



# DISCUSSION PAPERS

DP/123/2024

## What Drives the Demand for Cash in Bulgaria?

Tania Karamisheva



**BULGARIAN NATIONAL BANK**

— 145 YEARS —



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**Tania Karamisheva**

2024

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**Abstract:** The demand for large denomination banknotes in Bulgaria has exhibited high growth in recent years despite the rapid development of payment technologies and the widespread use of electronic payments. This phenomenon, known as the “paradox of banknotes”, suggests that part of the cash demand, especially for large banknotes, is driven by non-transactional motives. Estimated money demand equations suggest that apart from transactional purposes the demand for large banknotes in Bulgaria is driven by the price level and real estate prices, as well as by non-transactional/hoarding motives. Defining hoarding as all possible uses of cash apart from transactions we estimate a hoarding share of large banknotes which varies in the range of 30% to 80% over the period 2011-2024, depending on the method used for estimation and on particular assumptions. Including in the estimations a proxy for the shadow economy, we find that this proxy does not contribute to explaining the growth in banknotes in circulation—particularly large banknotes—over the sample period, which could be explained by the gradual reduction of the informal economy during the period under study.

**Keywords:** *Currency in circulation, Banknotes, Money demand, Hoarding share, Shadow economy*

**JEL – classification:** E41, E52, E58

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# 1. Introduction

Currency in circulation is an important component of the monetary base and, accordingly, of the money supply. The study of the factors driving the demand for currency in circulation is of key importance for the performance of one of the main functions of the central bank - the issuance of banknotes and coins. In recent years there has been a significant increase in the demand for cash in Bulgaria, despite the rapid development of payment technologies and the increasingly widespread use of electronic payments. Money circulating in the economy has been growing ahead of nominal GDP and private consumption, suggesting that the increased demand for cash is driven not only by demand for conducting transactions, but also for other purposes, namely for hoarding, precautionary savings or servicing of the shadow economy. Furthermore, in recent years there has been a steady increase in the number of large banknotes in circulation, while at the same time the number of smaller denominations has not changed much, which points to the potential relevance of specific determinants behind the high demand for large banknotes other than economic activity and price developments.

Demand for cash usually increases in times of heightened economic uncertainty, which prompts economic agents to demand cash for store-of-value or precautionary saving purposes. For example, during periods of crisis or economic instability, individuals may turn to banknotes as a means of protecting their wealth. Moreover, in an environment of very low or negative interest rates, as seen in the last decade, economic agents may also resort to holding cash, as low interest rates reduce the opportunity cost of holding banknotes. In a third place, the increased demand for large banknotes could also be associated with criminal activity, such as money laundering and tax evasion, i.e. with the shadow economy.

Central banks are interested in analysing the share of banknotes used for transaction and for other purposes. This is relevant both for managing the supply of banknotes and for conducting monetary policy. Central banks are also interested in monitoring and analysing cash developments because of their role in operating the payment systems.

While the motives for demanding currency in circulation have been extensively researched for many countries, including the euro area, there is limited research on this topic for Bulgaria. The aim of this paper is to shed additional light on the factors driving the demand for cash in Bulgaria and on the share of banknotes, especially large banknotes, held for transactions and for hoarding purposes.

The focus on Bulgaria is motivated by the specific institutional and monetary framework of the country. Operating under a currency board arrangement since 1997, Bulgaria provides a unique setting to study cash demand where

monetary policy is constrained and banknote issuance reflects real economic and behavioural factors rather than active policy intervention. In addition, country-specific analyses remain scarce in the literature, which underlines the contribution of this study.

We apply two different methods for studying the factors driving the demand for currency in circulation, namely the dynamic ordinary least squares method (DOLS) and an error correction model (ECM), which are used in econometrics and time-series analysis to model and analyze relationships among variables, particularly when dealing with non-stationary time series data and cointegrated variables. We perform estimations for total currency in circulation and for different denominations. More precisely we make a distinction between large denominations (BGN 100 and BGN 50 banknotes) and medium and small denominations (BGN 20, BGN 10 and BGN 5 banknotes). Furthermore, we use several approaches to estimate the share of banknotes demanded for hoarding purposes, our definition for hoarding comprising of all possible uses of cash apart from transactions. Finally we make an attempt to measure the influence of the shadow economy on the demand for cash. The study covers the period from the end of 2000 to mid-2024, which is determined by data availability.

This paper aims to empirically test several hypotheses regarding the drivers of cash demand in Bulgaria. Specifically, it examines whether currency in circulation is influenced predominantly by transactional motives, non-transactional or hoarding motives, and potential shadow economy effects. By quantifying the relative importance of these determinants, the study contributes to a better understanding of money demand behaviour under Bulgaria's currency board arrangement.

The paper is structured as follows. Section 2 elaborates on the so called paradox of banknotes. Section 3 presents some stylized facts regarding the value and number of banknotes in circulation in Bulgaria in a historical perspective. Section 4 presents the data used for the estimations and their sources. In section 5 we estimate money demand equations by denomination group (total, large and not large) and investigate the elasticity of cash demand with respect to transaction variables, interest rates, the price level, house prices, economic uncertainty and proxies for the degree of development of the payment system. Section 6 provides estimates of the share of banknotes demanded for motives different from transactional and makes an attempt to measure the influence of the shadow economy on the demand for cash. Finally section 7 summarizes and concludes.

## 2. The paradox of banknotes

The seemingly contradictory phenomenon, related to the fact that the value of banknotes in circulation has been continuously rising at a pace higher than that of nominal economic activity or consumption, while their use as a payment mechanism has been declining, as a consequence of financial innovations and electronic payment systems, is known as the “paradox of banknotes”. This counterintuitive paradox can be explained by demand for banknotes for the purpose of storing value or for servicing of the shadow economy.

Starting from Keynes (1936), the academic literature distinguishes three main motives for demanding cash – transactional, precautionary and speculative. A lot of empirical studies on the paradox of banknotes find that a significant share of banknotes (predominantly large denominations) is held by the public for non-transactional purposes.

Early studies for the United States dating back to the 1980s show that the U.S. \$100 bill had a value share of nearly 50 percent in total currency in circulation, pointing to a possible use of this note for store of value reasons or for servicing of the underground economy (Anderson (1977); Kimball (1981); Porter and Bayer (1984)). Results from an extensive sectoral survey, conducted in the Netherlands in the 1990s, suggest that between 60% and 70% of the F1. 1000 notes in circulation had been used as a means of hoarding (Boeschoten and Fase (1992)). More than one third of F1. 1000 notes were traced to be held by the drug trade, gambling industry and motor trade sectors, while around 10% were found to be held by households, half for the purpose of transactions and half for the purpose of hoarding. Earlier estimates for the Netherlands, based on information from a continuous budget survey among one thousand households on spending patterns, gave higher percentages – 80% to 90% of F1. 1000 notes in circulation were found to be used as a means of hoarding (Boeschoten and Fase (1989)). Without making a disaggregation of banknotes in circulation into different denominations, a study of the demand for cash in the euro area suggests that only around 20% of total banknotes in circulation are held for domestic transactions. These estimates suggest that around 80% of banknotes are not actively used for transactions, i.e. they are held for other purposes. The results from the study indicate that between 28% and 50% of the value of banknote circulation are used as a store of value, and other 30% to 50% are held abroad (Zamora-Perez (2021)). Analysing the different motives for holding cash in France Seitz et al. (2022) come to similar conclusions. According to their results in 2019 only around 15% of the banknotes in circulation in France were used for domestic transactions. More than half of the cumulated net issues were held outside France, either in other euro area countries,

or outside the euro area. Finally, around 25% of the cash in circulation in France in 2019 was used for domestic hoarding purposes. Similarly, estimation based on the use of indirect approaches for Germany suggest that at the end of 2009 around 70% of the cumulated net issuance of banknotes was held outside Germany. Approximately 20% of banknotes in circulation in Germany were hoarded and only around 10% were used for transaction purposes (see Bartzsch, Rösl and Seitz (2011)). Using different approaches to estimate the share of Swiss banknotes that are not used for transactions, Assenmacher, Seitz and Tenhofen (2019) find a sizeable amount of hoarding (domestically or abroad), in particular for the two largest denominations, the CHF 1000 and the CHF 200 banknote. The hoarding share of the CHF 1000 was estimated to be in the range from 79% to 87% in 2017 depending on the estimation method used, while for the CHF 200 this share was estimated to be in the range of 42% to 60%. On average over the sample period 1950-2017 the authors estimated a hoarding share for the CHF 1000 banknote of 73% and 48% for the CHF 200 banknote, which results in an overall hoarding share of 51%.

Studies of the trends in currency in circulation during recessions and heightened economic uncertainty show unambiguous results. The demand for banknotes rises during crisis periods, especially in an environment of low interest rates, which reduce the opportunity cost of holding cash (as a non-interest bearing store of value) (see for example Bailey (2009), Jobst and Stix (2017a); Jobst and Stix (2017b); Ashworth and Goodhart (2020b); Liñares-Zegarra and Willeson (2021). Ashworth and Goodhart (2020b) document two main reasons for the growing importance of cash (as a ratio to GDP) in the last decade, the first one being the sharp decline in nominal interest rates on alternative asset holdings, particularly on deposits, and the second one being the grey economy. Jobst and Stix (2017a) show that cash demand reacts significantly to interest rates and that the interest rate elasticity of cash demand goes to zero as interest rates approach zero. For economies that experienced a financial crisis in 2008, the authors find an increase in cash demand, on average. However, an “unexplained” increase is also obtained for wealthier economies that did not have a financial crisis in 2007/08 but before, which was most likely related to increased uncertainty. Liñares-Zegarra and Willeson (2021) document that changes in interest rates below the zero lower bound make cash more attractive for consumers as a medium of payment and wealth storage. The results from their research indicate that countries where negative interest rates have been implemented, have observed an increase in cash usage.

The COVID-19 pandemic has once again proven the importance of cash, with banknote holdings having increased in many countries after its outbreak (see

Ashworth and Goodhart (2020a); Ashworth and Goodhart (2021); Rösl and Seitz (2021); Bank of Slovenia Staff Analysis (2021); Seitz, Devigne and de Pastor (2022)). Baldo et al. (2021) find that during the COVID-19 pandemic the exceptional increase in cash circulation was mostly the result of both an increase in precautionary demand due to the rise in economic uncertainty, and restrictions on mobility, which resulted in a marked decline in lodgments at the central bank. Ashworth and Goodhart (2020a) point out that the exceptional increases in cash circulation in the countries, which were most severely affected by COVID-19 are puzzling given the unprecedented fall in consumption, which should require less cash in the economy. They speculate that the rise in cash balances is likely to reflect some panic-driven hoarding.

In contrast to crisis periods and times of heightened economic uncertainty, when demand for banknotes generally increases, the dynamics of currency in circulation in high inflationary periods is not so straightforward. During periods of high inflation economic agents may increase their demand for cash for transaction purposes, as rising prices require more cash to carry out the same volume of transactions. However in hyperinflationary settings, the real value of cash erodes quickly, thus possibly leading economic agents to reduce cash holdings in favor of alternative stores of value, such as foreign currency or tangible assets (see for example Cagan (1956), Bailey (2009)). There is also a link between inflation, currency in circulation and the shadow economy. High inflation, especially when accompanied by economic instability, can push businesses and individuals into the informal sector to avoid the rising costs of compliance in the formal economy, thus increasing demand for cash as the shadow economy relies heavily on cash transactions to avoid traceability (Tanzi (1983), Feige (1989), Schneider and Enste (2000)).

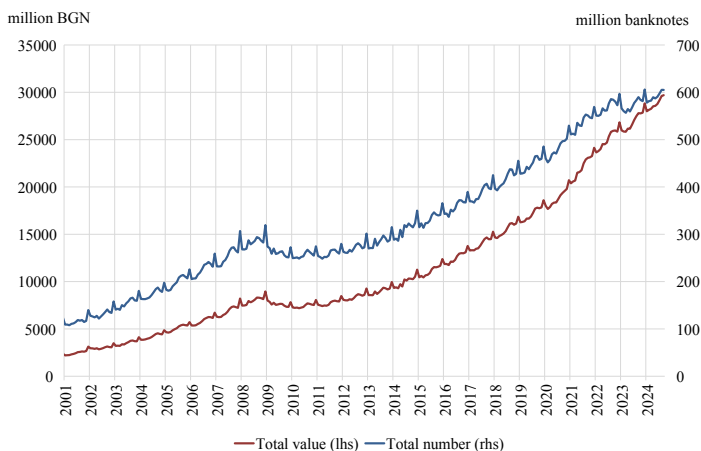
More generally the academic literature focused on studying the drivers of demand for currency in circulation points to a number of potential important factors, which besides transaction variables, interest rates, inflation and uncertainty, also include exchange rates, consumer confidence, the depth and degree of development of the financial system (approximated by the usage of debit and credit cards, number of POS terminals and ATMs), the average age of the population, education etc. (see for example Неновску и Христов (2000); Attanasio, Guiso and Jappelli (2002); Huynh, Schmidt-Dengler and Stix (2014); Bagnall et al. (2016); Bech et al. (2018); Assenmacher, Seitz and Tenhofen (2019); Cabezas and Jara (2021); Baldo et al. (2021); Seitz, Devigne and de Pastor (2022)). Concerning the techniques applied in the academic literature for the estimation of money demand equations, the most commonly applied econometric approaches are variations of the cointegration techniques, such as the Engle-Granger Two-

Step Method, Johansen’s Cointegration, Vector Error Correction Models (VECM), Autoregressive Distributed Lag (ARDL) approach, Dynamic Ordinary Least Squares (DOLS) approach and Fully Modified Ordinary Least Squares (FMOLS) approach (see for example Bartzsch, Rösl and Seitz (2011); Rodríguez et al. (2016); Assenmacher, Seitz and Tenhofen (2019); Seitz, Devigne and de Pastor (2022)). Cointegration techniques are commonly employed to analyse long-term equilibrium relationships among non-stationary time series variables. In the case of currency in circulation such techniques are favoured because the theory of money demand suggests the existence of a long-term relationship between money, the price level, economic activity and the opportunity cost of holding cash.

### 3. Stylized facts for Bulgaria

In this section we present a number of stylized facts concerning cash circulation in Bulgaria. Data on currency in circulation in Bulgaria show a strong upward trend in the number and value of banknotes circulating in the economy for the last more than one decade (2011-2024), with this trend being especially strongly pronounced regarding the two largest denominations – namely the BGN 100 and the BGN 50 banknotes.

Chart 1: Banknotes in circulation in Bulgaria

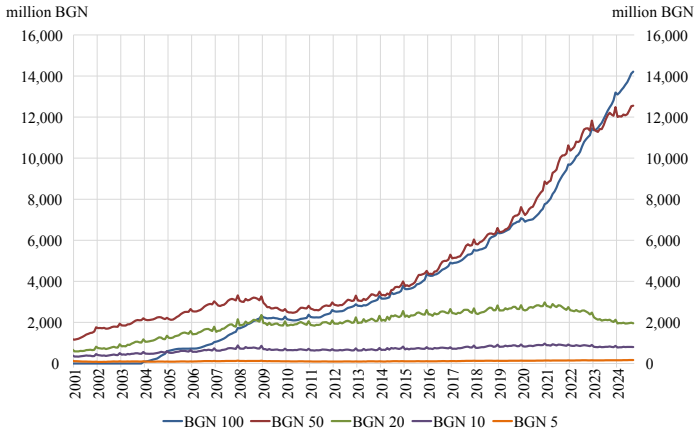


Source: BNB.

From the end of 2011 to the end of the third quarter of 2024 the value of total banknotes in circulation in Bulgaria increased by BGN 21.2 billion, while their number rose by 325 million. As of September 2024, the total number of banknotes came to 605 million, more than doubling from the end of 2011 (see Chart 1), which surpassed the increases in the price level, consumption and economic activity in the country. The

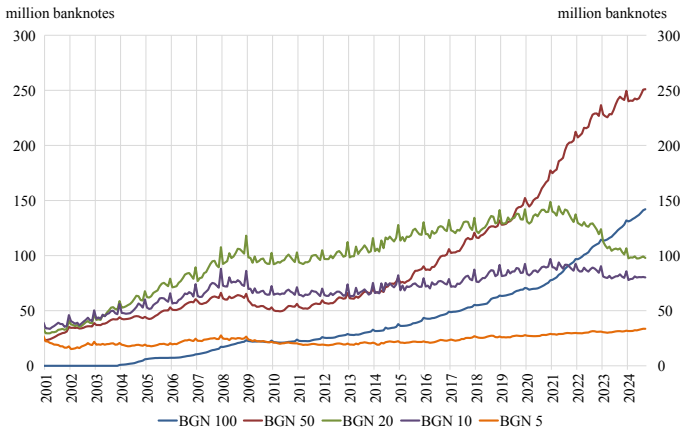
composition of banknotes by denomination shows that for the respective period there was a massive increase in the number and respectively value of banknotes of the two largest denominations. As of September 2024 the growth in the number of the largest denomination banknote in circulation (100 BGN) from the end of 2011 amounted to 445.7% and that of the second largest (50 BGN) to 322.1% respectively. At the same time the growth in smaller denominations was modest, with the number of banknotes being not much different from those circulating in the economy more than a decade ago (see Chart 2 and Chart 3).

Chart 2: Value of banknotes in circulation



Source: BNB.

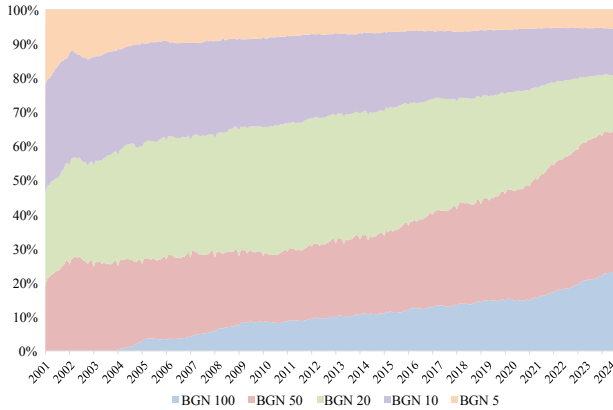
Chart 3: Number of banknotes in circulation



Source: BNB.

The shares of the BGN 100 and BGN 50 banknotes in the total number of banknotes circulating in the economy were constantly increasing from the end of 2011 and as of September 2024 reached 23.5% and 41.5%, thus forming almost two thirds of the total number of banknotes in circulation (see Chart 4).

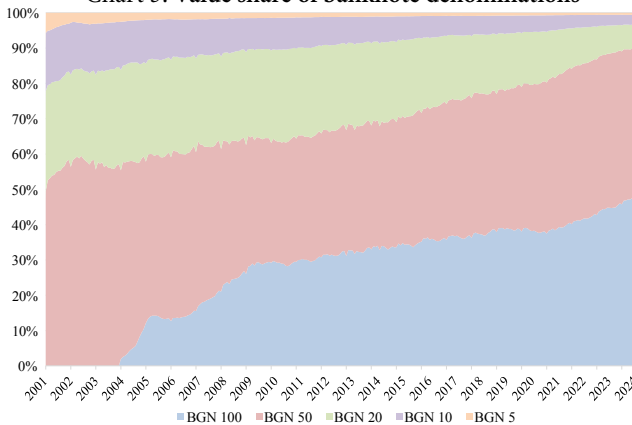
**Chart 4: Share of banknote denominations in total number of banknotes**



Source: BNB.

The value shares of the two largest denominations showed similar dynamics, with the share of the BGN 100 banknote in the total value of banknotes circulating in the economy increasing from 30.7% at the end of 2011 to 47.9% at the end of the third quarter of 2024, while that of the BGN 50 banknote posted an increase from 35.1% to 42.3% for the same period. As of September 2024 the value share of the two biggest banknotes in the total value of banknotes in circulation came to 90% (see Chart 5).

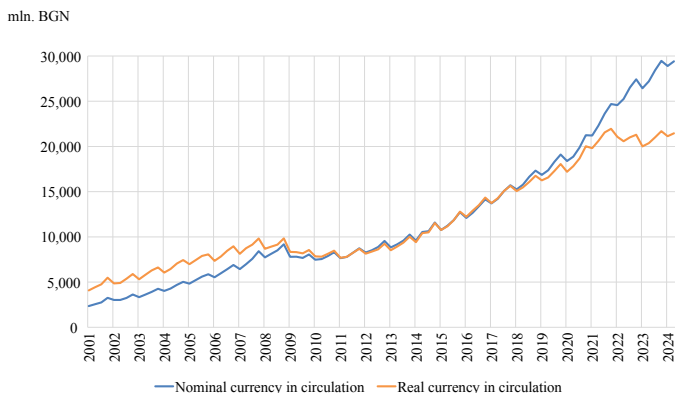
**Chart 5: Value share of banknote denominations**



Source: BNB.

In the period 2012-2018 the real value<sup>1</sup> (adjusted for the price level with 2011 taken as a base year) of currency in circulation was constantly rising and was very close to its nominal value. From 2019 to the end of 2021 part of the increase in nominal currency in circulation could be explained by the rising price level, but most of it was obviously due to other reasons (see Chart 6). These reasons could be related to increased demand for banknotes for transaction purposes, but also for purposes different from transactional. The slowdown in the velocity of currency circulation in the period 2011-2021 could be used as an argument that part of the cash circulating in the economy during this period was not used for transactions (see Chart 7). Yet this lower velocity may also reflect, to some extent, a compositional shift—namely, the substitution of smaller banknotes with larger ones, which typically circulate less frequently.

Chart 6: Nominal and real currency in circulation

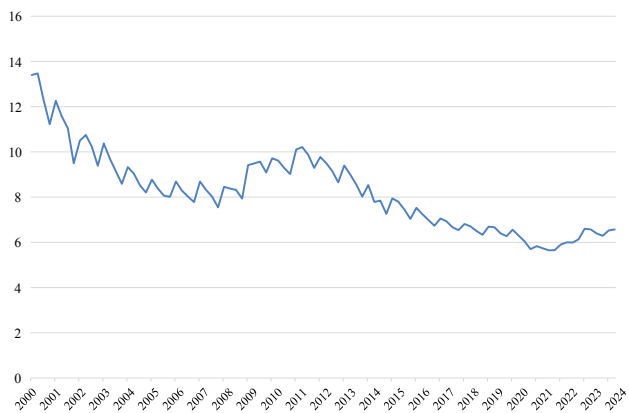


Source: BNB, NSI, own calculations.

**Note:** The real value of currency in circulation is calculated as the nominal value of currency in circulation deflated by the harmonised index of consumer prices (HICP) with 2011 taken as a base year. The base year is chosen to be 2011, as more substantial increase in nominal currency in circulation is observed after this year.

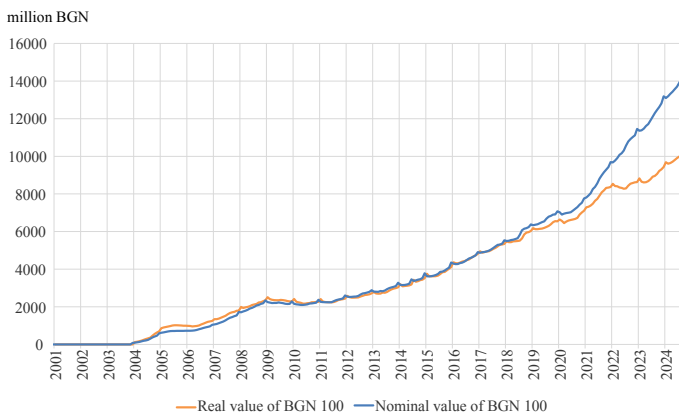
<sup>1</sup> The real value of currency in circulation is calculated as the nominal value, deflated by the harmonized index of consumer prices (HICP) with 2011 taken as a base year.

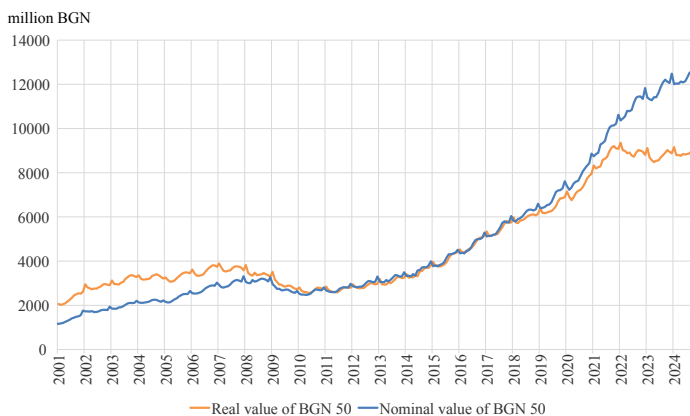
### Chart 7: Velocity of currency circulation



Source: BNB, NSI, own calculations

### Chart 8: Nominal and real value of the two largest denominations (BGN 100 and BGN 50)



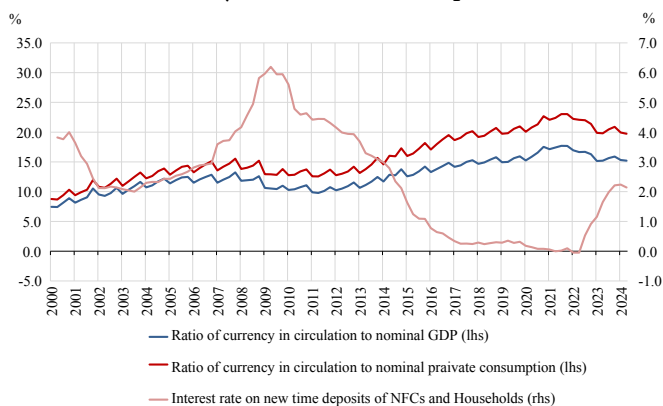


Source: BNB, NSI, own calculations

Note: The real value of the two largest denominations in circulation (BGN 100 and BGN 50) is calculated as the nominal value deflated by the harmonised index of consumer prices (HICP) with 2011 taken as a base year. The base year is chosen to be 2011, as more substantial increase in the nominal value of the two largest banknote denominations is observed after this year.

After 2021 the increase in the value of the second largest denomination in circulation (BGN 50) was almost entirely due to the increase in the price level, as its real value (adjusted for HICP with 2011 taken as a base year) remained broadly unchanged. However the real value of the largest banknote denomination (BGN 100) continued to rise in the period 2022-2024, which implies that part of the increase was due to factors different from the increasing price level (see Chart 8).

Chart 9: Currency in circulation and deposit interest rates



Source: BNB, NSI, own calculations

The dynamics of the ratios of currency in circulation to nominal GDP and to nominal private consumption, displaying a steady upward trend from the

beginning of 2012 till the end of 2021, also suggests that money circulating in the economy was growing ahead of economic activity, domestic transactions (as of end-2021 currency in circulation amounted to 17.7% of nominal GDP and 23.0% of nominal private consumption increasing from 10.8% and 13.7% at the end of 2011 respectively) and the overall price level in the economy. This implies that part of money demand was driven by purposes other than transactional and in particular might result from hoarding. This hypothesis is supported by the fact that nominal deposit interest rates had been following a downward trend for several years after the global financial and economic crisis and then stayed at very low levels till the end of 2021. Close to 0% deposit interest rates in nominal terms and negative in real terms destroy economic agents' incentives for holding savings at banks and stimulate the hoarding of money, because opportunity costs are the same. The factors for the declining deposit interest rates in Bulgaria in the last decade were the expansionary monetary policy of the ECB as a response to the global financial crisis and after that to the European debt crisis, as well as the accumulated significant liquidity and strong competition in the banking sector in Bulgaria. The undertaken by the ECB from the second half of 2022 increases in key interest rates in the euro area, aimed at combating surging inflation have been partially transmitted to Bulgaria. The transmission was faster regarding deposit interest rates in the sector of non-financial corporations, while deposit interest rates in the households' sector displayed slower and rather limited increase.

As standard money demand theory would suggest there is a clear negative correlation between money circulating in the economy and deposit interest rates. Against the background of gradually increasing deposit interest rates in the period from the second half of 2022 till the middle of 2024 the annual growth of currency in circulation was following an overall trend towards deceleration and the ratios of currency in circulation to nominal GDP and nominal private consumption started to decline.

Besides deposit interest rates, which represent the opportunity cost of holding cash, there are also other factors, which are important in explaining the demand for banknotes, namely economic activity, the volume of transactions, the price level, uncertainty etc. In the next chapters we examine these and other factors driving the transactional and non-transactional demand for cash in Bulgaria.

## 4. Data

For estimating demand equations for currency in circulation in Bulgaria we use monthly data on total cash circulating in the economy, as well as monthly data on the number and value of different denomination banknotes and coins, namely BGN 100 banknotes, BGN 50 banknotes, BGN 20 banknotes, BGN 10 banknotes, BGN 5 banknotes, BGN 2 coins, BGN 1 coins, BGN 0.5 coins, BGN 0.2 coins, BGN 0.1 coins, BGN 0.5 coins, BGN 0.02 coins and BGN 0.01 coins. As banknotes form 98.0% of the total value of currency in circulation and as we are interested in investigating not only the transactional, but also the non-transactional demand for cash, which is unlikely to be oriented towards coins, we concentrate our analysis only on banknotes. As the motives for holding different denominations differ and some substitution could exist between banknotes of similar value, it is implausible to assume that the coefficients of the variables determining the demand for each denomination would be the same. For example, the transactional motive should be more important for the smaller denominations and less important for the larger ones. By contrast, the non-transactional, or store-of-value motive could be expected to dominate the demand for large denomination banknotes and to be less pronounced concerning medium and even more concerning small denominations. For this reason, we estimate long run-demand equations not only for total banknotes in circulation, but additionally two separate equations for large denominations and for medium and small denominations (for simplicity called “not large” denominations). As explanatory variables in the money demand equations we test alternatively different macroeconomic indicators including: real GDP, retail trade turnover and households’ expenditures (per capita) to capture the transactional demand for cash; deposit interest rates, 10 year government bond yields and the exchange rate of the Bulgarian lev against the US dollar to capture the opportunity cost of holding cash; the harmonized index of consumer prices (HICP) as a variable, capturing the influence of the price level on cash demand; the business climate in the country, an economic sentiments indicator and an uncertainty indicator to capture the non-transactional demand for cash, in particular with a hoarding motive; the value of conducted ATM and POS transactions as a proxy for the degree of development of the payment system. Furthermore, as purchases of real estate may be partially made in cash, we also take into account the house price index (see Table 1).

Table 1: Variables used in the empirical analysis

Groups of variables	Variables	Notation	Source
Banknotes	Total banknotes (BGN 100+BGN 50+BGN 20+BGN 10+BGN 5 banknotes)	total	BNB
	Large banknotes (BGN 100+BGN 50 banknotes)	large	BNB
	Medium banknotes (BGN 20+BGN 10 banknotes)	medium	BNB
	Small banknotes (BGN 5 banknotes)	small	BNB
	Not large banknotes ((BGN 20+BGN 10+BGN 5 banknotes)	not_large	BNB
Transactional variables	Real GDP	rgdp	NSI
	Real retail turnover	retail_turn	NSI
	Households' expenditure (nominal, per capita)	hh_exp	NSI
Opportunity cost of holding cash	Interest rates on new time deposits	dir	BNB
	10 year government bond yields	10y_gov	BNB
	Exchange rate of the Bulgarian lev against the US dollar	ex_rate	BNB
Non-transactional demand for cash	Business climate	bc	NSI
	Economic sentiment indicator	esi	NSI
	Uncertainty indicator	uncrt	NSI
Degree of development of the payment system	Value per conducted ATM transactions	atm_tr	BORICA
	Value per conducted POS transactions	pos_tr	BORICA
Price level	Harmonized Index of Consumer Prices	hiep	NSI
House prices	House price index	hpi	NSI
Other	Proxy for economic agents' preference to substitute smaller banknote denominations with larger ones	sub_eff	BNB, BORICA, own calculations
	Proxy for the shadow economy	sh_gdp	NSI, BNB, own calculations

Most of the macroeconomic data used in the analysis have monthly frequency, except for real GDP, house prices and households' expenditures, which are quarterly. In order to work with data with the same frequency we use interpolation to transform the quarterly data into monthly. As most of the variables display a strong seasonal pattern we use seasonal adjustment methods to transform them to seasonally adjusted time series. Interpolation and seasonal adjustment are performed in the statistical software "R". The seasonally adjusted time series are indicated with "sa". Our sample spans from the end of 2000 to the middle of 2024, which means that we have 283 observations for most of the variables,

included in the analysis. Exceptions are the data for the value of ATM and POS transactions, which are available from the beginning of 2011. Due to the inclusion of these indicators in the econometric estimations, presented in the next section, the sample period is reduced to 162 observations. The sources of the data are the Bulgarian National Statistical Institute (NSI), the Bulgarian National Bank (BNB) and the Bank Organization for Payments by using cards (BORICA). Additionally, we construct two proxies: the first one captures agents' propensity to substitute smaller banknotes for larger denominations—measured as the ratio of the value of small denomination notes to the value of a single ATM withdrawal—and the second one (described in Section 6.3) proxies the size of the shadow economy.

For the econometric analysis, presented in the next chapter, all macroeconomic variables used are transformed in natural logarithms in order to be able to interpret the estimated coefficients in front of them as elasticities. The transformed variables are indicated with  $\log$ .

## 5. Econometric framework and results

Our empirical approach for estimating money demand equations consists of two alternative methods: 1) estimation of single-equation cointegration regressions with dynamic ordinary least squares (DOLS) and 2) an error correction model (ECM). DOLS and ECM are two different approaches used in econometrics and time-series analysis to model and analyze relationships among variables, particularly when dealing with non-stationary time series data and cointegrated variables, cointegration implying the existence of a long-term equilibrium among the variables. Although both methods are suitable for handling non-stationary data, there are some differences between them. DOLS is primarily used for estimating a single equation that captures only the long-run relationship among the variables. ECM, on the other hand, is used to analyze short-term and long-term relationships simultaneously in a system of cointegrated variables. It is especially useful for studying the dynamics of the adjustment process when variables deviate from their long-term equilibrium.

As both aforementioned methods are based on the assumption that the variables are non-stationary, as a first step in our analysis we perform tests for stationarity, using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. All specifications include a constant and additionally part of them include a trend, depending on whether the variable being tested exhibits trending behavior. The results from both test are presented in Table 2.

Table 2: Unit root tests

H0 : Variable has a unit root	ADF Test t-Statistic				Phillips Perron Test Adj. t-Statistic			
	Level	First difference	Second difference	Degree of integration	Level	First difference	Second difference	Degree of integration
log_total_sa	-2.29	-5.34***		I(1)	-3.19*	-20.42***		I(1)
log_large_sa	-2.30	-4.58***		I(1)	-2.94	-14.15***		I(1)
log_medium_sa	-1.44	-5.03***		I(1)	-1.23	-20.29***		I(1)
log_small_sa	-2.20	-7.55***		I(1)	-3.71**	-18.85***		I(1)
log_not_large_sa	-1.44	-4.95***		I(1)	-0.98	-20.17***		I(1)
log_rgdp_sa	-2.75	-3.54**		I(1)	-2.16	-4.58***		I(1)
log_retail_turn_sa	-1.79	-15.13***		I(1)	-1.79	-15.07***		I(1)
log_hh_exp_sa	0.66	-2.44	-4.66***	I(2)	1.17	-10.46***		I(1)
log_hpi_sa	-2.11	-3.60***		I(1)	-1.55	-2.71**		I(1)
dir	-1.07	-17.26***		I(1)	-1.28	-17.95***		I(1)
10y_gov	-1.72	-13.45***		I(1)	-1.82	-13.42***		I(1)
log_ex_rate	-2.23	-12.49***		I(1)	-2.41	-12.44***		I(1)
bc_sa	-3.30**	-18.39***		I(0)/I(1)	-3.18**	-18.62***		I(0)/I(1)
log_esi_sa	-3.90***			I(0)	-3.76***			I(0)
log_uncrt_sa	-1.60	-17.07***		I(1)	-1.73	-17.08***		I(1)
log_atm_tr_sa	-1.13	-12.44***		I(1)	-1.06	-21.25***		I(1)
log_pos_tr_sa	-2.58	-16.60***		I(1)	-2.58	-16.60***		I(1)
log_hicp_sa	-1.56	-7.25***		I(1)	-1.50	-10.88***		I(1)
log_sub_eff_sa	-1.13	-12.43***		I(1)	-1.06	-21.25***		I(1)
log_sh_gdp_sa	-0.55	-5.43***		I(1)	-1.02	-2.32	-4.63***	I(2)

\*\*\*Reflects statistical significance at the 1% level; \*\*Reflects statistical significance at the 5% level; \*Reflects statistical significance at the 10% level.

Based on the results from the ADF and PP tests it can be concluded that most of the variables, which are going to be used in the empirical analysis, are integrated of the first order. Exceptions are the households' expenditure variable, which according to the ADF test is integrated of the second order, but is I(1) according to the PP test, and the proxy for the shadow economy, which is integrated of the first order according to the ADF test, but is I(2) according to the PP test. Furthermore, part of the variables approximating the non-transactional demand for cash could be I(0) or I(1), depending on the level of significance considered.

Given that most of the time series, which are going to be used in the empirical analysis are integrated of the first order, in order to justify the use of DOLS and ECM it still needs to be tested if there is a cointegrating relationship between them, i.e. if they share a common stochastic trend. In theory, if a group of variables are individually integrated of the same order and there is at least one linear combination of these variables that is stationary, then the variables are said to be cointegrated. The cointegrated variables will never move far apart, and will converge to their long-run relationship (Pesavento 2004). The testing for the presence of a cointegrating relationship between the variables of interest is based

on the use of the Engle and Granger (1987) procedure, which is widely used in the academic literature to achieve this goal. The essence of the Engle and Granger test consists in estimating a regression between the variables of interest by the method of ordinary least squares (OLS) and testing its residuals for stationarity. Stationarity of the residuals is indicative of the presence of a cointegration relationship between the considered variables.

We test a number of different specifications, whereby the dependent variable is either the total value of banknotes in circulation or the value of the large and not large banknote denominations and as explanatory variables we try alternatively variables from the groups defined in Table 1. The selection procedure for the variables that we decide to retain in our final specifications is based on testing their statistical and economic significance, we also give importance to the signs of the estimated coefficients and want them to coincide with economic theory and expectations. The finally selected long-run demand equations for total banknotes in circulation and for the large banknotes denomination group include the following explanatory variables: seasonally adjusted retail trade turnover ( $\log\_retail\_turn\_sa$ ) as a transactional variable; a weighted average interest rate on new time deposits of non-financial corporations and households<sup>2</sup>( $dir$ ) as a variable measuring the opportunity cost of holding cash; the seasonally adjusted harmonized index of consumer prices ( $\log\_hicip\_sa$ ) as a measure of the price level; the seasonally adjusted index of house prices ( $\log\_hpi\_sa$ ) to take into account that real estate purchases may be partially paid in cash; seasonally adjusted uncertainty indicator ( $\log\_uncrt\_sa$ ) to measure the non-transactional demand for cash, especially with a hoarding motive; the seasonally adjusted volume of POS transactions ( $\log\_pos\_tr\_sa$ ) as a variable measuring the degree of development of the payment system and technologies. In the long-run demand equation for the not large banknotes denomination group the variable measuring house prices is excluded from the regressions, as it doesn't enter significantly. Actually, this could be expected as it is highly unlikely that cash payments for the purchase of real estate are made in small denomination banknotes. Furthermore we include additional variable that proxies the accessibility and ease of obtaining cash, namely the seasonally adjusted value per ATM transactions. Moreover instead of deposit interest rates we use the 10 year government bond yields to capture the opportunity cost of holding cash, as this variable improves the fit of the regression. In the long-run demand equations for total and large banknotes we also include a dummy variable for June 2014, when there were massive withdrawals of money related to the bank run on the former Corporate Commercial Bank. The constructed proxy

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<sup>2</sup> The weighted average interest rate is calculated from interest rates for all maturities and currencies weighted by the relevant volumes of new deposits.

for the substitution effect between smaller and larger banknote denominations doesn't enter the specifications significantly, possibly because this effect is partially captured by the overall increase in the price level. For this reason we omit it from the regressions.

In order to test for cointegration we apply the Engle and Granger procedure by estimating regressions using OLS and testing the residuals from those regressions for unit roots. The results from the tests are presented in Table 3.

Table 3: Engle and Granger procedure

Null hypothesis : Residuals have a unit root	t-Statistics	MacKinnon critical values		
		1%	5%	10%
Total banknotes in circulation	-6.09***	-5.404	-4.811	-4.507
Large banknotes	-5.70***	-5.404	-4.811	-4.507
Not large banknotes	-3.60	-5.404	-4.811	-4.507

Notes: The lag selection is based on the Schwarz Information Criterion (SIC). MacKinnon critical values take into account the number of observations and the number of explanatory variables in the OLS regressions.

\*\*\*Reflects statistical significance at the 1% level; \*\*Reflects statistical significance at the 5% level;

\*Reflects statistical significance at the 10% level.

Based on the results from the Engle and Granger procedure, it can be concluded that the residuals from the estimated equations for the total value of banknotes in circulation and for the value of large banknotes are stationary, i.e. there exists a long term equilibrium between the variables while concerning not large banknotes no cointegrating relationship can be found.

### 5.1. Estimating long-run money demand equations using DOLS

The Dynamic Ordinary Least Squares (DOLS) estimator was proposed by Saikkonen (1991) and Stock and Watson (1993). This estimator is obtained by augmenting the static cointegrating regression with leads and lags of the first differences of the I(1) regressors. One of the advantages of the DOLS model compared to the OLS estimator is that it takes care of the small sample bias (Banerjee et al. 1986) and an endogeneity bias (second-order bias) by taking the leads and lags of the first-differenced regressors into account (Stock and Watson 1993). Furthermore, DOLS yields valid results also in the case of structural breaks (Campos et al. 1996). Saikkonen (1992) suggested to use data dependent rules to select the number of leads and lags in the cointegrating regression, such as the Akaike information criterion (AIC) (Akaike 1973) or the Bayesian information criterion of Schwarz (1978). This was also confirmed by Kejriwal and Perron 2008, who showed that, relative to sequential general to specific testing procedures, the use of data dependent information criteria can produce estimates with smaller mean squared errors and confidence intervals with better coverage rates.

For determining the number of leads and lags to be included in the equations we use the Schwarz information criterion (SIC), as compared to the Akaike information criterion it imposes a higher penalty for model complexity, thus favouring models that are more parsimonious and do not include unnecessary lags or leads. We abstain from including too many lags and leads in the equations due to data constraints, i.e. not sufficiently long time series<sup>3</sup>. The results from the finally selected long-run estimation equations for the total value of banknotes in circulation and for the two different denominational groups – large and not large banknotes are presented in Table 4.

Overall the results confirm the theoretical expectations that transactional activity, the price level and housing prices positively affect cash demand, while the opportunity cost of holding money and the degree of payment system development negatively influence it. These findings support the hypothesis that both transactional and hoarding motives are relevant in Bulgaria's cash demand dynamics.

Table 4: DOLS estimates

Variables	Total banknotes	Large banknotes	Not large banknotes
C	2.97*** (0.44)	2.81*** (0.56)	10.65*** (0.64)
log_retail_turn_sa	0.60*** (0.09)	0.31*** (0.12)	0.11 (0.07)
dir/10y_gov	-0.03*** (0.01)	-0.05*** (0.01)	-0.03*** (0.01)
log_hicp_sa	0.38*** (0.10)	0.86*** (0.10)	-0.73*** (0.12)
log_hpi_sa	0.79*** (0.06)	0.94*** (0.08)	
log_uncrt_sa	0.08*** (0.02)	0.09*** (0.03)	0.05** (0.02)
log_pos_tr_sa	-0.49*** (0.07)	-0.91*** (0.10)	-0.20** (0.10)
log_atm_tr_sa			0.20*** (0.08)
D_2014_06	0.11** (0.05)	0.11** (0.06)	
R <sup>2</sup>	0.99	0.99	0.98
S.E. of regression	0.01	0.01	0.02
Leads/lags (SIC)	2/0	6/6	0/0
Number of observations (after adjustments)	159	149	161
Phillips-Ouliaris $\tau$	-6.23***	-5.51**	-3.60

Notes: The number of leads and lags in the DOLS estimates are selected by the Schwarz information criterion (SIC). Phillips-Ouliaris  $\tau$ -test of cointegration with the null of no cointegration.

\*\*\*Reflects statistical significance at the 1% level; \*\*Reflects statistical significance at the 5% level; \*Reflects statistical significance at the 10% level. Standard errors in parentheses.

<sup>3</sup> Due to the inclusion of the value of conducted POS transactions in the specifications our estimation sample reduces to 162 observations from originally 283, as data for POS transactions starts only from 2011 onwards.

The results from the DOLS estimates for the total value of banknotes in circulation as well as for the value of the large banknotes' denomination group show that all coefficients are statistically significant at the 1% level and have the expected signs. In both specifications we find a positive and significant transactions elasticity, proxied by the retail trade turnover, with the elasticity being higher in the specification for total banknotes, which is an expected outcome. We also find a positive and statistically significant relationship between the price level and house prices and the demand for banknotes, with this relationship being stronger concerning large banknotes, which could also be expected, given that higher consumer and especially house prices prompt demand for higher denominations if payments are made in cash. The coefficient in front of the uncertainty indicator, which is used as a proxy for the non-transactional demand for cash with a store-of-value motive, is also positive and similar in both specifications. This result can be interpreted in the following way: increased economic uncertainty prompts economic agents to demand cash with a hoarding motive and as storing banknotes requires physical place it is more convenient to hoard large denomination banknotes. With some degree of certainty it could be also argued that increased demand for total currency in circulation for hoarding purposes is driven to a higher extent by demand for large banknotes. The effect of deposit interest rates, used to proxy the opportunity cost of holding cash is, as expected, negative in both specifications, although the estimated elasticity is rather low. The degree of development of cashless payment technologies, proxied by the value of POS transactions, exerts a negative influence on the demand for cash and especially on the demand for large denominations.

The results from the DOLS estimates for the not large banknotes' denomination group are not as conclusive as those for total and large banknotes, but still the estimated coefficients have the expected signs, except that of the consumer price level, which turns out to be negative. However, the exclusion of the price level variable from the equation leads to wrong signs of some of the other explanatory variables. When inspecting the variables for non-large banknotes and for inflation visually, we actually find a strong negative correlation between them, especially in the period from 2021 onwards, when inflation started surging, while the value of non-large banknotes was on a declining path, predominantly due to the decline of the value of the medium banknotes – BGN 20 and BGN 10 (see Chart 2 and 3). A possible explanation of this phenomenon could be that high inflation boosts demand for large banknotes as the prices of goods and services increase, but this is not the case with smaller denomination banknotes.

The coefficient in front of the transactional variable is relatively low and not significant, which is not an expected outcome. However, we find a statistically

significant negative impact on the demand for medium and small banknotes of the opportunity cost of holding cash, with the coefficient in front of it being similar to those in the total and large banknotes specifications. Actually there is no reason to believe that higher opportunity cost of holding cash would have a different impact on the preferences of economic agents to save in specific denominations. The development of cashless payment technologies is also found to have a statistically significant and negative impact on the demand for not large banknotes, although this impact is smaller compared to the demand for larger ones. This result could also be expected as normally in large retailer stores or in furniture, appliance or other durable goods stores it is more likely for customers to pay by bank cards, in contrast to small shops, where POS devices are generally less widespread. ATM transactions, as expected, have a positive and statistically significant impact on the demand for not large banknotes. The significance of this variable in the equation for not-large banknotes, as opposed to the large ones could be explained by the fact, that for most of the analyzed period ATMs were predominantly loaded with BGN 20 and BGN 10 banknotes and only in recent years some ATMs have started providing larger denominations – BGN 50, and less frequently BGN 100 banknotes. Economic uncertainty is found to have a smaller impact on the demand for not large banknotes, which is an expected outcome as well, as demand for banknotes with hoarding motive should be concentrated towards higher denominations due to the need of physical place to store them.

Apart from giving importance to the statistical significance of the estimated coefficients and the presence of expected signs in accordance with economic theory, we additionally perform a Phillips-Ouliaris test of cointegration on the already estimated long-run equations. The reason for performing this test is to check the robustness of the results from the previously performed Engle and Granger procedure. The Phillips-Ouliaris test is a residual-based test, which is used in the same way as the unit root tests, but the data are the residuals from the cointegrating regression. This test is designed to test the null hypothesis of no cointegration by testing the null that there is a unit root in the residuals against the alternative that the root is less than unity. If the null of a unit root is rejected, then the null of no cointegration is also rejected (Phillips and Ouliaris 1990).

The results from the Phillips-Ouliaris  $\tau$ -test presented in Table 4 confirm the results from the performed Engle and Granger procedure. The residuals from the estimated cointegrating regressions for the total value of banknotes in circulation and for the value of large banknotes are stationary, meaning that there exists a long-run equilibrium between the variables included in the regression. However concerning the not large banknotes' denomination group the null hypothesis for the presence of a unit root cannot be rejected, so the null of no cointegration cannot be rejected either.

## 5.2. Estimating money demand equations using ECM

In this section we estimate similar regressions to the ones presented above, but instead of dynamic ordinary least squares, we use an error correction model in order to gain insight not only into the factors that determine the long-term equilibrium, but also into the driving forces of the short-run deviations from the long-term trend. As we have already performed unit roots tests of the variables of interest, as well as tests for cointegration, we take the presence of a cointegrating relationship as given and proceed with the econometric estimation. Given the lack of a conclusive long-run relationship regarding the variables in the estimated equation for the not large banknotes denomination group we focus only on total and large banknotes. The estimated error-correction model for total banknotes in circulation has the following form, with that for large banknotes being the same:

**Long-run equation:**

$$\log (total\_sa\_star) = \beta_0 + \beta_1 \log (rgdp\_sa) + \beta_2 (dir) + \beta_3 \log (hicip\_sa) + \beta_4 \log (hpi\_sa) + \beta_5 \log (uncrt\_sa) + \beta_6 \log (pos\_tr\_sa) \quad (5.2.1)$$

**Short-run equation:**

$$d\log (total\_sa) = \beta_0 [\log (total\_sa_{t-1}) - \log (total\_sa\_star_{t-1})] + \beta_1 d\log (rgdp\_sa) + \beta_2 d(dir) + \beta_3 d\log (hpi\_sa) + \beta_4 \log (uncrt\_sa) + \beta_5 \log (pos\_tr\_sa) + \beta_6 dummy2014\_06 + \beta_7 dummy2014\_07 + \beta_8 dummy2020\_02 + \beta_9 d\log (total\_sa_{t-1}) + \beta_{10} d\log (total\_sa_{t-2}) \quad (5.2.2)$$

where  $total\_sa\_star$  is the estimated long-run equilibrium of the value of banknotes in circulation, while  $[\log (total\_sa_{t-1}) - \log (total\_sa\_star_{t-1})]$  is the error correction term, which measures the speed of adjustment to the long-term trend. Generally, the aim of the long-run equation is to capture the equilibrium relationship between the dependent variable and its determinants. The aim of the short-run equation is to incorporate the factors that drive the short-run fluctuations of the variable and to show how long it takes for the dependent variable to return back to its long-run path. The results from the estimated long-run equations for total and large banknotes are presented in Table 5, while those from the short-run equations are presented in Table 6.

The short-run results reported in Table 6 indicate that temporary deviations in cash demand are mainly driven by transactional activity and house prices. This aligns with the short-term behavioural adjustment of agents responding to consumption and housing market dynamics.

The long-run coefficients in Table 5 further corroborate the presence of stable relationships consistent with money demand theory. The significant positive coefficients on price and uncertainty indicators validate the role of both inflationary and precautionary motives in explaining long-term cash demand behaviour.

Table 5: ECM estimates – long-run equation

Variables	Total banknotes	Large banknotes
C	-3.54*** (1.16)	-7.07*** (1.41)
log_rgdp_sa	0.89*** (0.15)	1.06*** (0.18)
dir	-0.06*** (0.01)	-0.08*** (0.01)
log_hicp_sa	0.48*** (0.08)	0.74*** (0.09)
log_hpi_sa	0.82*** (0.05)	0.97*** (0.06)
log_uncrt_sa	0.14*** (0.01)	0.15*** (0.02)
log_pos_tr_sa	-0.64*** (0.04)	-0.76*** (0.05)
R <sup>2</sup>	0.99	0.99
S.E. of regression	0.02	0.03
Number of observations (after adjustments)	162	162

\*\*\*Reflects statistical significance at the 1% level; \*\*Reflects statistical significance at the 5% level; \*Reflects statistical significance at the 10% level. Standard errors in parentheses.

Both in the long-run and in the short-run equations we include the seasonally adjusted real GDP instead of the retail trade turnover as an explanatory variable approximating the transactional demand for cash, as it enters more significantly. In the short-run equations we include two lags of the dependent variable to deal with autocorrelation of the residuals and several dummies to account for outliers, partly related to the bank run on the former Corporate Commercial Bank and to the outbreak of the COVID-19 pandemic.

In the long-run equations all explanatory variables have the expected signs and are statistically significant at the 1% level. According to the estimated equations the demand for banknotes in the long run is positively affected by transactional

motives, the price level and real estate prices, as well as by non-transactional/hoarding motives, approximated by the uncertainty indicator. On the other hand the higher degree of development of the payment system and the availability of opportunities for making cashless payments, as well as higher opportunity costs of holding cash exert negative influence on the demand for banknotes. Similar to the DOLS estimates, we find a stronger positive relationship between the price level and house prices and the demand for large banknotes, as higher consumer and especially house prices prompt demand for higher denominations if payments are made in cash. Again similar to the DOLS estimates, the degree of development of cashless payment technologies, proxied by the value of POS transactions, exerts a stronger negative influence on the demand for large denominations banknotes.

According to the estimated short-run equations the demand for banknotes in the short-run is driven mainly by house price dynamics and transactional motives and to a much lesser extent by hoarding motives. An interesting observation is that house prices enter all equations (long-run and short-run for total and especially for large banknotes) statistically significant and the estimated elasticity is also relatively high (especially in the long-run equations). This gives grounds to suggest that real estate purchases are partially paid in cash. The opportunity cost of holding cash exerts negative influence on the demand for both total and large banknotes, but the estimated elasticity is rather small. The coefficient of the error correction term is highly significant in both equations and it is estimated at -0.15 and -0.06 regarding total and large banknotes respectively, meaning that it takes approximately 7 and 17 months respectively for the dependent variable to return to its long-run equilibrium. The lags of the dependent variable and all dummy variables included in the equations are highly significant. The performed tests for autocorrelation, normal distribution and heteroscedasticity suggest that such are not present regarding the equation for large banknotes. However non-normality of the residuals might be an issue regarding total banknotes, which, given the relatively small sample, potentially compromises the validity of the p-values in the short-run equation on total banknotes.

Table 6: ECM estimates – short-run equation

Variables	Total banknotes	Large banknotes
Error correction term	-0.15*** (0.03)	-0.06*** (0.02)
dlog_rgdp_sa	0.26** (0.13)	0.21** (0.09)
d_dir	-0.01*** (0.00)	-0.01*** (0.00)
dlog_hpi_sa	0.59*** (0.12)	0.22*** (0.09)
dlog_uncrt_sa	0.02* (0.01)	0.02* (0.01)
dlog_pos_tr_sa	-0.09* (0.05)	-0.02 (0.03)
D_2014_06	0.06*** (0.01)	0.05*** (0.00)
D_2014_07	-0.03*** (0.01)	-0.05*** (0.01)
D_2014_09	0.03*** (0.01)	0.02*** (0.00)
D_2015_01	-0.02*** (0.01)	-0.02*** (0.01)
D_2020_02	-0.02*** (0.01)	-0.02*** (0.00)
lag(-1)	0.15*** (0.06)	0.39*** (0.05)
lag(-2)	0.26*** (0.06)	0.42*** (0.05)
R <sup>2</sup>	0.46	0.58
S.E. of regression	0.01	0.01
Number of observations (after adjustments)	161	161
DW statistics	2.00	2.07
Jarque-Bera Test	0.00	0.97
Breusch-Pagan-Godfrey Test	0.72	0.92

\*\*\*Reflects statistical significance at the 1% level; \*\*Reflects statistical significance at the 5% level;  
\*Reflects statistical significance at the 10% level. Standard errors in parentheses.

Notes: The table presents the results of the Durbin–Watson (DW) test for serial correlation, suggesting that no serial correlation is observed in the residuals, the Jarque-Bera test for normal distribution, suggesting that normal distribution of the residuals might be an issue regarding total banknotes, and the Breusch-Pagan-Godfrey test for heteroscedasticity, which is indicative for the lack of heteroscedasticity.

## 6. Transactional vs. non-transactional demand for cash

After estimating money demand equations, the goal of this section is to provide an estimate of the share of banknotes (and more specifically of the share of large banknotes) demanded for transactional purposes and that demanded with motives different from transactional. Two possible approaches for performing such estimates are the so-called *Denomination Approach*<sup>4</sup> and *Seasonal Variation Approach*<sup>5</sup>.

### 6.1. Denomination Approach for estimating the non-transaction demand for large banknotes

The denomination approach is based on the assumption that different denominations are used in similar proportions over time to effect payments. More specifically this assumption implies that different banknote denominations should grow proportionally over time such that their relative share remains constant. From this follows that if large denominations are also demanded for other purposes, different from transactional, their growth rate would be higher than that of smaller denominations and their relative share in total banknotes in circulation would increase. If we assume that small and medium banknote denominations in Bulgaria are used predominantly for transactions, while large banknotes are used both for transactional and non-transactional purposes, we could investigate the ratio of the number of large to not large banknotes and its evolution over time. Data on the different denomination banknotes show that this ratio was relatively stable over a period of 10 years (from 2002 to 2011), standing at close to 0.3, and it started increasing gradually from 2012 coming to nearly 0.8 in the middle of 2024. If we assume that the period of relative stability of the ratio between the number of large and not large banknotes is representative for banknotes demand with a transactional motive only, we can calculate the imputed demand for large banknotes based on this ratio. Alternatively we could use the ratio of the number of large banknotes to small banknotes for the same historical period, thus assuming that only the very small denominations are used only for transactions, while part of the medium banknote denominations are also used for purposes, different from transactional. The difference between the actual and imputed demand for large banknotes will then represent the non-transactional demand. Having calculated the value of large banknotes demanded for non-transactional purposes and dividing it by the total value of large banknotes we can estimate the so called hoarding share. Having in mind that part of the increase in

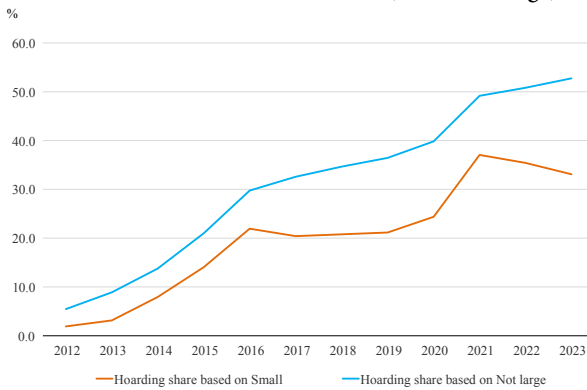
<sup>4</sup> See for example Otani and Suzuki (2008).

<sup>5</sup> The Seasonal Variation Approach is one of the methods which the Federal Reserve Board developed to estimate the volume of U.S. dollars in circulation abroad. For more details see Porter et al. (1996).

banknotes in circulation during the period under investigation was due to the rise in the price level (see Section 3), to make the previous assumptions more realistic we adjust the value of banknote denominations for HICP and use their real value to estimate the hoarding share.

The estimated hoarding shares of large banknotes (based on historical ratios to small banknotes or to not large banknotes) are presented on Chart 10. According to the estimates the hoarding share of large banknotes when using as a reference only the very small denominations reached approximately 30% in 2023. The estimates based on a historical ratio of the large banknotes to not large banknotes show even a larger hoarding share, which exceeds 50% in 2023, meaning that over 50% of the total real value of BGN 100 and BGN 50 banknotes are demanded for purposes, different from transactional.

**Chart 10: Estimated hoarding share of large banknotes based on a ratio to smaller banknotes (annual average)**



Source: Own calculations.

Notes: The estimate is based on a historical ratio to smaller banknotes; base period: 2002-2011. For this estimation small banknotes consist of BGN 5, BGN 2 and BGN 1. The BGN 1 banknote is in circulation till the end of 2015, while the BGN 2 banknote is circulating till the end of 2020. Banknote denominations' nominal values are adjusted for the harmonised index of consumer prices (HICP) with 2011 taken as a base year.

When interpreting the results of this estimation it should be taken into account that it is based on certain assumptions regarding the reference period and the reference banknote denominations. It is possible that these assumptions do not correspond to the true circumstances, so the concrete numbers should be interpreted with care and shouldn't be taken as highly precise.

## 6.2. Seasonal Variation Approach for estimating the non-transaction demand for banknotes

The basic idea behind the method based on seasonal patterns is that banknote demand for transactions is influenced by events that occur regularly over the year like Christmas shopping or summer holidays. By contrast, banknote demand for hoarding is typically not affected by such seasonal factors. As a result, the seasonal variation of banknote demand should become less pronounced when the share of banknotes that are not used for transactions increases. Generally, the seasonal method for estimating the non-transactional demand for banknotes is based on a comparison of the seasonal pattern of banknotes (in our case large banknotes) to that of a benchmark series that exclusively relates to transactions.

More formally the seasonal variation technique is based on a multiplicative decomposition of an unadjusted series into trend-cycle component ( $T_t$ ), seasonal component ( $S_t$ ) and an irregular (noise) term ( $E_t$ ):

$$Y_t = T_t * S_t * E_t \quad (6.2.1)$$

In the multiplicative model the seasonal effects are assumed to be regular and predictable and to scale proportionally with the level of the time series. Since the seasonal pattern is assumed to be consistent,  $S_t$  will repeat for the same month or quarter every year. When using the multiplicative model the seasonal term in the unadjusted series is around 1 in periods without a discernible seasonal influence, it registers its largest values above 1 in periods of significant seasonal increases (regarding currency in circulation this typically occurs around Christmas), and it is typically the furthest below 1 after such periods, when the seasonal term declines sharply (most often at the end of the first quarter).

To calculate the share of banknotes (in our case large banknotes) that is demanded for reasons different from transactional in year  $t$ , from the seasonal pattern, we use the following equation (for a derivation see Porter et al. (1996), p. 891; Assenmacher et al (2017), p.10-11):

$$(1 - \beta_t) = 1 - \frac{S_{max,t} - S_{min,t}}{s^{tr}_{max,t} - s^{tr}_{min,t}} \quad (6.2.2)$$

where  $S_{max,t}$  and  $S_{min,t}$  are the largest and smallest seasonal factors for the series of interest and  $S^{tr}_{max,t}$  and  $S^{tr}_{min,t}$  are those for a purely transaction-related variable.  $\beta_t$  is the share of banknotes used for transactions and  $(1-\beta_t)$  is the so called hoarding share or the share of banknotes demanded for non-transactional purposes. The challenge with this approach is related to the fact that the seasonal

factors for the purely transactions-related series,  $S^{tr}$ , are unknown and have to be approximated through the use of a suitable benchmark series. Possible choices for such benchmark series, which can be found in the literature, are the demand for banknotes in a reference country which does not feature hoarding or a variable like retail trade or private consumption expenditures that is solely related to transactions. Another alternative is to compare the seasonal factors across different banknote denominations, assuming that smaller denominations are mainly used for transactions, whereas large banknotes are more prone to hoarding or to demand for other non-transactional purposes<sup>6</sup>.

We decide to use two alternative benchmark series to approximate the purely transactional demand for cash – the first one is the generated series for not large banknotes and the second one is the retail trade turnover. Using these two benchmark series, we aim at estimating the share of the non-transactional demand for large banknotes ( $1-\beta_t$ ).

Data on the different banknote denominations in Bulgaria show that the seasonal high (SH) is reached in December each year. Regarding large banknotes there are two seasonal lows (SL) – one in March and one in May, while in respect to not large banknotes the seasonal low is reached in March. Data on retail trade turnover reveal a seasonal high in December each year and a seasonal low in February of the following year (see Chart 14 in the Appendix). We can alternatively choose SL to be March for all series, in order to have consistency, or we can take the actual SL for each series, meaning SL for large banknotes in May, SL for not large banknotes in March and SL for retail trade turnover in February. In the case of choosing SL to be March for all three series of interest – large banknotes and the two benchmark series, we can rewrite equation 6.2.2 to get:

$$(1 - \beta_t) = 1 - \frac{S_{dec,y} - S_{march,y+1}}{S^{tr}_{dec,y} - S^{tr}_{march,y+1}} \quad (6.2.3)$$

where  $S_{dec,y}$  is the seasonal high of large banknotes in December each year and  $S_{march,y+1}$  is the subsequent seasonal low in March of the following year.  $S^{tr}_{dec,y}$  and  $S^{tr}_{march,y+1}$  are the seasonal highs and lows of every one of the benchmark series, which approximate the purely transactional demand for cash – alternatively not large banknotes and retail trade turnover.

Our estimates based on the above described approach show that if we choose SL to be March for all series, the hoarding share of large banknotes (which should be interpreted as the share of large banknotes not demanded for transactions) is around 48% when using not large banknotes as a benchmark and around 60%

<sup>6</sup> For an overview of possible alternatives see for example Seitz (1995) or Bartzsch et al. (2013).

when as a benchmark variable is used the retail trade turnover. If we take the actual SL for each series we find a similar hoarding share of large banknotes when using not large banknotes as a benchmark (47%), however the hoarding share rises to 72% when the benchmark is retail trade (see Table 7).

**Table 7: Estimated hoarding share of large banknotes based on a multiplicative seasonal adjustment model**

	Benchmark:	Benchmark:
	Not large banknotes	Retail Trade Turnover
SH December/SL March	48%	60%
SH December/SL large banknotes-May/ SL not large banknotes-March	47%	
SH December/SL large banknotes-May/ SL retail trade-February		72%

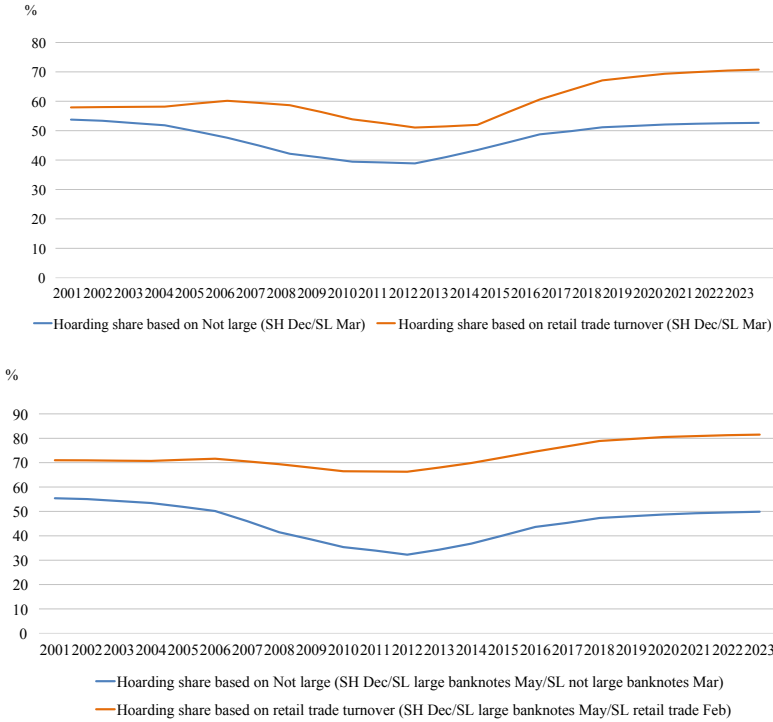
Source: Own calculations.

Notes: The multiplicative seasonal adjustment model is based on the assumption that the seasonal pattern is consistent across years, so the seasonal factor is the same for the same month of each year.

A way to impose a changing seasonal pattern, rather than consistency across years, is to apply the so called STL method (Seasonal and Trend decomposition using Loess)<sup>7</sup>. STL applies an iterative algorithm to alternately smooth and separate the seasonal, trend, and residual components. As the STL procedure natively supports additive decomposition, for multiplicative adjustment we take the log transformation of the time series to convert them to an additive form, apply the STL decomposition on the log-transformed data and then exponentiate the result. We take the estimated seasonal components of the three series of interest – large banknotes, not large banknotes and retail trade turnover and perform the same analysis as with the multiplicative seasonal adjustment model. The results show that if SL is chosen to be March for all series, the hoarding share of large banknotes is estimated to be in the range of 40% to over 50% when not large banknotes are used as a benchmark and in the range of 50% to 70%, when the benchmark series is retail trade turnover. If SL is the actual low for each series, the hoarding share of large banknotes is estimated in the range of 30% to 50%, when the reference variable is not large banknotes and in the range of 65% to over 80%, when the reference variable is retail trade turnover (see Chart 11). The average hoarding shares of large banknotes for the whole analyzed period are very close to those estimated with the multiplicative seasonal adjustment model, which is an expected outcome as the seasonal factor from the multiplicative seasonal adjustment reflects the average proportional effect for a given time period. As a whole our estimates of the share of large banknotes not demanded for transaction purposes in Bulgaria are comparable with the estimates for other countries, obtained by applying seasonal methods.

<sup>7</sup> Cleveland et al. (1990).

Chart 11: Estimated hoarding share of large banknotes based on a Seasonal and Trend decomposition using Loess (STL)



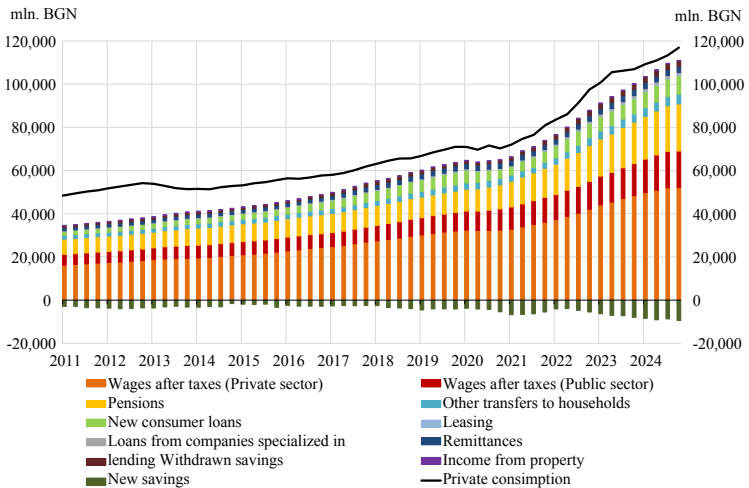
Source: Own calculations.

### 6.3. Cash and the shadow economy

After estimating the approximate hoarding shares of large-denomination banknotes, this section aims to assess the influence of the shadow economy on cash demand. One way to address this issue is by extending the estimations from Section 5.1 with an additional explanatory variable that serves as a proxy for cash demand related to non-official activities. A commonly used proxy in the literature is the tax-to-GDP ratio, based on the premise that a higher tax burden may incentivize individuals and businesses to underreport or conceal income, thereby increasing participation in the shadow economy and raising cash usage. However, interpreting changes in the tax-to-GDP ratio is not straightforward. On one hand, a rising ratio may indicate growing tax pressure and thus a stronger incentive for tax evasion. On the other hand, it may also reflect ongoing reduction of the shadow economy. A further limitation of using the tax-to-GDP ratio is that its fluctuations may result not from changes in the shadow

economy, but from direct effects of fiscal policy interventions—such as adjustments in tax rates or social security contributions. In light of these limitations, we refrain from using the tax-to-GDP ratio as a proxy for the shadow economy. Instead, we construct an alternative measure, defined as the gap between the nominal value of private consumption and the total of all identifiable official household financing sources that may be used for consumption, net of new household savings. These sources include labor income, pensions, government or foreign transfers to households, extended consumer credit (from banks or other financial institutions), leasing, property income and withdrawn savings (see Charts 12 and 13). To remove price effects, this gap is scaled relative to GDP and used as a proxy indicator for the shadow economy in the regressions presented in Section 5.1. The results from the DOLS estimates are presented in Table 8.

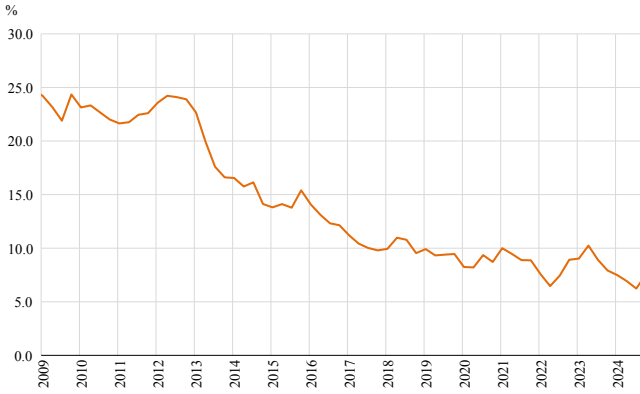
Chart 12: Nominal private consumption, household financing sources and new savings



Source: Wages (NSI, Quarterly national accounts) - Wages are reduced by personal income taxes paid; Pensions and other transfers to households (Non-financial accounts of the General government); New consumer loans (BNB, Interest rate statistics) - Data after 2019 exclude new consumer loans for refinancing and renegotiated consumer loans; Leasing (BNB, Other financial institutions, Leasing companies) - Financial leasing for Households and NPISHs; Loans from companies specialized in lending (BNB, Other financial institutions, Corporations specialising in lending) - Quarterly change in the stock of consumer lending; Remittances (BNB, Balance of payments statistics); Withdrawn savings and income from property (NSI, Household budget survey, Demographics statistics); New savings (BNB, Monetary statistics, Sectoral survey of other MFI) - Quarterly change in the stock of Households' deposits. The data presented on the Chart are moving sums over four quarters

As can be seen from Charts 12 and 13 the gap between private consumption and the total of all identifiable official household financing sources, net of new savings, has been shrinking in the period under investigation, indicating gradual reduction of the shadow economy. In 2024 this gap amounted to approximately BGN 15.3 billion or 7.5% of GDP, compared to BGN 18.3 billion or 22.6% of GDP in 2011.

Chart 13: Gap between nominal private consumption and the total of all identifiable official household financing sources, net of new household savings (in % of GDP)



Source: NSI, BNB, own calculations.

Table 8: DOLS estimates with included proxy for the shadow economy

Variables	Total banknotes	Large banknotes
C	2.75*** (0.43)	2.38** (1.12)
log_retail_turn_sa	0.56*** (0.08)	0.28** (0.15)
dir	-0.04*** (0.01)	-0.06*** (0.02)
log_hicp_sa	0.39*** (0.09)	1.05*** (0.19)
log_hpi_sa	0.84*** (0.06)	0.88*** (0.16)
log_uncrt_sa	0.08*** (0.01)	0.05 (0.05)
log_pos_tr_sa	-0.49*** (0.06)	-0.86*** (0.14)
log_sh_gdp_sa	0.03 (0.02)	0.00 (0.06)
D_2014_06	0.13 (0.04)	0.06 (0.14)
R <sup>2</sup>	0.99	0.99
S.E. of regression	0.01	0.01
Leads/lags (SIC)	2/0	6/6
Number of observations (after adjustments)	159	149
Phillips-Ouliaris $\tau$	-6.49***	-5.82**

Notes: The number of leads and lags in the DOLS estimates are selected by the Schwarz information criterion (SIC). Phillips-Ouliaris  $\tau$ -test of cointegration with the null of no cointegration.

\*\*\*Reflects statistical significance at the 1% level; \*\*Reflects statistical significance at the 5% level; \*Reflects statistical significance at the 10% level. Standard errors in parentheses.

The inclusion of our constructed proxy for the shadow economy in both equations (total and large-denomination banknotes) does not materially affect the significance or magnitude of the other coefficients: most remain statistically significant at the 1% level and exhibit the expected signs. By contrast, the coefficient on the shadow-economy proxy is near zero and statistically insignificant in both specifications. Overall, the DOLS estimates with the proxy for non-official activities are broadly similar to those without it. This finding implies that our proxy does not contribute to explaining the growth in currency in circulation—particularly large banknotes—over the sample period. One plausible interpretation is that the shadow economy steadily contracted during the period under study.

## 7. Conclusion

The number and value of large denomination banknotes in Bulgaria have increased steadily in recent years surpassing the growth rates in economic activity, consumption and the price level, despite the rapid development of payment technologies and the widespread use of electronic payments. This phenomenon, known as the “paradox of banknotes” suggest that part of the cash demand, especially for large banknotes is driven by motives different from transactional ones.

We use two different econometric approaches for estimating money demand equations – DOLS and ECM and make a distinction between total, large and not large banknote denominations. We establish long-run equilibrium relationships for total and large banknotes, while for the not large banknote denominations the evidence for the existence of cointegration relationship is relatively weak. According to our estimates the demand for banknotes in the long run is positively affected by transactional motives, but also by the price level and real estate prices, as well as by non-transactional/hoarding motives, approximated by an uncertainty indicator. On the other hand the higher degree of development of the payment system and the availability of opportunities for making cashless payments, as well as higher opportunity costs of holding cash exert negative influence on the demand for banknotes. We find a stronger positive relationship between the price level and house prices and the demand for large banknotes, as higher consumer and especially house prices prompt demand for higher denominations if payments are made in cash. The degree of development of cashless payment technologies, proxied by the value of POS transactions, is also found to have a stronger negative influence on the demand for large denomination banknotes.

According to the estimated short-run equations the demand for banknotes in the short-run is driven mainly by house prices and transactional motives and to a

much lesser extent by hoarding motives. An interesting observation is that house prices enter all equations (long-run and short-run for total and especially for large banknotes) statistically significant and the estimated elasticity is also relatively high (especially in the long-run equations), suggesting that real estate purchases are partially paid in cash.

Having concluded that the demand for banknotes, and especially for large denominations, is driven not only by transactional motives, we apply two different approaches (*Denomination Approach* and *Seasonal Variation Approach*) to estimate the hoarding share of banknotes, our definition for hoarding comprising of all possible uses of cash apart from transactions. Depending on the method used and on the assumptions made we find a hoarding share of large banknotes, which varies in the range of 30% to 80% in the period under study. Having in mind that these estimates are sensitive to the concrete assumptions and the method used they should be interpreted with care and shouldn't be taken as highly precise.

As a last step we try to assess the influence of the shadow economy on the demand for cash. For this purpose we include in the DOLS estimations an additional explanatory variable, approximating the shadow economy. This proxy is constructed as a gap between the nominal value of private consumption and the total of all identifiable official household financing sources that may be used for consumption, net of new household savings. Our results suggest that our proxy does not contribute to explaining the growth in banknotes in circulation—particularly large banknotes—over the sample period, which could be explained by the gradual reduction of the shadow economy during the period under study.

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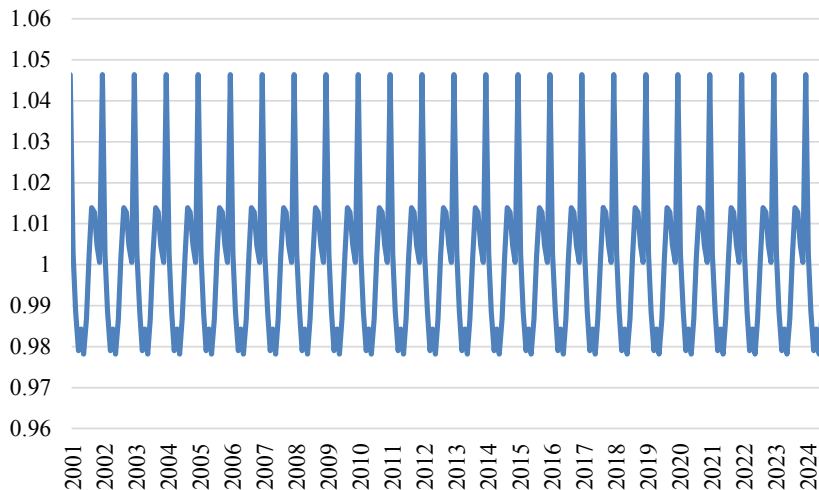
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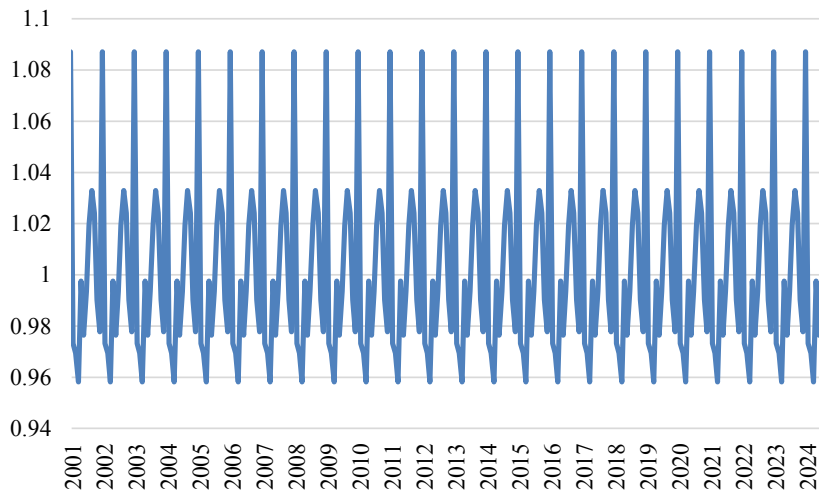
# Appendix

Chart 14: Seasonal factors estimated using a multiplicative seasonal adjustment models

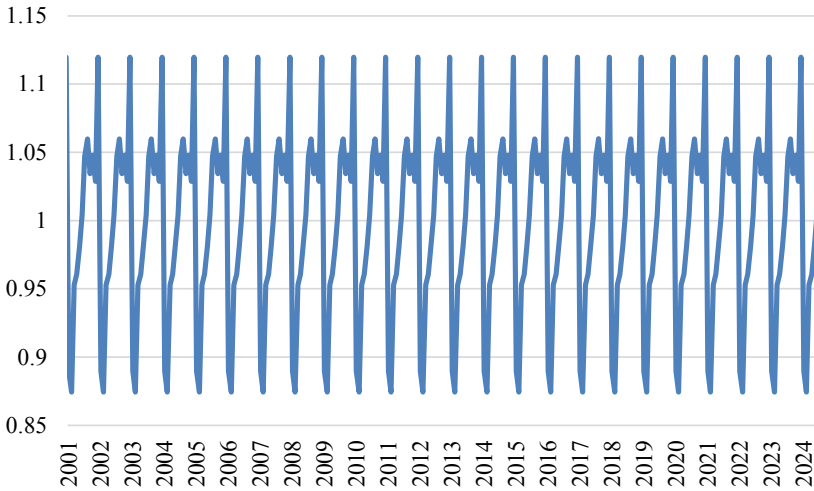
## a) Seasonal factor of large banknotes (BGN 100+ BGN 50)



## b) Seasonal factor of not large banknotes (BGN 20 + BGN 10 + BGN 5)



c) Seasonal factor of retail trade turnover

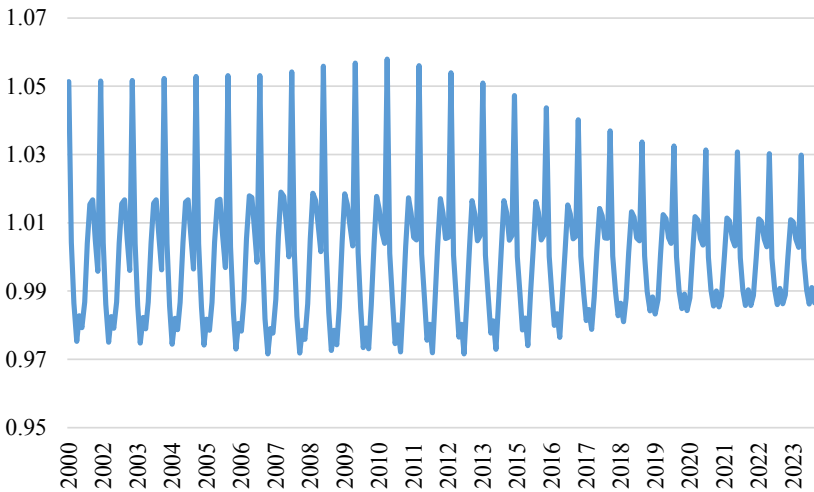


Notes: The multiplicative seasonal adjustment model assumes that the seasonal pattern is consistent.

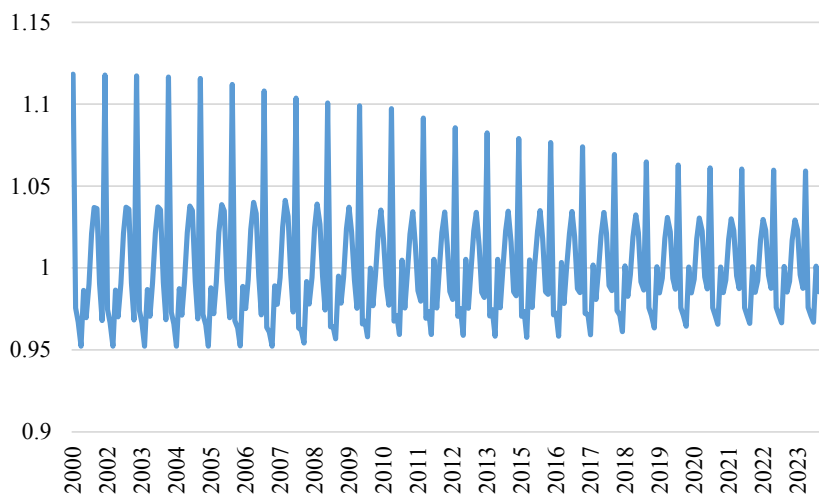
Source: BNB calculations.

Chart 15: Seasonal factors estimated using STL

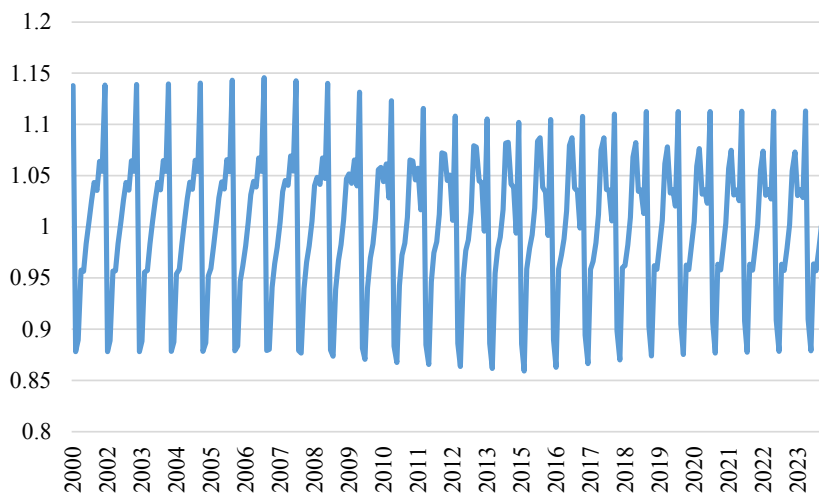
a) Seasonal factor of large banknotes (BGN 100+ BGN 50)



b) Seasonal factor of not large banknotes (BGN 20 + BGN 10 + BGN 5)



c) Seasonal factor of retail trade turnover



Notes: The STL decomposition assumes changing seasonal pattern over time.

Source: Own calculations.



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