slightly negative importance, indicating a less favourable or neutral impact on perceptions of the euro. These results support Banducci et

al. (2009) and Fernández and Eigmüller (2018), confirming that higher education and exposure to cross-border mobility are associated with stronger support for the euro. The positive influence of countries such as Ireland, Luxembourg, and Finland aligns with Roth and Jonung (2022), who found that trust in national governance and stable economic performance enhance confidence in the common currency. Conversely, the weaker or negative contributions observed for France, Italy, and Cyprus reflect earlier findings by Hobolt and Leblond (2009) and Gabel (1999), which underlined how national economic pressures and institutional dissatisfaction can reduce support for the euro.

In the 2022 graph (right side of Figure 4), C2 once again emerges as the most important variable positively influencing euro perceptions, reinforcing its dominant role. Ireland (IE) and age at the end of studies follow in importance, with Construct III (C3) and countries such as Slovakia (SK), Estonia (EE), and France (FR) also contributing positively. However, negative impacts are more pronounced in 2022, with Cyprus (CY), Construct I (C1: Institutional Reforms), and several other countries, such as Luxembourg (LU) and Italy (IT), showing significant negative importance. This suggests a shift, with certain demographic and regional factors exerting an increasingly negative effect on euro perceptions compared to 2019.

These findings confirm the persistence of economic utility as the main driver of euro support, consistent with Banducci, Karp, and Loedel (2003) and Baldwin and Wyplosz (2020), while also indicating growing sensitivity to institutional performance and national context. The emergence of stronger negative effects for Construct I (Institutional Reforms) and countries such as Italy and Cyprus aligns with Gabel (1999) and Roth and Jonung (2022), who emphasised that declining trust in governance and reform outcomes can weaken public confidence in the euro. At the same time, the continued positive role of education and cross-border convenience (C2) supports Fernández and Eigmüller (2018) and Hobolt and Leblond (2009), reinforcing that informed and mobile citizens remain the most consistent supporters of the common currency.

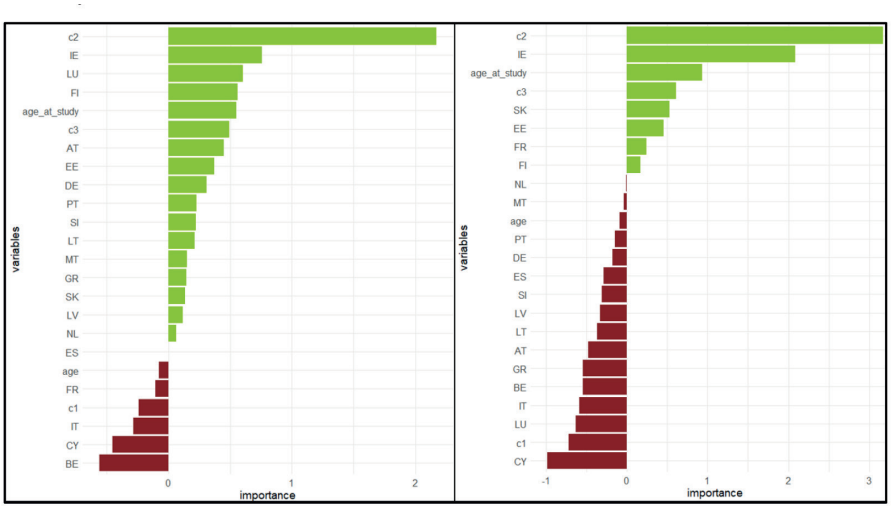

Figure 4. Importance of independent variables in the MLP network 13

Source: personal processing in Rstudio

When comparing the results of the two years, C2 consistently holds the highest positive importance, indicating that travel and business facilitation remain key factors in shaping favourable perceptions of the euro. The influence of individual countries and demographic variables, such as age at the end of studies, is also significant in both years, although with some shifts in their relative importance. In 2022, negative influences are more pronounced, especially from certain countries and C1, suggesting growing regional and institutional concerns affecting euro perceptions. This change highlights evolving public attitudes and possibly emerging economic or political factors influencing citizens' perceptions of the currency.

These comparative results are consistent with Banducci et al. (2003) and Baldwin and Wyplosz (2020), confirming that the euro continues to be valued primarily for its economic and practical benefits related to mobility and business facilitation. The growing weight of country-specific and institutional effects supports the findings of Gabel (1999) and Roth and Jonung (2022), who argued that trust in governance and national economic performance strongly condition citizens' views of the euro. The rise of negative influences from Construct I (Institutional Reforms) further echoes Hobolt and Leblond (2009), suggesting that institutional dissatisfaction and uneven reform outcomes increasingly shape regional differences in citizens' attitudes towards the euro.

Conclusion

Since its launch, the euro has triggered a range of debates regarding its impact and efficacy as the common currency of the European Union. This study uses a machine-learning algorithm to analyse factors influencing perceptions of the euro in 2019 and 2022. The goal was to provide insights for policymakers to enhance strategies supporting the euro by examining extensive datasets for trends and correlations among diverse variables.

The analysis shows that demographic variables, such as age, educational attainment, and country, have significant impacts on euro perceptions. Both 2019 and 2022 were influenced by variables such as age at the end of studies and specific countries (e.g., Ireland and Luxembourg). In 2022, the importance of certain demographic factors, such as age at the end of studies and specific countries, increased, highlighting evolving public attitudes towards the euro. This supports H1, indicating that demographic factors do play a significant role in shaping perceptions. C2 consistently emerged as the most important factor in both years, emphasising the role of awareness of the advantages of the euro related to travel and business in shaping positive perceptions. The increasing importance of this construct from 2019 to 2022 suggests that people's economic expectations are a key determinant in influencing how the euro is perceived, validating H3. In 2022, negative influences from specific countries and C1 (Institutional Reforms) became more pronounced. This change suggests growing regional and institutional concerns influencing perceptions and indicates areas on which policymakers need to focus their efforts to improve acceptance of the euro. This change also suggests that effective national policies have a positive impact on perceptions of the euro, validating H2. Furthermore, the varying importance of different countries in shaping perceptions highlights the role of national government performance.

The study's findings validate all three hypotheses, showing that demographic factors, national government performance, and economic expectations significantly influence perceptions of the euro. The growing importance of travel and business facilitation policies, together with economic expectations related to payment methods, highlights the need for targeted strategies to address regional and demographic concerns. This information can help policymakers increase public support for the euro by focusing on the areas that matter most to Eurozone citizens.

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Appendix A.

Eurobarometer Questions Used in Construct Formation

The following items from **Flash Eurobarometer 481 (2019)** and **Flash Eurobarometer 512 (2022)** were used to build the three constructs (C1–C3). Original codes and response options are reproduced below.

Construct I – Institutional Reforms (C1)

Q9_1 – *There is a need for significant reforms to improve the performance of our economy.*

Response scale:

1 – Totally agree

2 – Tend to agree

3 – Tend to disagree

4 – Totally disagree

5 – Don’t know

Q9_2 – *Successful reforms in other Eurozone countries have facilitated reforms in our country. (Same response scale as above.)*

Q9_3 – *Governments need to save more today in order to prepare public finances for ageing populations. (Same response scale.)*

Q9_4 – *Retirement age should be increased to ensure sustainability of the pension system. (Same response scale.)*

Q10_1–Q10_7 – *Please tell me for each of the following areas whether you think reforms are necessary in your country.*

Areas:

1. Labour market reforms
2. Health system reforms
3. Pension system reforms
4. Social security system reforms
5. Market reforms (telecom, gas, electricity, etc.)
6. Taxation reforms
7. Education system reforms

Response scale:

1 – Yes, reforms are necessary

2 – No, reforms are not necessary

3 – Don't know

Construct II – Travel and Business Facilitation (C2)

Q7_1–Q7_4 – *To what extent do you agree or disagree with the following statements about the euro?*

1. The euro has made travelling easier and less costly.
2. The euro has reduced banking charges for those travelling in different EU countries.
3. The euro has made it easier for people to do business in different EU countries.
4. The euro has made it easier to compare prices and shop in different EU countries, including those online.

Response scale:

1 – Totally agree

2 – Tend to agree

3 – Tend to disagree

4 – Totally disagree

5 – Don't know

Construct III – Payment Methods (C3)

Q3a_1–Q3a_2 – *When you pay cash, how easy is it to distinguish and handle…*

1. Euro banknotes
2. Euro coins

Response scale:

1 – Very easy

2 – Fairly easy

3 – Fairly difficult

4 – Very difficult

5 – Don't know

Q4 – *Do you consider there are too many, not enough, or just the right number of euro coins with different values?*

Response scale:

1 – Too many

2 – Not enough

3 – Just the right number

4 – Don't know

Q5 – *Are you in favour of abolishing 1- and 2-euro cent coins and rounding the final sum to the nearest 0 or 5 cents?*

Response scale:

1 – Yes

2 – No

3 – Don't know

Source: European Commission – Flash Eurobarometer 481 (The Eurozone, 2019) and Flash Eurobarometer 512 (The Eurozone, 2022), conducted by Kantar Public, archived by GESIS.

Annexes

Table 1. Cumulative importance of variables in constructs

		2019		2022	
Construct	VARIABLE	AGGREGATE IMPORTANCE	AVERAGE IMPORTANCE (%)	AGGREGATE IMPORTANCE	AVERAGE IMPORTANCE (%)
I.	Education system reforms (Q10.7)	19	4.60%	60.45	9.01%
	Health care reforms (Q10.2)	43	10.50%	16.07	2.39%
	Labour market reforms (Q10.1)	20	4.90%	62.39	9.29%
	Pension reforms (Q10.3)	128	31.40%	47.55	7.08%
	Significant reforms (Q9.1)	111	27.10%	253.78	37.81%
	Social security reforms (Q10.4)	52	12.70%	70.73	10.54%
	Tax system reforms (Q10.6)	14	3.40%	77.83	11.60%
	Utility market reforms (Q10.5)	22	5.40%	82.43	12.28%
II.	Cheaper travel (Q7.1)	411	58.5%	494.70	59.85%
	Ease of comparing prices (Q7.4)	121	17.3%	59.61	7.23%
	Lower commissions (Q7.2)	110	15.6%	192.02	23.28%
	Easier business (Q7.3)	62	8.8%	73.60	8.92%
III.	Payment with coins (Q3a2)	305	60.8%	34.66	51.88%
	Payment with banknotes (Q3a1)	197	39.2%	32.14	48.11%
IV	Number of euro coins (Q4)	44	100%	53	100%

Source: personal processing in Rstudio

Table 2. CART algorithm results by sample for constructs

Sample	CONSTRUCT	IMPORTANCE	PERFORMANCE INDICATORS	INDICATOR VALUE
2019				
I.	C2	97%	Accuracy	71.5%
	C3	3%	Sensitivity	76.60%
			Specificity	56.07%
II.	C2	87%	Accuracy	64.93%
	C3	11%	Sensitivity	64.09%
	C1	2%	Specificity	67.45%
III.	C2	87%	Accuracy	64.93%
	C3	11%	Sensitivity	64.09%
	C1	2%	Specificity	67.45%
2022				
I.	C2	100%	Accuracy	68.73%
	C3		Sensitivity	72.41%
			Specificity	55.25%
II.	C2	97%	Accuracy	67.55%
	C1	2.5%	Sensitivity	70.05%
	C3	0.5%	Specificity	58.42%
III.	C2	92%	Accuracy	65.88%
	C3	4%	Sensitivity	67.5%
	C1	4%	Specificity	59.96%

Source: personal processing in Rstudio

Table 3. CART algorithm results per sample for demographic variables

Sample	VARIABLE IMPORTANCE	IMPORTANCE	PERFORMANCE INDICATORS	INDICATOR VALUE
		2019		
I.	Country	42%	Accuracy	62.99%
	Age at end of studies	36%	Sensitivity	64.36%
	Age	17%	Specificity	58.90%
	Job	5%		
II.	Age at end of studies	46%	Accuracy	64.68%
	Country	30%	Sensitivity	67.71%
	Age	19%	Specificity	55.55%
	Job	4%		
III.	Country	44%	Accuracy	64.62%
	Age at end of studies	42%	Sensitivity	67.99%
	Age	9%	Specificity	54.49%
	Job	5%	Accuracy	
		2022		
I.	Country	68%	Accuracy	59,69%
	Age at end of studies	30%	Sensitivity	58,80%
	Age	1.5%	Specificity	62,86%
	Job	0.5%		
II.	Age at end of studies	56%	Accuracy	64.11%
	Country	37%	Sensitivity	67.39%
	Age	6%	Specificity	52.37%
	Job	1%		
III.	Age at end of studies	48%	Accuracy	67.56%
	Country	41%	Sensitivity	74.17%
	Age	6%	Specificity	43.89%
	Job	5%	Accuracy	

Source: personal processing in Rstudio

Table 4. CART algorithm results per sample

Sample	VARIABLE IMPORTANCE	IMPORTANCE	PERFORMANCE INDICATORS	INDICATOR VALUE
		2019		
I.	C2	62%	Accuracy	71.7%
	Country	23%	Sensitivity	76.51%
	Age at end of studies	11%	Specificity	57.25%
	C3	4%		
II.	C2	70%	Accuracy	67.78%
	Age at end of studies	18%	Sensitivity	68.78%
	Country	12%	Specificity	64.75%
III.	C2	59%	Accuracy	70.08%
	Country	29%	Sensitivity	72.30%
	Age at end of studies	12%	Specificity	63.42%
		2022		
I.	C2	85%	Accuracy	61.3%
	Country	13%	Sensitivity	59.81%
	Age	1%	Specificity	66.86%
	Age at end of studies	1%		
II.	C2	83%	Accuracy	64.4%
	Country	13%	Sensitivity	64.7%
	Age at end of studies	3%	Specificity	63.25%
	Age	0.6%		
	C1	0.4%		
III.	C2	70%	Accuracy	67.18%
	Country	27%	Sensitivity	70.28%
	Age at end of studies	2%	Specificity	55.62%
	Age	1%		

Source: personal processing in Rstudio

Table 5. MLP neural networks

2019							
Network number	Layer 1	Layer 2	Learning function	Accuracy	Sensitivity	Specificity	F1
1	10	-	Rprop	75.93%	78.75%	52.60%	0.8538
2	13	4		75.51%	79.45%	50.53%	0.8486
3	20	-	Quickprop	76.3%	77.52%	57.63%	0.8600
4	20	14		76.41%	77.97%	56.38%	0.8595
5	15	-	SCG	76.24%	77.26%	58.20%	0.8603
6	15	7		76.62%	79.32%	55.49%	0.8574
7	17	-	BackpropWeightDecay	73.58%	80.47%	45.45%	0.8574
8	18	9		74.31%	80.12%	46.93%	0.8374
9	12	-	BackpropMomentum	72.87%	81.10%	46.41%	0.8309
10	12	8		74.5%	79.89%	47.37%	0.8394
11	19	-	Std_Backpropagation	71.81%	82.13%	43.32%	0.8106
12	15	7		74.56%	80.15%	47.67%	0.8392
13*	**17**	**-**	**BackpropBatch**	**75.99%**	**76.29%**	**63.39%**	**0.8612**
14	16	8		76.55%	78.52%	56.61%	0.8591
2022							
Network number	Layer 1	Layer 2	Learning function	Accuracy	Sensitivity	Specificity	F1
1	10	-	Rprop	76.56%	80.84%	39.57%	0.8608
2	13	4		78.37%	79.73%	45.59%	0.8762
3	20	-	Quickprop	77.42%	79.54%	36.92%	0.8700
4	20	14		78.06%	80.11%	44.20%	0.8732
5	15	-	SCG	78.6%	78.77%	33.33%	0.8800
6	15	7		78.7%	78.75%	42.85%	0.8807
7	17	-	BackpropWeightDecay	78.5%	79.18%	44.21%	0.8783
8	18	9		76.15%	81.03%	38.86%	0.8573
9	12	-	BackpropMomentum	68.04%	83.34%	32.11%	0.7852
10	12	8		74.66%	80.56%	33.93%	0.8474
11	19	-	Std_Backpropagation	75.88%	81.29%	38.83%	0.8547
12	15	7		77.32%	80.48%	41.28%	0.8671
13*	**17**	**-**	**BackpropBatch**	**78.7%**	**78.76%**	**44.44%**	**0.8807**
14	16	8		76.32%	78.48%	42.28%	0.8798

Source: personal processing in Rstudio
**Optimum network*